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### **BIOLOGICAL CONTROL OF THE INFLUENCE OF THE SHARE OF RAW FIBER IN THE DRY MATTER OF THE DIET ON THE COURSE OF PROCESSES OF CICATRICAL DIGESTION IN GOATS**

**Abstract:** To determine the relationship between the productivity of agricultural products. Animals with nutritional conditions, not only to study the general level of nutrition and structure of the diet, but it is necessary to study the indices of digestion processes in the rumen. Since, in the samples obtained before the morning feeding, the complex indices of the contents of the rumen (pH, total counts and ratios of the VFA, the number of microorganisms) are rich in information, and they completely reflect the ongoing biochemical and microbiological processes in the animals.

**Keywords:** dry matter, nutrients, crude protein, coarse feed, consumed, digested, scar tissue, blood, serum, serum proteins, albumins, globulins.

Development and increase of productivity of agricultural enterprises. Animals, especially pastoral animals, are interrelated with climatic and fodder conditions of pasture lands of the region. Raw fiber in turn limits the amount of food consumed, worsens the digestibility of nutrients and leads to a decrease in the productivity of animals. And this leads to a decrease in the profitability of the industry, and the cost of production becomes expensive. In addition, in a state of pregnancy compared with the dry period, the body's need for nutrients increases 1,5–2,0 times.

Although there is experimental evidence indicating a positive effect, using various effective methods and new technologies in feeding large ruminants, milk production and fat content of milk are increased by increasing the amount of dry matter consumed, increasing the digest-

ibility of the nutrients of the feeds consumed [5; 6], it was also noted that an excessive increase in the amount of raw fiber in the diet from the norm leads to a worsening of the processes of cicatrerial digestion, Nutrients and the synthesis of milk [6].

Since, without the definition of a change in productivity, available natural pastures, the provision of the organism of animals with nutrients in connection with the physiological condition of animals with the seasons and natural climatic factors, it is impossible to improve and improve the quality of the latter.

Thus, the improvement of the problem of high-grade feeding, small cattle in the winter period of the year are one of the actual problem. However, the available literature on feeding small cattle in the winter period, no materials and data are not met. Proceeding from this, all

balance and physiological experiments in our experimental studies were carried out on local goats.

The purpose of our study was to study the effect of the level of fiber in the diet on consumption, digestion of nutrients and scar metabolism in goats in the autumn-winter period of the year. To achieve the goal, the following tasks were set: will study the botanical, chemical composition and biological usefulness of the feed of the constituent diet, and give recommendations to the production; determine the amount consumed, and digested dry matter and fiber; study the change in biochemical parameters of scar, blood and blood serum due to the composition of the diet.

The organization of scientific and industrial experiments [8] and in the course of these experiments the chemical composition of fodder, faeces and urine was determined, as well as other samples from the exchange experiment were used according to generally accepted methods and the nutritional value of the ration of experimental animals was determined [1].

For zoo technical analysis, samples of fodder and excrement were used in the generally accepted methods of zootechny and biology [1; 2; 3].

In the study of scar tissue, the following methods were used: pH-electropotentiometric method at the LPU-01 type; the amount of total and non-protein nitrogen by the Kjeldahl method; protein nitrogen by calculation; ammonia – by the microdiffusion method in Conway's cup; the amount of bacterial mass – by centrifugation; “the amount of volatile fatty acids – by steam distillation in the apparatus – Markhamma” [10]; “the total number of infusorians and for individual species in the Goryaev grids according to the method of VI Georgievsky” [2].

During the course of 7 days for adults (4,0–4,5 years), healthy goats performed balance and physiological experiments [8].

Winter time of the year the amount of dry matter consumed compared to the autumn periods of the year decreased almost threefold.

If in autumn, the goats consumed 1,31 kg of dry matter during the light days from natural pastures, then in the composition containing 7,55 mJ of exchange energy, 0,55 fodder units and 116,7 g of crude protein, in the winter period these indices sharply decreased and amounted, respectively, 0,43; 2,55; 0,19; and 35,3 g. In

addition, in the autumn, goats consumed a dry matter with a high content of crude fiber (37,7%) when grazing grass, while the winter period of the year increased by 5,5% or 43,21%.

In our opinion, the main reason for the decrease in the number of feeds consumed during the winter season was a sharp decrease in the components containing high-grade nutrients (especially easily-split carbohydrates) and an increase in difficultly disintegrating components.

As is known, the digestibility ratios of nutrients consumed by feeds are closely related to the metabolites formed, in the results of the synthetic and hydrolytic processes occurring in the pancreatic forebears. Thus, the change in the processes of digestion in connection with food factors, are expressed with a change in the individual biochemical indices of the scar's fluid. These indicators include pH – scar tissue, total nitrogen, quantity and ratio of volatile fatty acids, ammonia and, finally, actively participating in the digestion of coarse forages different species and populations of scar microorganisms [4; 5].

Change in individual biochemical indicators of scar fluid in goats for pasture maintenance in the autumn-winter period of the year: Autumn – pH ( $7,09 \pm 0,18$ ), Total nitrogen, mg% ( $174,23 \pm 2,8$ ), Protein nitrogen, mg% ( $118,7 \pm 6,4$ ), Amine nitrogen, mg% ( $10,8 \pm 1,3$ ), Ammonia, mg% ( $14,91 \pm 1,1$ ), Winter – pH ( $6,57 \pm 1,07$ ), Total nitrogen, mg% ( $149,89 \pm 6,1$ ), Protein nitrogen, mg% ( $101,76 \pm 4,6$ ), Amine nitrogen, mg% ( $9,3 \pm 1,4$ ), Ammonia, mg% ( $12,56 \pm 0,9$ ).

In our opinion, the main reason for obtaining this result was a sharp decrease in some nutrients, including protein and an increase in fiber content in pasture forage.

According to the data received, in the winter time of the year, consumed fodder compared to the autumn periods, the total amount of nitrogen was 13,98% less. Accordingly, the amount of protein nitrogen content of the scar decreased by 14,28%. In autumn, when the goats received the necessary amount of nutrients with the feeds consumed, the acidity of the contents of the rumen to a certain extent tended to decrease towards a slightly alkaline (pH – 7,09), and the acidity of the winter period of the year (pH – 6,57), We can explain, with a deficiency of nutrients, especially a low protein content in the composition of feed.

In accessible literature there is evidence that the acidity of the contents of the rumen affects to some extent the

number and types of microorganisms actively participating in fermentation processes [9].

Quantities and ratios formed by the PLV in the scar's goats' fluid in the autumn-winter period of the year: Autumn – VFA, g/eq/l ( $7,98 \pm 0,3$ ), Acetic acid, % ( $63,01 \pm 0,4$ ), Propionic acid, % ( $20,18 \pm 0,6$ ), Oil pump, % ( $14,9 \pm 2,6$ ), Winter – VFA, g/eq/l ( $6,31 \pm 0,4$ ), Acetic acid, % ( $51,06 \pm 1,3$ ), Propionic acid, % ( $29,75 \pm 1,7$ ), Oil pump, % ( $18,81 \pm 0,9$ ). In this regard, the amount of infusoria in 1 ml of scar tissue was  $615,52 \pm 54,06$  thousand/ml, in winter time, their quantity decreased by 18,21% or  $503,40 \pm 7,28$  thousand/ml. As can be seen from the above data, the total amount of edible goat in the rumen of the LHC in autumn was  $7,98 \pm 0,3$  g/eq/l, the winter period of the year decreased by 21,03% or  $6,31 \pm 0,4$  g/eq/l. It is known that microbial processes in the pancreatiles and the total amount of VFA formed in the rumen and their correlation among themselves in to some extent predict the future of ruminant productivity.

In studies to assess the state of metabolism in the body of goats, one of the most important tests is the study of the change in the amount of serum proteins of the blood, since they change rapidly, and reacts peculiarly to alimentary deficiency [4; 5].

A number of authors have comparatively studied the content of protein fractions of blood serum in small and highly productive Karakul sheep and found that albumin amounts were higher in highly productive sheep.

The following shows the data showing the change in the fraction of whey proteins due to the season of the year and feed factors. Change in accordance with dietary conditions in goats, total protein and their fraction in blood serum: Autumn – Total protein, g ( $7,00 \pm 3,40$ ), Albumins, % ( $44,2 \pm 1,46$ ), Globulins, % ( $55,8 \pm 1,43$ ),  $\alpha$ -globulins, % ( $11,18 \pm 0,60$ ),  $\beta$ -globulins, % ( $7,6 \pm 0,97$ ),

$\gamma$ -globulins, % ( $37,01 \pm 1,80$ ), Winter – Total protein, g ( $6,08 \pm 0,58$ ), Albumins, % ( $53,36 \pm 2,54$ ), Globulins, % ( $46,64 \pm 1,07$ ),  $\alpha$ -globulins, % ( $11,29 \pm 0,09$ ),  $\beta$ -globulins, % ( $12,1 \pm 1,02$ ),  $\gamma$ -globulins, % ( $23,26 \pm 2,40$ ). As can be seen, from the data of the total protein in the blood serum, the goats in the autumn period of the year were  $7,00 \pm 3,40$  g, and in the winter period of the year it was  $6,08 \pm 0,58$  g or decreased by 13,14%.

However, as shown by the data obtained, that in the circulating blood, the albumin share in the winter period of the year was  $53,36 \pm 2,54$ %, or 8,9% more than in the autumn, and this in our opinion is related to the mobilization feature of the organism at inadequate intake of essential nutrients from rations.

We also determined that the proportion of albumins from the total amount of protein was 15,83%, then in the winter period this figure increased by only 4,44% in autumn and amounted to 11,39%.

#### Conclusions:

1. To determine the productivity of farm animals in relation to food conditions, the study of only the general nutritional and structure of rations is not enough, it is also necessary to study individual biochemical and microbiological indices of the processes of cicatricial digestion. Since the samples obtained before the morning feeding of blood and rumen fluid are very rich complex indicators, and they completely reflect the ongoing metabolic processes in the whole body and individual organs.

2. Taking into account the physiological condition of the animals for controlling the usefulness of fed rations, studying the indices of biochemical and other internal fluids among the organism, it is possible to purposefully change the metabolism of the organism and the digestive processes in ruminant pre-larvae.

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## Section 2. Information technology

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### BLOCK STRUCTURE OF CLASSIFICATION ALGORITHM NAIVE BAYES

**Abstract:** This paper describes general representation of data mining algorithms by block structure, and based on this, the Naive Bayes algorithm divided into blocks. Division of algorithms into separate blocks allows to create new algorithm with less efforts, and also it is easy to change algorithm, by replacing one or more blocks, and get a new result.

**Keywords:** Data Mining, Classification, Naive Bayes.

Data mining algorithms, as well as any algorithms include such blocks as operations, conditional branches and cycles. However, they have other common blocks are specific only for data mining algorithms. Decomposition of algorithms into separate blocks and marking identical blocks among them will reduce the efforts for the development and debugging of data mining algorithms. Hence, suggested the block structure of data mining algorithms.

In case of a block structure the algorithm divided into separate subtasks (blocks, steps). Each such block obtains processing data, settings and model created at the previous stages on an input [1]. The following principle is thus implemented: data and settings aren't subject to change – the model can change only. Each block is “monolithic” from the point of view of the main algorithm. In fact, it represents mini-algorithm. On an output of such block we will receive the changed model which has arrived on its input.

In case of partition on blocks it is necessary to observe the following requirements:

- block implements logically finished operation of algorithm and can be replaced with another and/or is used in other algorithm;
- in the block there is no appeal to the external variables, all operation is performed based on the settings transferred to the block, the current vector in input data

and the model statuses, thus all changes are made only to model;

- block doesn't contain other standard blocks, for example cycles on vectors or cycles on attributes;
- after block execution the model remains integral, i. e. it conforms to all requirements superimposed on it.

The main analysis algorithm of data will be built of such blocks also. The described structure of algorithm is given in (Figure 1).

We will consider block model of algorithm which specifies the diagram provided in picture 1, and executes everything described above the requirement.

According to the described structure on an input of algorithm the set of input data and a set of settings which enter moves:

- task settings;
- algorithm settings;
- model constructed by the previous block.

On an output we receive the model constructed by algorithm.

The algorithm divided into some steps (blocks) which are forming sequence and being executed one after another. The block accepts on an input the same parameters, as algorithm (data and settings), plus the model constructed by the previous block of algorithm. From this it follows that and the very first block shall

receive initial (empty) model on an input. For this purpose the algorithm begins not directly with execution of

sequence of blocks, and has a preparatory step on which there is a model initialization.

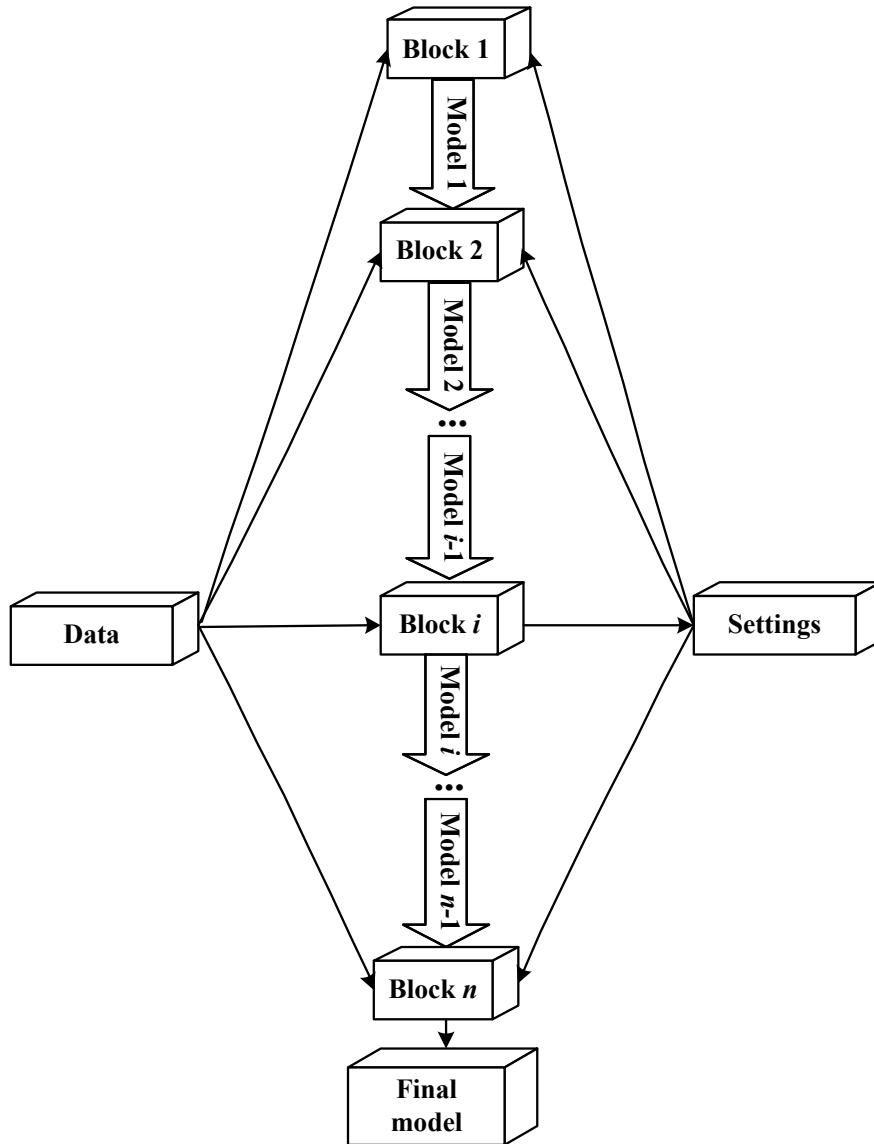


Figure 1. Block structure of algorithm

In case of initialization of model its empty preparation which filling will happen in blocks of algorithm is created. It will move on an input of each of them and to change them.

The sequence of blocks will be executed further. Each block may contain both executable code (subtask), and sequence of other blocks. Generally the block may contain not one subsequence. Thus, a certain hierarchy, similar figured in picture 2 will be formed.

To provide universality of the block model, all blocks shall have the general interface launching their execution.

We will consider main blocks.

**Linear block** doesn't contain other blocks. It has only unified interface via which makes the solution of the task.

**Cycle block** contains sequence of blocks and defines the operations executed in case of initialization of a cycle, before iteration execution, and also a loop termination condition. The unified interface launches execution of these functions in the following order:

- cycle initialization;
- check of a condition of loop termination;
- function executed before iteration;
- execution of nested sequence of blocks;
- function executed after iteration.



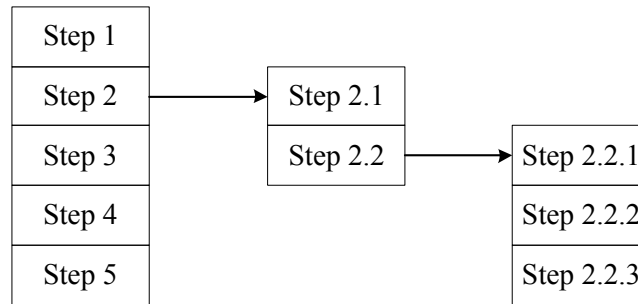


Figure 2. Example of block hierarchy

**Decision block** contains a checked condition and two sequences of blocks. By results of check of a condition this or that nested sequence of blocks is executed.

Let's consider structure of classification algorithm Naive Bayes [2] (Figure 3). It contains directly all declared general blocks. Coming out of the bottom of the block arrow indicates that he is the next in the sequence block. The arrow coming on the right testifies to existence of the sequence enclosed in the block.

CycleTargetValue is a cycle on values of the certain attribute (variable), in this case dependent variable. CycleByVectors – a simple loop on basic data, it touches in turn all vectors. CycleAttributes is a cycle on all independent attributes, i. e. on length of a vector a minus block (dependent attribute). It should be created as the cycle inherited from a cycle on all attributes of a vector,

redefining output conditions from a loop body and incrementing of the counter of iterations.

The block MainCycle is a cycle on all possible combinations of values of independent attributes. FindProbabilityOfAttributeValue – the linear block which is always executed for the same time, irrespective of data. It skids in model of classification rules information on presence at the current vector of data of value of the current independent attribute from the combination made in a basis cycle of algorithm. After the combination review in the linear block NormaliseProbability the normalized probabilities of equality of dependent variable to each of possible values are calculated in case of the current set of values of independent attributes and the classification rule having the greatest probability is selected.

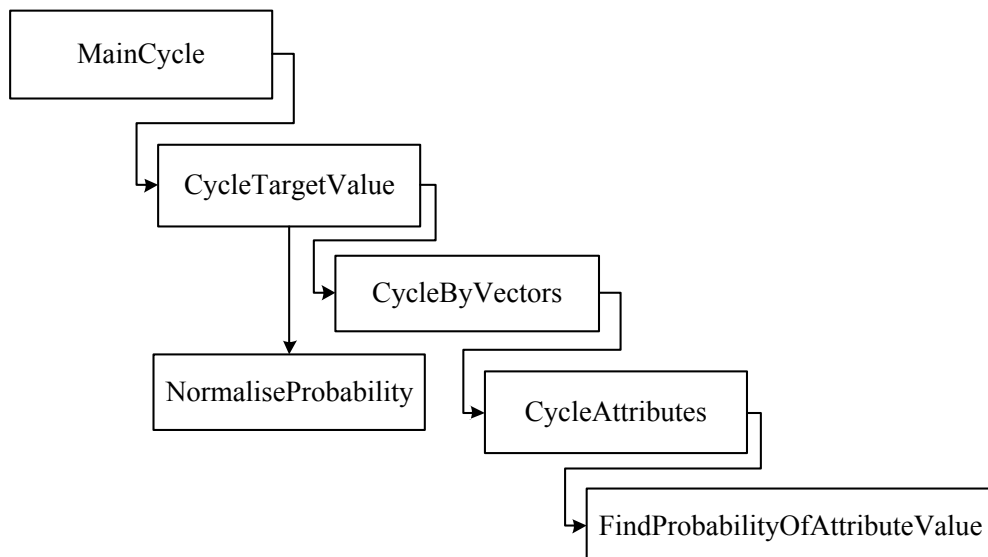


Figure 3. Block structure of Naive Bayes algorithm

By means of the blocks provided in given algorithm, it is possible to modify easily algorithm, using existing and having added new blocks (Figure 4).

The block CountClassWeight calculates number of appearances of each value of a class in trainees of data. In case of the current value of a class the block CountAttribute-

Weight is engaged in computation of number of appearances of the current value of attribute. The block CalculateProbability calculates probabilities. From a figure it is visible that the block CountAttributeWeight is executed for each value of attribute in a cycle on attributes which in case of each it-

eration takes value of the following attribute. This cycle, in turn, and also the block CountClassWeight are executed in an external cycle on vectors. On each iteration the model that is one of advantages of this version changes. Besides, the minimum quantity of cycles is executed.

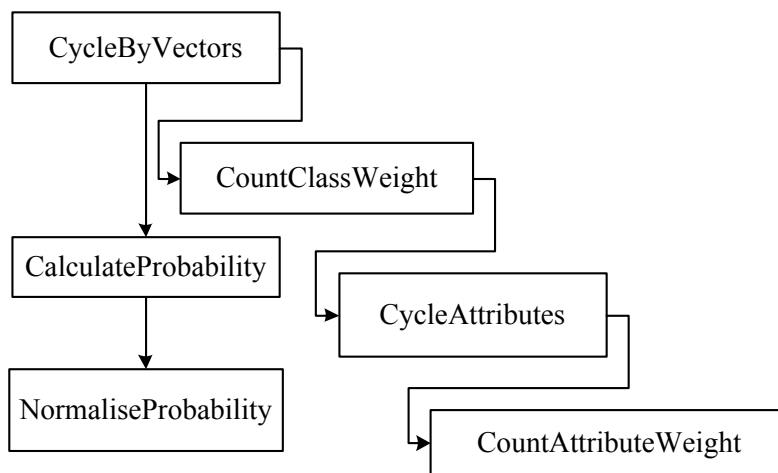


Figure 4. Block structure of Naive Bayes algorithm (modified)

The names of the blocks were obtained from the flowchart of classification algorithm Naive Bayes and written in abbreviated form.

Thus, in this paper proposed the block structure of data mining algorithms. By using this structure classification algorithm Naive Bayes decomposed into blocks and on the basis of these blocks received a new

algorithm by changing some of them and adding new blocks. Decomposition of algorithms into separate blocks and marking identical blocks among them will reduce the efforts for the development and debugging of data mining algorithms. Besides, such block division allows to reform algorithm for its parallel execution.

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## Section 3. Machinery construction

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### MODEL TEST OF A BUILDING DESIGN FOR DESTRUCTION AT INFLUENCE OF THE COMPELLED FLUCTUATIONS

**Abstract:** Studied the effect of modern building materials, bricks and foams which basis on local materials to increase the seismic-proving of buildings and constructions. The practices experimented by Fruds criteria. Tested by the effect of demper systems to bricks and building mixtures by the loading which is forced oscillation to the special building constructions. The durability of building materials and experimented the holding functions. The results scientifically analyzed.

**Keywords:** Axonometric diagram, neoprene, paranit, dynamic practice.

Historically at building of minarets in Central Asia for increase of seismic stability of a construction through certain intervals were established special damper bricks. In our work damper bricks are created from modern materials with application foam vermis with potassium additives. Bricks with foam вермикулитом were established in a laying and played a role damping extinguishers. During test were used as and damper pillows from neoprene and paronits [1].

For test the frame part of model has been executed in the form of a bricklaying by section 100 see also in height 100 see As observed criteria groups the criterion of Fruda was used:

$$Fr = v^2 / lg$$

Where  $v$  – speed of a liquid far from a body flowed round by it;

$l$  – Characteristic linear parametre;

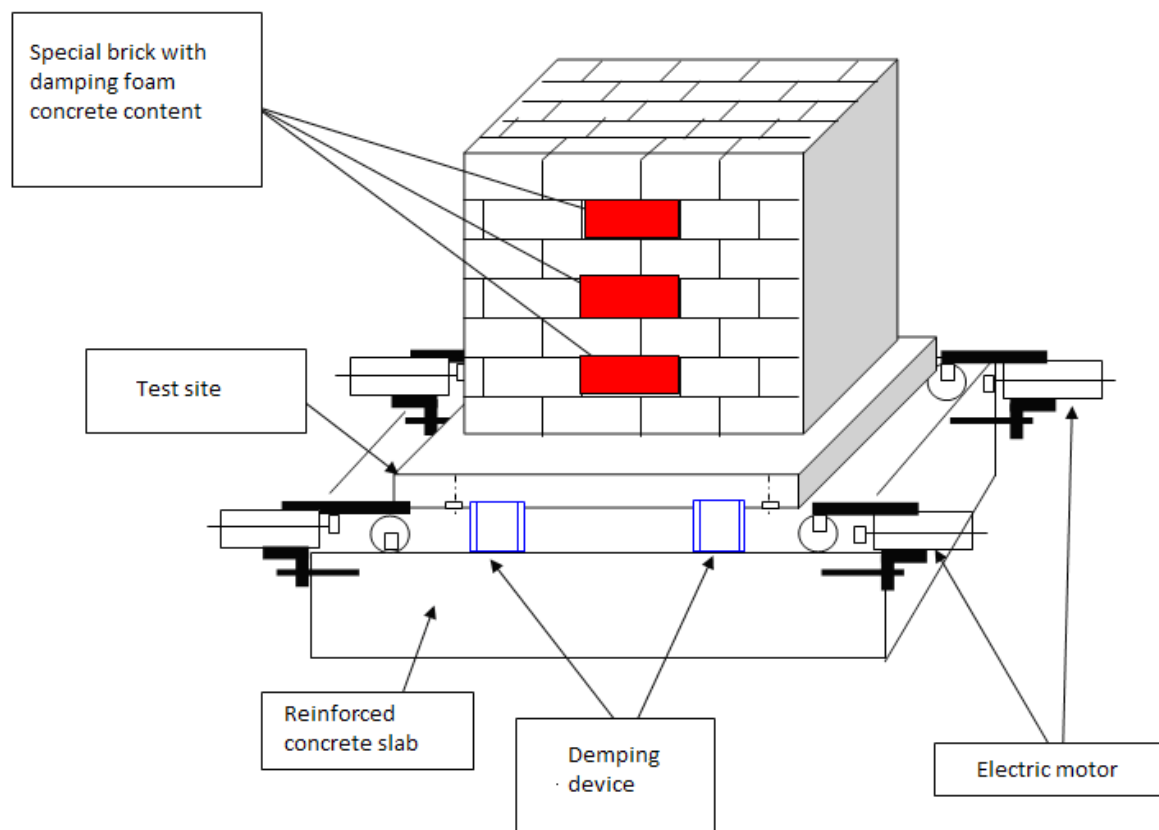
$g$  – gravity Acceleration.

Modelling parametres also were checked on conformity to criterion of Bio:

$$Bi = hl / k$$

Before seism platform dynamic tests for static tests of model of the brick block with inserts from a special brick with damping foam concrete the maintenance have been conducted.

On model overlapping gauges for record of moving and accelerations have been established. The period of own fluctuations of a frame part of the system, defined on record of fading fluctuations of model after tests has appeared equal 0,18 seconds [2].



Scheme 1. The axonometrical of carrying out of test of bricklaying with special damping inserts

Table 1. – Results of researches of durability of model of a building design without additional loading during dynamic influence (test of a fragment of model located vertically)

| № | Material for damping  | Destroying force, кН |         |       |
|---|---|----------------------|---------|-------|
|   |   | On compression       | Torsion | Bend  |
| 1 | The model, was not exposed to loading                           |                      |         |       |
|   | Neoprene marks elast 0003                                       | 29.69                | 31.17   | 26.95 |
|   | Paronite (PON) reinforced by a basalt fibre                     | 32.10                | 36.41   | 29.45 |
|   | Special damping bricks with foam concrete the maintenance       | 23.4                 | 22.45   | 23.76 |
| 2 | The model, was exposed to dynamic loading                       |                      |         |       |
|   | neoprene marks elast 0003                                       | 24.58                | 26.05   | 21.82 |
|   | paronite (PON) reinforced by a basalt fibre                     | 27.30                | 31.67   | 24.89 |
|   | Special damping bricks with foam concrete the maintenance       | 18.7                 | 16.74   | 15.23 |
| 3 | The model, after dynamic loading was exposed to thermoinfluence |                      |         |       |
|   | neoprene marks elast 0003                                       | 21.29                | 22.72   | 19.17 |
|   | paronite (PON) reinforced by a basalt fibre                     | 23.06                | 28.37   | 21.54 |
|   | Special damping bricks with foam concrete the maintenance       | 17.7                 | 17.21   | 14.63 |

Preceding from results of the spent tests it is possible to draw a conclusion that both without loading and at increase by floor loadings, merits of an offered composition remain.

That circumstance is characteristic also that at disposable (once in a current of one hour) dynamic loading design models, difference of bearing loadings (at use paronite from use variant neoprene) for damping made

no more than 4%, even at increase in additional cargo in 6 times more own weight of model of a design.

The increase in dynamic loading at model of the design located at test vertically, at one more time in one hour, reduced durability of a design by 2–6% without additional loading. At 4 single loading, the distinction size increased to 10%.

The behavior of model of the design located at tests has horizontally shown that essential differences begin, only at increase in additional loading in 5 times when for cases of loading with torsion and compression, durability has changed on 6–7%, at a bend on 1–3%, in advantage paronite bases for damping.

The conducted tests, also have confirmed. That delay of process of allocation of a smoke from a material is connected with increase of durability of a material [3].

The increase in dynamic loading at model of a design located at test is horizontal, on one more time, in one hour, reduced durability of a design by 1–3%. In this case, at increase in additional loading in 4 times there is more than weight of the design of model, the distinction size increased to 7% in favor of offered a variant damping devices.

The appendix by floor loadings on model of a building design has allowed checking up experimentally and anti-dump qualities tested damping devices. With an

establishment of additional cargo from above, actually there was a displacement of the centre of gravity of all test complexes, especially at a vertical arrangement of tested model. However, this circumstance has not led to a collapse not only a test complex, but also tested models of building designs.

To such conclusions it is possible to come on the basis of following reasons [4]:

Carrying out of separate gauging on a deviation of fluctuation of a building design have shown that the maximum deviation of the highest point of models at the compelled fluctuations does not exceed value which is observed for use variant neoprene (material widely used in the world for damping devices) and in particular equal 2,4 see.

Durability of tested models, after identical dynamic loadings (at application of both types of materials for dump devices), with stage-by-stage increase in loading if with neoprene about 50% for a case of application of an offered material, durability decreased no more, than on 75% were lead up. That has allowed approaching conditions of carrying out of tests to the critical. In case of joint influence of dynamic and thermal loadings, reduction of bearing ability of tested model of a building design by 75%, and bearing ability of the same models was observed at an offered variant dumping, decreased all for 47%.

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## Section 4. Medical science

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### THE COURSE OF RHEUMATOID ARTHRITIS IN VARIOUS CLIMATIC CONDITIONS

**Abstract:** Results of the study indicate that climatogeographic factors have a certain influence on the course of rheumatoid arthritis according to the regions in Uzbekistan living.

**Keywords:** rheumatoid arthritis, climatogeographic factors.

Rheumatoid arthritis (RA) is a heterogeneous disease in which the interaction of the genetic component and environmental factors causes a pronounced clinical polymorphism [1, 4; 5]. According to the literature data, weighting of diseases occurs under simultaneous influence of many factors, in particular, environmental factors [2, 86]. It is well known that environmental factors have a significant effect on the functional activity of the human body. So when studying the influence of various environmental indices, environmental factors of up to 30% are of primary importance. From them, environmental pollution accounts for 20% and climatic conditions – 10% [3, 156–157]. This means that the problems associated with diseases cannot be considered without taking into account and discussing the characteristics of the environment. Thus, according to the studies [4, 184–185], the clinical and immunological parameters of the rheumatoid arthritis have their own peculiarities depending on the patient's living areas in the conditions of Uzbekistan. Therefore, during the last few years, possible links between the development and features of the subsequent course of rheumatoid arthritis (RA) with

adverse environmental factors are discussed.

By now, Uzbekistan is the subject of many works of medical and geographic focus, as the republic is unique in its geographic location and especially in its climatic conditions. In general, the climate of Uzbekistan is an arid continental type. The average July temperature varies over flatland territory from 26 °C in the north to 30 °C in the south, the maximum reaches 45–47 °C. The average January temperature drops to 0 °C in the south and to – 8 °C in the north, the minimum temperature in some years reaches – 38 °C (Ustyurt plateau). On the territory of Uzbekistan there are five natural ecosystems: desert ecosystems of plains; piedmont semi-deserts and steppes; river and coastal ecosystems; ecosystems of humid areas and deltas; mountain ecosystems. According to climatic indicators, three main climatic zones will be distinguished: a zone of deserts and dry steppes, a foothill zone and a mountain zone. Consequently, the study of correlation of RA morbidity with these or other meteorological factors is an actual problem. The solution of these issues in different climatic



and geographic conditions in Uzbekistan is of both scientific and practical interest. According to studies [5, 37], on the background of fluctuations in certain physical parameters of the climate, regular changes occur in the joint syndrome in RA. Therefore, we consider it relevant to study in this area, especially in the issues of the peculiarities of the course of this disease on the background of various conditions of climatic comfort.

The purpose of this study was to assess the features of the clinical course of RA on the effects of climatic factors, depending on the different conditions of climatic comfort in Uzbekistan.

### Material and Methods

The materials of the studies was a retrospective analysis of 900 outpatient cards and extracts from the patient's case histories from the RA among residents of the following regions of Uzbekistan: I zone, western region of Khorezm ( $n = 300$ ); II zone, the eastern Namangan region ( $n = 300$ ) and the III zone, the southern region ( $n = 300$ ) over a 10-year period.

The actual levels of meteorological parameters were obtained from the regional Hydrometeorological Centers. On the basis of these data, a bank of information on meteorological factors of the first order atmospheric pressure (in mb), air temperature (in C<sup>0</sup>), relative humidity (in%) and duration of sunshine (in hours) have been accumulated.

The retrospective analysis included questions reflecting cases with positive clinical dynamics; duration of remission of the disease (more than 6 months); need for hospitalization; the frequency of contact with a doctor about problems (2 times or more per month during the year); comorbid conditions and extraarticular manifestations of RA.

The obtained results were subjected to static processing with the help of the computer program EXCEL and STATISTICA 6.0, with the calculation of the arithmetic mean and deviation errors ( $M \pm m$ ). The reliability of the

differences was calculated using the Wilcoxon method. Correlation analysis between the indicators was carried out using Spearman's ( $r$ ) coefficient.

### Results and discussion

Among the studied patients, women predominated – 810 (90%). The duration of the disease ranged from 8 months to 35 years (an average of  $9.5 \pm 7.8$  years). The retrospective studies show that the clinical course of RA in three different climatic and geographical zones have a certain difference. So in I zone prevailed such indicators as the tendency to the progression of the disease for the last 3 years – 83.4%; frequency of cases with the need for inpatient treatment for one year – 62.4%; high rates of seropositive results – 65% of cases. In this zone, cases with clinically pronounced variants (visceral form) of the course – 51.7% and necessity for high doses of aggressive methods of treatment (methotrexate – 25–30 mg/week) prevailed in this zone – in 83.4% of cases. In the third zone, the manifestation of the disease in most patients was noted at an earlier age – 55.4% of cases; changes in the reproductive system, i. e. women with RA during the year most often treated with problems associated with violations of the menstrual cycle – 50%, in the II zone and this figure was only 12% ( $p < 0.01$ ), and in the III zone – 24% ( $p < 0.05$ ). According to the record in outpatient cards, spontaneous abortion was noted in the 1st zone in 36.4% of women, secondary amenorrhea was registered in 30% of patients, and in 66.4% of cases, various types of menstrual cycle irregularities. In turn, the II zone was distinguished by relatively low (positive) indices in comparison with other zones ( $p < 0.05$ ). Studying the indicators, it was found (Table 1) that among the patients of the I and III zones the indices compared to the II zone were high in the frequency of cases with the need for inpatient treatment for one year ( $p < 0.05$ ), the frequency of medical attention, in the time in these zones with a long-term remission compared with others was low ( $p < 0.05$ ).

Table 1. – Comparative data of RA patients in different zones

| Indicators  | I zone ( $n = 300$ ) | II zone ( $n = 300$ ) | III zone ( $n = 300$ ) |
|---|----------------------|-----------------------|------------------------|
| The percentage of patients with long-term remission | 20.4                 | 66.7                  | 33                     |
| The percentage of patients needing hospitalization  | 67.4                 | 20                    | 53.7                   |
| The percentage of patients who often visit doctor   | 72.7                 | 40.7                  | 68.5                   |
| The percentage of patients with comorbid conditions | 69                   | 54.4                  | 67.4                   |

However, in these zones, cases with a tendency to progression of the disease over the last 3 years prevailed, as well as manifestation of the disease at an earlier age. It should be noted that zone II differed with relatively low (positive) indicators in comparison with other zones. However, in all zones ( $p > 0.05$ ) in most patients, the manifestation of the disease was characterized by a gradual deterioration of the state on the background of comorbid conditions.

As the results of the analysis show, RA patients have meteosensitive reactions depending on climatic factors and certain regularities were revealed by us when comparing the month and the season of the year. The correlation analysis showed a significant role and influence of climatic factors on the clinical course of RA and that the most significant indicators were the weather stiffness index ( $r = 0.57$ ), the frequency of wet and cloudy weather ( $r = 0.68$ ), the number of days with fluctuations in the atmospheric pressure ( $r = 0.53$ ) and the duration of the discomfort period ( $r = 0.7$ ). It should be noted that

the duration of hot and dry summers from a high temperature above  $40\text{ }^{\circ}\text{C}$  ( $r = -0.71$ ) with low humidity  $f < 80\%$  ( $r = -0.77$ ), as well as the intensity of solar radiation ( $r = -0.67$ ) favorably influenced the course of RA.

When comparing the average annual characteristics over the past three years, there was a correlation between the climatic factors and the clinical parameters of the RA. Thus, as can be seen from Fig. 1, in the zone of high atmospheric pressure (I and III zones – 971–975 mb, respectively), there is an increase in the frequency of patients' access to the doctor ( $r = 0.6$ ,  $r = 0.72$ ,  $p < 0.05$ ) and indications for hospitalization  $r = 0.84$ ,  $r = 0.88$ ,  $p < 0.05$ ). In the first and third zones, an inverse correlation is observed ( $r = -0.9$ ,  $r = -0.7$ , respectively) with the indices of patients with long-term remission. In turn, with a decrease in atmospheric pressure (zone II – 945–929 mb), cases in the need for hospitalization decrease ( $r = -0.8$ ,  $p < 0.05$ , respectively) and patients' recourse to problems ( $r = -0,85$ ;  $p < 0.05$ , respectively).

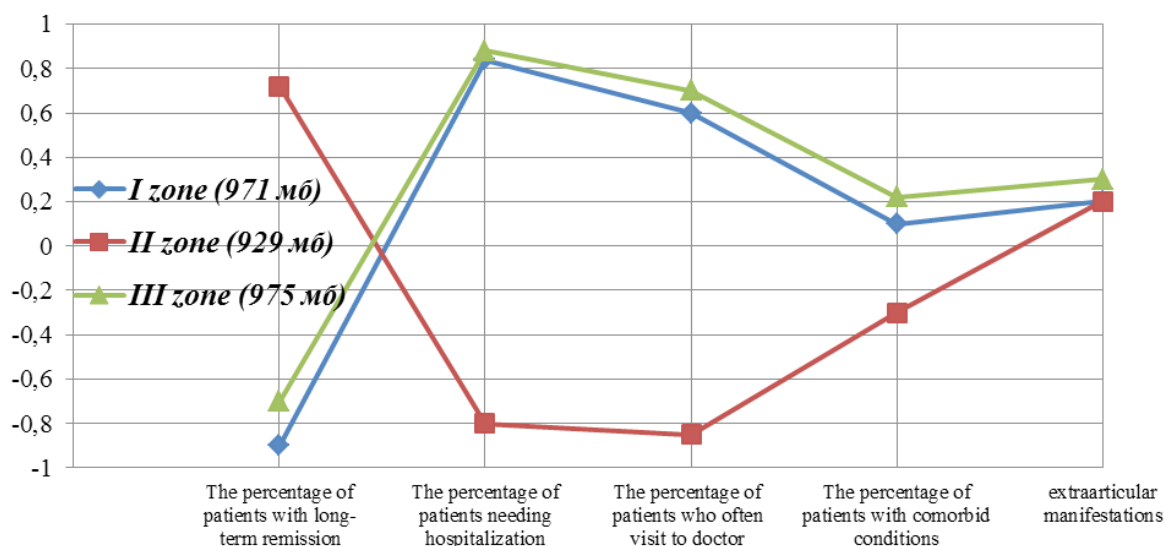


Figure 1. Correlation between atmospheric pressure levels and indicators

The results of the analysis showed that the clinical course of RA depends on the temperature fluctuation of the external medium. Thus, the frequency of various types of disturbances in the reproductive system increased in direct proportion to the level and temperature fluctuation of the external environment. At low ambient temperature levels of  $-8.30$  and below (I zone), the incidence of spontaneous abortion ( $r = 0.70$ ,  $p < 0.05$ ) and various types of menstrual cycle disorders ( $r = 0.73$ ,  $p < 0.05$ ).

When analyzing the influence of the sunshine time on the course of the disease, it was found that there were no reliable correlation relationships between the indices. It should be pointed out that the complex of elements installed during the period of high relative humidity in certain zones is unfavorable. Thus, a regular variation was observed with the incidence of cases with long-term remission. As can be seen from (Figure 2), with decreasing in humidity levels (zone II,  $r = 0.88$ ,  $p < 0.05$ ), cases with long-term remission of RA are increasing.

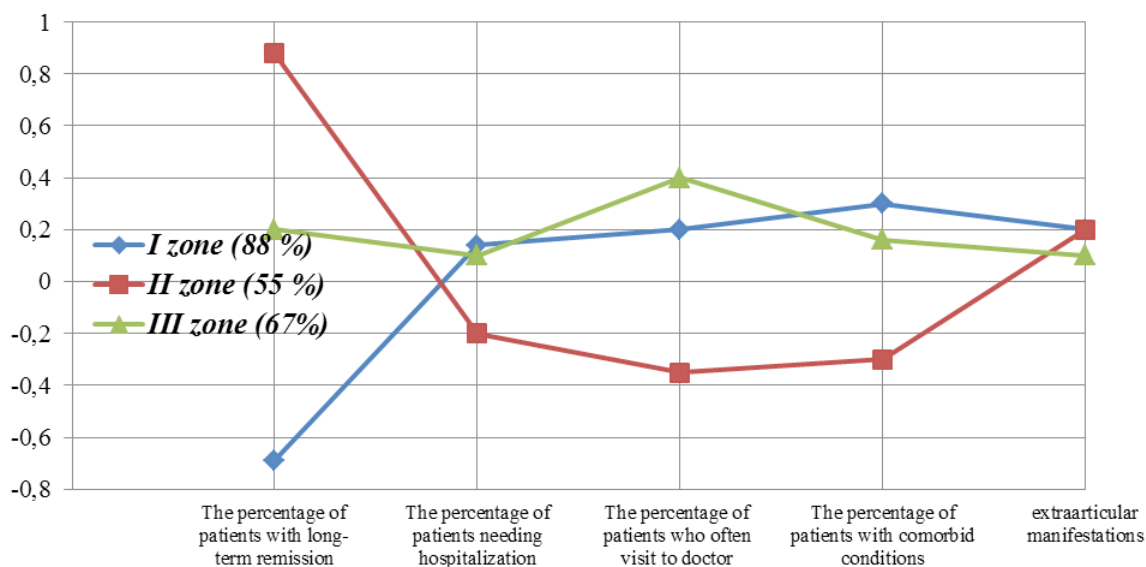


Figure 2. Correlation between humidity levels of atmospheric air and indicators

Thus, the retrospective-correlation analysis shows that RA indicators differ in three zones of Uzbekistan and climatic factors influence the course of the disease. This indicates the existence of a regional specificity of the clinical course of RA in the conditions of the sharp-

ly continental climate of Uzbekistan. Based on the data obtained, it is possible to allocate: high-risk territory (I and III zone) for RA progression and low-risk territory (II zone).

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## **MINIMALLY INVASIVE SURGERY OF TRAUMATIC VERTEBRAL FRACTURES**

**Abstract:** In the injury of spinal column, due to compression breaking of spinal column, strong pain and limiting of action will be appeared. As result, the patient will have needs to keep sprawling during long period. As result of following conducted clinical examinations, because of using percutaneous vertebra-plastic operation in patients with compression breaking of spinal column, determined sharply decrease of pain syndrome and maintenance of spine stability.

**Keywords:** fractures of vertebral bodies, percutaneous vertebroplasty.

**Introduction:** The problem of injuries remains the leading social and economic problem among the working-age population and takes tenth place among the diseases that take the lives of the world's population. Injury of the spine, among the total number of injuries of the body takes according to different sources from 8% to 14%. From them 55–68% the person of working age [1]. The social signifi-

cance of the problem of treating spinal injuries is characterized, in addition to adequate treatment of patients with this pathology, also further rehabilitation and restoration of their ability to work. In some cases (72–85%), patients with spinal trauma need surgical intervention [2]. Nowadays, the most important role of surgical treatment of spinal injuries is to improve the quality of patients' life, a

small invasion surgical intervention and rapid postoperative rehabilitation of patients. In this regard, we are using the method of percutaneous vertebroplasty (PVP) in the treatment of traumatic compression fractures of vertebral bodies of I–II degree (according to Beck’s classification) without disturbing the function of the spinal cord and its roots. In view of the fact that the front parts, in particular their bodies (60–70% of stabilization), are the main part of the vertebrae providing stabilization of the spine, with an isolated compression fracture of the body of the I–II degree without compression of the structures of the spinal cord and nerves, we chose the treatment tactics by PVP. This technique involves the introduction of bone cement (polymethylmethacrylate) through a special needle “percutaneously” into the body of the damaged vertebra. Along with the restoration of the supporting function, the introduction of bone cement also has an effective reduction in acute pain syndrome. In the clinic of the Tashkent Medical Academy on the basis of the Department Traumatology-Orthopaedics, MFS (military field surgery)

and neurosurgery, these operations are conducted since 2016 and prove their effectiveness and relevance.

**Objectives:** Analysis of the effectiveness of percutaneous vertebroplasty in the treatment of traumatic compression fractures of vertebral bodies of I–II degree.

**Material and Methods:** In clinic of the Tashkent Medical Academy on the basis of the Traumatology-Orthopaedics Department, MFS and Neurosurgery since 2011 in connection with traumatic lesions of the vertebral bodies 11 PVP have been performed in 8 patients. From them, men were 5 (62.5%), women 3 (37.5%). The average age of the patients was 38 years (from 21 to 55). Clinically, according to the VDS pain score in 3 patients the pain was 8 points, in 5 patients 6 points [3]. Patient examination was based on a clinical examination, including a detailed examination of the neurological status, X-ray examination of the spine in two projections, CT with 3D reconstruction, MRI – to exclude the compression of the structures of the spinal cord and/or roots, general clinical tests and a developed coagulogram.

Algorithm 1

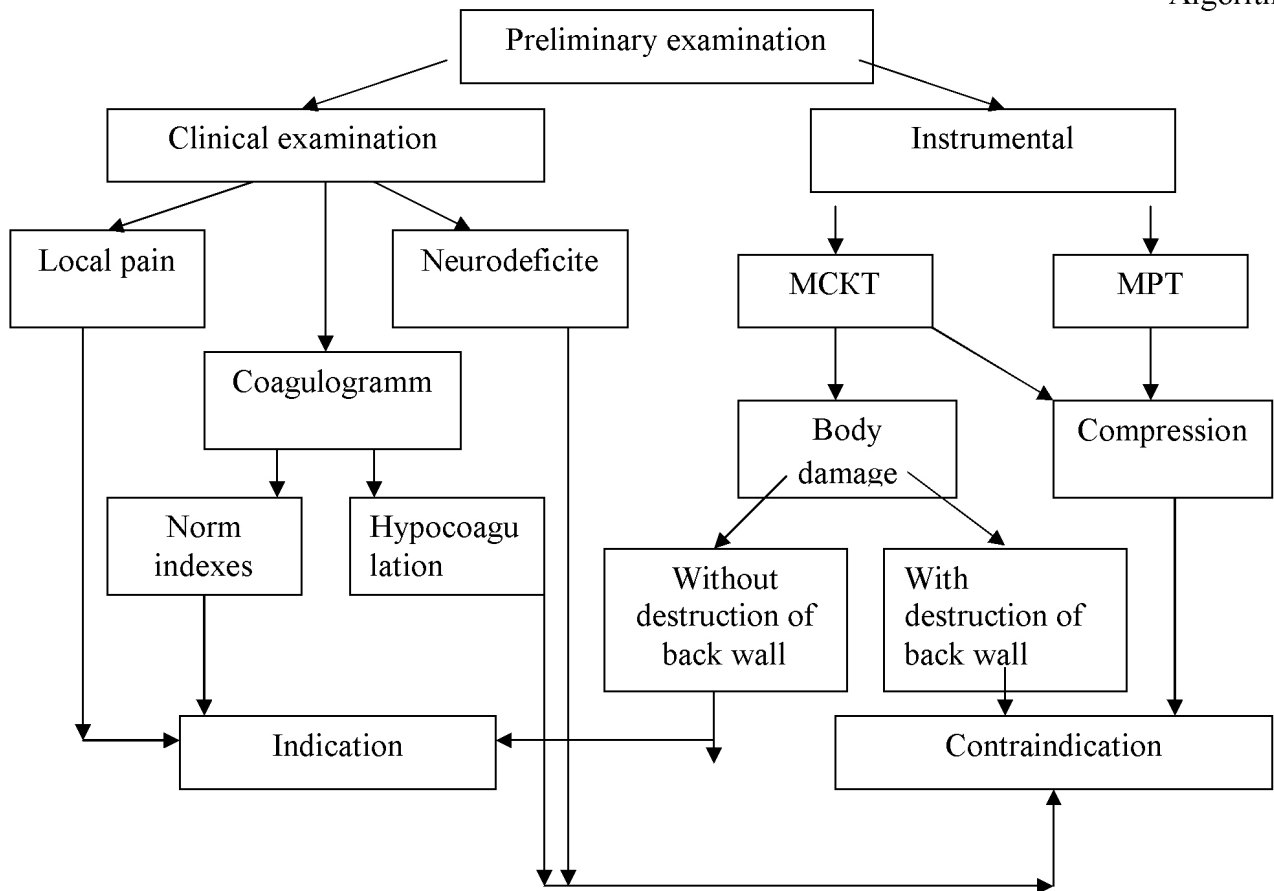


Figure 1.



In all cases (8 patients) PVP was performed. Indications for PVP were the presence of single and multiple compression fractures of vertebral bodies with a strong pain syndrome without spreading the process beyond the affected body and without gross neurologic symptoms. The examination and selection of indications for the PVP was carried out according to Algorithm 1. Before the implementation of PVP, preoperative administration of antibiotics was performed. It was used cefazolin 1g intravenously or intramuscularly. All patients underwent local anesthesia with 1% lidocaine solution and 0.5% novocaine layerwise accord-

ing to the future needle route. After insertion of the needle into the lesion, the target lesion zone was used to evaluate the venous drainage of the damaged vertebral body [4]. After venosondilography, the final stage of the procedure was the introduction of bone cement. PVP was performed for 3 patients simultaneously at two levels, the remaining 5 patients on the same level. In 3 patients, the compression fracture of the vertebra was localized in the lumbar region, in 1 patient in the cervical region, in 3 patients in the lumbar and lower thoracic spine, in one patient in the lower thoracic spine (see Table 1).

Table 1.

| Number of Patients |               | Damaged vertebrae according to the localization |               |             |                           |
|--------------------|---------------|---|---------------|-------------|---------------------------|
|                    |               | Cervical part                                   | Thoracic part | Lumbar part | Thoracic and lumbar parts |
| Men                | 5             | 1   | –             | 2           | 2                         |
| Women              | 3             | –   | 1             | 1           | 1                         |
| <b>Total</b>       | <b>8 (11)</b> | <b>1</b>  | <b>1</b>      | <b>3</b>    | <b>6</b>                  |

The average amount of cement introduced was 3.75 ml (from 2.5 to 5). During interventions on the thoracic and lumbar spine, transpedicular access was predominantly used by Mathis J.M [5], less often used posterior (inter-bone-vertebral) access. In case of localization of the pathological process in the cervical region, the operation was performed in the position of the patient on the back from the anterolateral access. When diluting bone cement, special X-ray supplements were used. Postoperative mode. Within an hour after the procedure, bed rest was observed, every 15 minutes an examination was carried out, including an assessment of vital functions and neurological status. During this period, bone cement reaches 90% or its maximum hardness [6]. In hour after the procedure the patient was allowed to sit in bed with the help of. The control MSCT of the treated level was performed in the first 3 days after the procedure for visualization of the implant length.

**Results and Discussion.** Evaluation of the treatment results was carried out according to the following criteria: the dynamics and severity of the pain syndrome after percutaneous vertebroplasty, motor activity of the patient, dependence on analgesics. After PVP, 6 patients had a complete or significant reduction in the pain syndrome within 24 hours after the procedure (but the VDS scale 0 points). In the remain-

ing 2 patients, a marked decrease in pain began to appear on day 3 after the procedure, patients were discharged with weak pain (according to the VDS scale of 2 points). Complication was in the 1 patient in the form of an output of a small amount of bone cement into the venous bed with occlusion of small branches of the pulmonary arteries. In this case, clinical manifestations from the pulmonary-cardiac activity were not observed. This type of complication is described in the literature as a result of excessive introduction of bone cement into the vertebrae or as a result of an excessively large caliber of draining veins of the vertebral body [4]. This category of patients was treated at the clinic for 3 to 5 days. Later the patients were discharged with the recommendations of rehabilitation treatment. During the follow-up after the operation, there was not a collapse of the vertebra after PVP, the pain syndrome completely regressed.

**Conclusion:** The use of percutaneous vertebroplasty in the treatment of traumatic compression fractures of vertebral bodies of I–II degree without disruption of the function of the spinal cord provides early recovery of the defensibility of the damaged vertebra, rapid regression of the pain syndrome, reduces the duration of patients' stay in hospital and ensures early recovery of work capacity.



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## **GENETIC FACTORS DETERMINING THE PROGRESSION OF CHRONIC HEPATITIS C IN THE UZBEK POPULATION**

**Abstract:** The purpose of this study was to assess the contribution of this genetic polymorphism of the CUR1A2 and CUR3A4 genes of cytochrome P450 to the development of chronic viral hepatitis (HCV) and cirrhosis in patients with Uzbek nationality. The obtained results show a distinctive decrease in the frequency of the observed homozygote A/A and an increase in the heterozygote A/G frequency of the CUR3A4 gene in a subgroup of patients with moderately active CVH in comparison with subgroups of patients with active CVHC and liver cirrhosis, suggesting the favorable role of heterozygous polymorphism during the course of the disease. The presence of genotype C/C of the gene CUR1A2 only in a subgroup of patients with cirrhosis of the liver may indicate its association with the progression of the disease and the development of fibrotic changes in the liver of patients with CVHC.

**Keywords:** chronic hepatitis C, gene polymorphism, cytochrome P450 isoenzymes.

**Relevance.** It is known that chronic viral hepatitis is the most common cause of liver cirrhosis, and in this connection there are many studies in the world related to the study of genetic polymorphism, which not only predisposes to the onset of the disease, but also determines its course. The literature presents a large number of works devoted to the search for the relationship between allelic variants of candidate genes, the rate of progression of chronic viral hepatitis and the occurrence of cirrhosis [1; 2; 3]. Molecular genetic analysis carried out in a specific patient within the framework of monitoring reveals a predisposition to the development of the disease, which allows to carry out preventive measures of an individual orientation, and the evaluation of polymorphic versions of genes associated with the course of the disease is the basis for the prognosis. There are very few scientific studies showing the involvement of CUR1A2 and CUR3A4 in the pathogenesis of liver diseases [4; 5; 6], and no studies have been conducted on the significance of this marker in the development of chronic hepatitis and fibrotic changes in the liver.

**The purpose** of this study was to assess the contribution of this genetic polymorphism of the CUR1A2 and CUR3A4 genes of cytochrome P450 to the development of CVHC and cirrhosis in patients with Uzbek nationality.

**Material and methods.** The main group of the study included 107 patients with CHC who received treatment at the Scientific Research Institute of Virology. To assess the association of polymorphic markers of the genes CUR1A2 and CUR3A4, patients with CVHC were divided into three subgroups. The first subgroup includes patients with a moderate degree of CHC activity ( $n = 33$ ). The second subgroup consisted of patients with a high degree of CHC activity ( $n = 37$ ). The third subgroup included patients with cirrhosis of the liver ( $n = 37$ ). The criteria for inclusion in the study were clinical-biochemical and instrumental verification of the diagnosis with the definition and stage and severity of the disease, as well as the detection of RNA of hepatitis C virus with the AmpliSens® HCV-FRT test system identified by polymerase chain reaction (PCR) on a RotorGene 6000 instrument.

As a comparison group, population control was used, which was represented by DNA samples ( $n = 81$ ) of conditionally healthy donors (with out CHC) from the DNA bank of the Institute of Hematology and Blood Transfusion of the Ministry of Health of the Republic of Uzbekistan.

The material for molecular genetic research was the peripheral blood of the subjects. DNA isolation was performed according to a standard procedure with some

modifications and using reagents from the company “Interlabservice” (Russia). Identification of alleles of gene polymorphism was carried out using a polymerase chain reaction.

**Research results and discussion.** A comparative analysis of the prevalence of allele frequencies and the distribution of the A392G genotypes of the CYP3A4 gene in the group of patients with CVHC and the population control group revealed certain features of this polymorphic site. The mutant allele “G” was 2.4 times more common in the main group of patients with chronic hepatitis syndrome than in the population control group (6.1% and 2.5%, respectively,  $X^2 = 2.78$ ;  $P = 0.09$ ;  $OR = 0.39$ ; 95% CI-0.1252–1.224). It was noted that the frequency of not only G allele, but also heterozygous A/G genotype (12.1% versus 4.9% in the control,  $X^2 = 2.91$ ,  $P = 0.09$ ,  $OR = 0.37$ , 95% CI – 0.1177–1.199). Nevertheless, despite the tendency to accumulation of a mutant allele in the group of patients, the absence of a reliable difference in the values of this index in these groups does not allow one to assume the involvement of A392G polymorphism of the CYP3A4 gene in the development of CVHC.

In the studied subgroups of patients with HCVC, the highest incidence of mutant allele “G” was observed in patients with moderately active HCVF (9.1%). When the process was activated, there was a decrease in the allele frequency “G”, and its lowest value was noted in a subgroup of patients with liver cirrhosis without a significant difference in the values of the indices ( $\chi^2 = 1.014$ ;  $P = 0.32$ ;  $OR = 0.57$ ; 95% CI – 0.1901–1.718).

In assessing the distribution of genotypes depending on the stage of the disease and the activity of the pathological process, we found a linear decrease in the frequency of the heterozygous genotype as the development of CVHC. At the same time, the frequency of the genotype “A/G” in patients with moderately active HCVF was 18.2%, which was 1.4 times higher than in patients with high-activity chronic HCG and 2.3 times greater than in patients with cirrhosis.

It should be noted that the homozygous genotype for the mutant allele (“G/G”) of the A392G polymorphism of the CYP3A4 gene was not detected by us in any case of the study, which can be explained by both its low occurrence frequency and the adverse effect of the mutant allele in homozygous form and, consequently,

by its directed elimination from the population. Thus, in a comparative analysis of genotypic variants of the polymorphism of the CYP3A4 gene, the accumulation of the allele “G” in the heterozygous form in patients with moderately active CVHC was revealed in our study.

The fact revealed by us allows to assume the presence of a connection between the high frequency of the heterozygous genotype and the lesser intensity of inflammation and fibro-formation in the liver and the course of the disease in a lighter form. However, the absence of statistically significant differences in the frequency distribution of the genotypes of the CYP3A4 gene polymorphism between the subgroups of patients with chronic hepatitis B virus ( $P > 0.05$ ) suggests that there is no direct association of this marker with the variant and severity of the disease course.

Comparative analysis of the prevalence of allele frequencies and the distribution of genotypes of A164C polymorphism of the CYP1A2 gene in the group of patients with CVHC and the population control group revealed that the mutant allele “C” was 2.3 times more common in the main group of patients with chronic hepatitis C virus than in the control group (14.0% and 6.2%, respectively, ( $\chi^2 = 5.97$ ,  $P = 0.014$ ,  $OR = 0.40$ , 95% CI = 0.1911–0.8518). This suggests that the mutant allele of the polymorphism of the CYP1A2 gene is related to the development of CVHC. The frequency of occurrence of the mutant allele “C” was higher than the control value and in all subgroups of patients with CVHC. In this case, the maximum value was observed in patients with cirrhosis of the liver (16.2%). In the group of patients with a moderately active process, the frequency of the mutant allele “C” was also characterized by a high index (15.2%). In patients with highly active CVHC, the frequency of allele “C” was 9.5% without significant difference with the indices of the first and third subgroups.

It was shown that in a subgroup of patients with moderately active HCVC there was observed not only an increased frequency of the allele “C”, but also a statistically significant increase in the A/S heterozygote genotype containing a mutant allele (30.3% vs 12.3% in the control,  $\chi^2 = 5.23$ ,  $P = 0.02$ ,  $OR = 3.09$ , 95% CI = 1.142–8.346). It is interesting to note that when assessing the distribution of genotypes, we found a decrease in the frequency of heterozygous genotype in subgroups of patients as the disease progressed. To the maximum frequency of the

genotype A/C (30.3%) in patients with moderately active CVHC, the value of this index was close in patients with highly active HCVC – 29.7% ( $\chi^2 = 1.23$ ,  $P = 0.27$ ,  $OR = 1.86$  95%  $CI$  0.6153–5.643). In patients with liver cirrhosis, the frequency of the heterozygous genotype was the lowest of all subgroups studied, although it exceeded the control value by 1.8 times (21.6%,  $\chi^2 = 1.69$ ,  $P = 0.19$ ,  $OR = 1.96$ , 95%  $CI = 0.7027$ –5.459). At the same time, the third subgroup was the only one in which the genotype (5.4%) was homozygous for the mutant allele. The presence of the C/C genotype only in this subgroup may indicate its association with the progression of the disease and the development of fibrotic changes in the liver of patients with chronic HCG. However, the total frequency of T/C and C/C genotypes in patients with liver cirrhosis (27.0%) is comparable with the frequency

of genotypes bearing a mutant allele in other subgroups of patients – T/C = 30.3% in patients with moderately active CVHC and T/C = 29.7% in patients with highly active HCVC.

**Conclusions.** The obtained results show a distinctive decrease in the frequency of the observed homozygote A/A and an increase in the heterozygote A/G frequency of the CUR3A4 gene in a subgroup of patients with moderately active CVH in comparison with subgroups of patients with active CVHC and liver cirrhosis, suggesting the favorable role of heterozygous polymorphism during the course of the disease. The presence of genotype C/C of the gene CUR1A2 only in a subgroup of patients with cirrhosis of the liver may indicate its association with the progression of the disease and the development of fibrotic changes in the liver of patients with CVHC.

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## **ESTIMATION OF PROGNOSTIC SIGNIFICANCE OF CARRIAGE OF ALLELIC VARIANTS OF CYTOKINE AND CYTOCHROME P450 ISOENZYMES IN PATIENTS WITH CHRONIC HEPATITIS C**

**Abstract:** The aim of the study is to evaluate the prognostic significance of the polymorphism of genes for TNF- $\alpha$ , CTLA-4, CYP2E1, CYP2C9, CYP3A4 and CYP1A2 cytochrome P450 genes in patients with chronic hepatitis C of Uzbek nationality. The study showed that, in accordance with the frequency of occurrence of the marker, the polymorphism – 49A/G of the CTLA-4 gene has good predictive efficacy in terms of development and course of CVHC. polymorphic gene CTLA-4.

**Keywords:** chronic hepatitis C, gene polymorphism, prognostic significance, cytokine, cytochrome P450 isoenzymes.

**Relevance.** The problem of chronic hepatitis is very actual due to its widespread, often asymptomatic course and high risk of complications [3]. The problem of chronic hepatitis remains relevant in modern science and practical medicine in connection not only with the increase in morbidity, but also with the insufficient effectiveness of modern methods of diagnosis and prevention [1; 2]. It should be emphasized the complexity of predicting the nature of the course of the disease, identifying a predisposition or resistance to the development of chronic liver damage. In addition, the fact that prolonged inflammatory liver disease may result in the development of irreversible fibrotic changes in the organ and pronounced hepatic insufficiency, which practically does not respond to treatment, also gives particular seriousness to this problem. This issue is relevant for our region [4].

**The aim** of the study is to assess the prognostic significance of the polymorphism of the genes TNF- $\alpha$ , CTLA-4, CYP2E1, CYP2C9, CYP3A4 and CYP1A2 cytochrome P450 in patients with chronic hepatitis C of Uzbek nationality.

**Material and methods.** In the course of the study, the main group was identified, consisting of 107 patients with chronic viral hepatitis C (CVHC) and a control group (81 conditionally healthy donors). Taking into account the degree of activity of the disease, the main group was divided into subgroups: the first group con-

sisted of patients with chronic hepatitis B with moderate activity ( $n = 33$ ), the second group with patients with high-activity CVHC ( $n = 37$ ), and the third with cirrhosis ( $n = 37$ ). When selecting the surveyed the main group took into account their nationality – all patients are persons of Uzbek nationality, with a verified diagnosis of chronic hepatitis C and liver cirrhosis. The control group consisted of conditionally healthy persons of Uzbek nationality, who did not suffer from this pathology, who permanently reside in different regions of the Republic of Uzbekistan.

The material for molecular genetic research was the peripheral blood of the subjects. DNA isolation was performed according to a standard procedure with some modifications and using reagents from the company “Interlabservice” (Russia). Identification of alleles of gene polymorphism was carried out using polymerase chain reaction.

To determine the effectiveness of the studied genetic markers, we calculated the sensitivity ( $Se$ ), the specificity ( $Sp$ ) and the marker of the marker’s predicted value ( $AUC$ ) (area under curve). Sensitivity ( $Se$ ) is the ability of the research method to give the correct result, which is defined as the proportion of truly positive results among all tests performed. Specificity ( $Sp$ ) is the ability of the research method not to give a false positive result in the absence of the disease, which is defined as the proportion of true negative results among healthy individuals in

the study group. Based on the sensitivity and specificity data, the predictive value of the marker is calculated, i. e. the probability of having a disease, provided a known result of the study. The value characterizing the predictive effectiveness of the marker is the *AUC* indicator. The *AUC*-classifier of genetic markers was determined by the standard formula:  $AUC = (Se + Sp)/2$ ; where *Se* and *Sp* are the sensitivity and specificity of the genetic marker, respectively. In accordance with the scale of predictive value, the marker is considered a random classifier, if  $AUC = 0.5$ ; a bad classifier if  $AUC = 0.5-0.6$ ; the average classifier, if  $AUC = 0.6-0.7$ ; A good classifier if  $AUC = 0.7-0.8$  and an excellent classifier, if  $AUC > 0.8$ .

**Research results and discussion.** The predictive efficacy of the studied polymorphisms of the *TNF- $\alpha$* , *CTLA-4*, *CYP2E1*, *CYP2C9*, *CYP3A4*, and *CYP1A2* genes were calculated for patients with CVHC at different stages of the disease.

Studies have shown that the polymorphisms *CYP3A4* ( $Se = 0.12$ ) and *CYP2C9 \* 3* ( $Se = 0.20$ ) were the least sensitive, and the most sensitive was *CTLA-4* ( $Se = 0.75$ ). Sensitivity of the latter was 6.2 times higher than *CYP3A4*; 3.8 times higher than *CYP2C9 \* 3*; 3.1 times higher than the sensitivity of *TNF- $\alpha$* ; 2.9 times higher than *CYP2C9 \* 2* and *CYP1A2*; is 2.8 times higher than *CYP2E1*. The high sensitivity of *CTLA-4* polymorphism suggests the possibility of using this marker to detect a moderately active form of HCV in its carriers, especially at the first stage of diagnosis. However, it must be taken into account that the use of a highly sensitive marker can yield many false positive results, which requires additional costs for further examination, especially since this polymorphism possessed the least specificity among all the polymorphic genes we are studying.

High specificity values in the main group of patients with CVHC (within 0.86–0.95) showed the polymorphisms *CYP3A4*, *TNF- $\alpha$* , *CYP2E1*, *CYP1A2* and *CYP2C9\*3*. High specificity suggests the possibility of using these markers to determine the risk of developing CVHC. Moreover, the high values of this prognostic indicator for the studied polymorphisms allow us to speak about the reliability of these genetic markers as confirmers of the disease, which prove the presence of a disease and do not allow us to regard a healthy person as a patient. However, when using the polymorphisms studied, as indicators of specificity, it is necessary to take into account the possibility of a significant number of omissions of the disease.

Our calculation of the integral indicator of the predictive efficacy of *AUC* made it possible to assess the balance between the sensitivity and specificity of the studied markers.

The study revealed that the prognostic efficacy of each of the genetic polymorphisms in the main group of patients was relatively low: the *AUC* value was in the range from 0.51 to 0.57. In general, for the main group of patients with CVHC, the prognostic efficacy index was averaged, and was characterized by values different from *AUC* values in different subgroups of patients. This fact can speak about the importance of the studied genetic markers as predictors, not so much the development of HCV, as the course of the disease and the severity of liver damage in patients.

**Conclusion.** The study showed that, in accordance with the frequency of occurrence of the marker, the polymorphism – 49A/G of the *CTLA-4* gene has good predictive efficacy in terms of development and course of CVHC.

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## RENOPROPHYLAXIS IN SECONDARY CHRONIC PYELONEPHRITIS IN CHILDREN

**Abstract:** The study involved 85 children with chronic pyelonephritis on the background of dysmetabolic disorders of the oxaluria type at the age of 4 to 15 years. Patients were conditionally divided into 4 groups depending on the method of treatment. In the period of exacerbation of chronic dismetabolic (oxalate) pyelonephritis, disturbances of partial kidney functions were noted in patients: a decrease in the glomerular filtration rate, osmolarity of urine, daily diuresis; processes of endotoxiosis: a significant reduction in the total albumin concentration, effective albumin concentration, the binding capacity of albumin in the blood plasma, and an increase in the total albumin concentration, of medium-molecular peptides in the urine.

**Keywords:** chronic pyelonephritis, children, lymphotropic.

**Introduction.** Preventive medicine is topical and in many ways discourteous. In connection with the high frequency of chronic kidney disease in children, the prevention of their exacerbations is gaining increasing recognition [3, 12]. The most prevalent in the structure of nephropathy now are kidney lesions of metabolic origin, which constitute the majority – 40.0% of all kidney diseases in children, and in young children up to 71.6% [4, 11]. In the practice of a pediatrician, signs of metabolic disturbances in the urine are found in every third child [1; 2; 13]. In Uzbekistan, in the structure of dismetabolic nephropathy in children, oxalate crystalluria is the most common, accounting for 68–71% of all metabolic disorders [5; 6]. Dysmetabolic disorders are one of the leading predisposing factors to the recurrence and progression of chronic pyelonephritis in children [8; 14]. At the basis of the pathogenesis of dismetabolic nephropathies, especially those caused by genetic factors, there are metabolic processes of interstitium, glomerulus and renal tubules [2; 7]. And therefore, the consequence of renoprophylaxis should be the prevention of marked glomerular sclerosis and tubulointerstitial fibrosis, which is the basis of chronic renal failure [3, 9, 15]. In the case of dismetabolic chronic pyelonephritis, the measures should be directed to reduce the concentration of nephrotoxic salts leading to ischemia, edema and sclerosing of the kidney [5; 10; 16].

**Objective:** to develop the principles of secondary prevention of chronic dysmetabolic pyelonephritis in children.

The study involved 85 children with chronic pyelonephritis on the background of dysmetabolic disorders of the oxaluria type at the age of 4 to 15 years. Patients were conditionally divided into 4 groups depending on the method of treatment. Group I included 48 children who received conventional therapy (in the first three days, it is usually i\m cefotaxime, after the results of bacteriological study – antibacterial drug, depending on the sensitivity of the pathogen). Group II consisted of 37 patients who received antibiotics in a lymphotropic way, that is, regional lymphotropic antibacterial therapy (RLAT) was performed in combination with 0.5% euphylln electrophoresis. The patients of all studied groups received a copious drink and followed a diet used for oxaluria. The control group consisted of 30 practically healthy peers.

All examined patients under went genealogical pedigree analysis in order to establish the fact of hereditary burden. Studies of indices of endogenous intoxication and functional state of the kidneys were performed in all children before and after treatment. Glomerular filtration of the kidneys was determined by the clearance of endogenous creatinine (Van Slayke), osmolarity of urine by cryoscopic method on OMK apparatus A – 1 C – 01, oxalate by NV. Dmitrieva (1966) method.

The severity of endotoxemia was assessed by the total concentration of albumin (TCA) and the effective concentration of albumin (ECA) in the blood plasma, and also TCA in the urine taking into account the binding capacity of albumin (BCA) in the description of P. E. Kiseleva [6]. The determination of the level of the average molecular peptides (AMP) was carried out according to the method of I. I. Zhadenova and co-authors (2002). Mathematical processing of the obtained results

was carried out using computer statistical programs Excel. In the study of indices of endogenous intoxication, depending on the method of treatment of chronic dysmetabolic pyelonephritis, it was revealed: in children receiving standard therapy (group I), before discharge from hospital, the level of TCA, ECA, BCA in blood plasma, as well as TAC and AMP in urine remained practically unchanged ( $P_1 > 0.1$ ) (Table 1, 2).

Table 1. – Dynamics of indices of endogenous intoxication of the kidneys in blood plasma in patients with CCP, depending on the method of treatment ( $M \pm m$ )

| Indices                | Healthy ( $n = 30$ ) | Before treatment<br>( $n = 85$ ) | After treatment                 |  |
|------------------------|----------------------|----------------------------------|---------------------------------|--|
|                        |                      |                                  | I группа ( $n = 48$ )           | II группа ( $n = 37$ )                               |
| TCA, g/l               | $47.5 \pm 0.55$      | $30.13 \pm 0.96$<br>$P < 0.001$  | $31.04 \pm 1.03$<br>$P_1 > 0.1$ | $40.16 \pm 0.81$<br>$P_1 < 0.001$ .<br>$P_2 < 0.001$ |
| ECA, g/l               | $40.4 \pm 3.7$       | $23.4 \pm 0.84$<br>$P < 0.001$   | $23.02 \pm 0.91$<br>$P_1 > 0.1$ | $35.5 \pm 0.3$<br>$P_1 < 0.001$ .<br>$P_2 < 0.001$   |
| BCA,<br>(ECA\TCAx100)% | $93 \pm 0.9$         | $77 \pm 0.3$<br>$P < 0.001$      | $73.3 \pm 0.8$<br>$P_1 > 0.1$   | $87.9 \pm 0.3$<br>$P_1 < 0.001$ .<br>$P_2 < 0.001$   |

Note: P-reliability of the difference between indices of healthy children and in children with chronic pyelonephritis.  $P_1$  – the reliability of the difference between the indicators before and after treatment.  $P_2$  – the reliability of the difference between traditional therapy and the group of children who received RLAT in combination with electrophoresis with about 5% of euphyllin.

Table 2. – Dynamics of endogenous kidney toxicity indicators in the urine of patients with CCP according to the method of treatment ( $M \pm m$ )

| Indices    | Healthy<br>( $n = 30$ ) | Before treatment<br>( $n = 85$ ) | After treatment                  |   |
|------------|-------------------------|----------------------------------|----------------------------------|---|
|            |                         |                                  | I группа<br>( $n = 48$ )         | II группа<br>( $n = 37$ )                           |
| AMP, units | $0.136 \pm 0.021$       | $2.23 \pm 0.08$<br>$P < 0.001$   | $0.754 \pm 0.047$<br>$P_1 > 0.1$ | $0.287 \pm 0.012$<br>$P_1 < 0.001$ .<br>$P_2 > 0.1$ |
| TCA, g/l   | $0.02 \pm 0.01$         | $2.34 \pm 0.09$<br>$P < 0.001$   | $1.66 \pm 0.05$<br>$P_1 > 0.1$   | $0.028 \pm 0.02$<br>$P_1 < 0.001$ .<br>$P_2 < 0.05$ |

Note: P-reliability of the difference between indices of healthy children and in children with chronic pyelonephritis.  $P_1$  – the reliability of the difference between the indicators before and after treatment.  $P_2$  – the reliability of the difference between traditional therapy and the group of children who received RLAT in combination with electrophoresis with about 5% of euphyllin.

More marked changes in the indices of endogenous intoxication in patients were revealed on the background of the use of RLAT in combination with

euphyllin electrophoresis (group II). Thus, the parameters of TCA, ECA and BCA in blood plasma did not only significantly improve with respect to the relevant

parameters before treatment and after the standard treatment ( $P_1 < 0.001$ ,  $P_2 < 0.001$ ), but also reached the level of healthy children ( $P > 0.1$ ).

Analyzing the state of kidney function in the examined patients who received traditional treatment, there was an improvement in the indices, but the difference was statistically unreliable ( $P_1 > 0.1$ ). In patients

of group II, a significant increase in the clearance of endogenous creatinine ( $P_1 < 0.001$ ), urine osmolality ( $P_1 < 0.001$ ), daily diuresis ( $P_1 < 0.001$ ), oxaluria ( $P_1 < 0.001$ ) was noted compared with similar indications before treatment and indicators after conventional treatment ( $P_2 < 0.001$ ) (table 3).

Table 3. – Dynamics of renal partial function indicators in patients with CCP, depending on the treatment method ( $M \pm m$ )

| Indices                           | Healthy<br>( $n = 30$ ) | Before treatment<br>( $n = 85$ ) | After treatment                |   |
|-----------------------------------|-------------------------|----------------------------------|--------------------------------|---|
|                                   |                         |                                  | I группа ( $n = 48$ )          | II группа ( $n = 37$ )                        |
| RGF, ml/min.m <sup>2</sup>        | 98.6 ± 7.8              | 72.0 ± 0.25<br>$P < 0.001$       | 72.5 ± 1.59<br>$P_1 > 0.1$     | 96.8 ± 1.61<br>$P_1 < 0.001$ . $P_2 < 0.001$  |
| Osmolarity of urine, mmol/24hours | 1000 ± 200              | 646.7 ± 9.9<br>$P < 0.001$       | 712.7 ± 24.73<br>$P_1 < 0.001$ | 935.7 ± 24.0<br>$P_1 < 0.001$ . $P_2 < 0.001$ |
| 24hours diuresis, l/24h.          | 1.7 ± 0.036             | 1.06 ± 0.015<br>$P < 0.05$       | 1.08 ± 0.027<br>$P_1 > 0.1$    | 1.22 ± 0.046<br>$P_1 < 0.05$ . $P_2 < 0.05$   |
| Oxaluria, mg/24hours.             | 25 ± 2.4                | 46.8 ± 1.14<br>$P < 0.001$       | 45.2 ± 1.66<br>$P_1 > 0.1$     | 26.4 ± 0.29<br>$P_1 < 0.001$ . $P_2 < 0.001$  |

Note:  $P$ -reliability of the difference between indices of healthy children and in children with chronic pyelonephritis.  $P_1$  – the reliability of the difference between the indicators before and after treatment.  $P_2$  – the reliability of the difference between traditional therapy and the group of children who received RLAT in combination with electrophoresis with about 5% of euphyllin.

The obtained results allowed to recommend complex treatment (RLAT + electrophoresis with 0.5% of euphyllin) of chronic dismetabolic pyelonephritis for the prevention of frequent relapses, development of renal failure, that is, to use as a method of renoprophylaxis.

**Conclusions.** 1. In the period of exacerbation of chronic dismetabolic (oxalate) pyelonephritis, disturbances of partial kidney functions were noted in patients: a decrease in the glomerular filtration rate, osmolality of urine, daily diuresis; processes of endotoxiosis: a significant reduction in the total albumin concentration, effective albumin concentration,

the binding capacity of albumin in the blood plasma, and an increase in the total albumin concentration, of medium-molecular peptides in the urine. 2. The use of complex treatment: RLAT + electrophoresis with 0.5% of euphyllin in CCP is the most acceptable method of therapy, which leads to recovery of daily diuresis, has a positive effect on the level of oxaluria, the functional state of the kidneys and the indices of endogenous intoxication: the level of TCA, ECA, BCA in blood plasma and TCA, AMP in urine.

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## PRECLINICAL STUDY OF DRUG FORMS BASED ON CHITOSAN

**Abstract:** Study of acute intragastric toxicity in white mice found that the classification of drugs on the toxicity of the drug “Chitosan with furacillin” refers to low-toxic substances (V class of danger). Revealed that “Chitosan with furacillin” does not have the restorative and irritating to skin and mucous membranes of the eyes.

**Keywords:** Chitosan, furacillin, internucleosomal.

One of the important tasks of modern combustiology is the selection of highly effective and safe drugs. However, equally important is the improvement and already known drugs, including used for topical antimicrobial effects. Drugs in this group are presented in the pharmaceutical market, in many cases, have a one-way effect, have osmotic or necrosis effect, in some cases, allergic reaction [6; 8]. Therefore, the treatment of wounds in recent preference is often given antiseptic. One of these is furatsilin antiseptics, which is widely used in surgical practice in the form of ointments, aqueous and alcoholic solutions. However, these formulations do not have a prolonged effect, which does not meet modern requirements for drugs intended for antimicrobial therapy, because it reduces its effectiveness. Providing prolonged effect, they allow you to maintain long-term therapeutic concentration at the wound surface, which reduces the possibility of the development of resistance and sensitization [6]. One such drug is chitosan. A large number of free amino groups in the molecule of chitosan can bind hydrogen ions and acquire an excess positive charge, so the chitosan is an excellent cation. He binds and firmly holds the metal ions (in particular radioactive isotopes and toxic elements) through a variety of chemical and electrostatic interactions [7]. Thus, chitosan is a universal sorbent capable of binding a huge range of organic and inorganic substances of nature that determines the widest possible applications in human life. We have shown that chitosan derivatives stimulate the healing process of burnt surface [5]. Also it was identified the

molecular mechanisms of the regenerative properties. Chitosan has tread properties in normalizing internucleosomal degradation of DNA in the skin after application of thermal shock [2; 3].

**Objective of the study.** To study the acute and chronic toxicity, cumulative properties of the drug “Chitosan with furatsilin” when administered to experimental animals.

**Materials and methods.** The objective of the research is “Chitosan with furatsilin” preparation intended for use as a wound healing remedy, antibacterial agent for the treatment of burns. Developed drug “Chitosan with furacillin” at the Institute of Physics and Chemistry of Polymers, Academy of Sciences of Uzbekistan. Investigations were carried out on various types of laboratory animals of both sexes: the white mice, white rats, guinea pigs and rabbits. Intragastric acute toxicity was studied in 60 white rats of both sexes weighing 140–150 g animals were divided into 6 groups of 10 animals in the group. Five animals of the experimental group were administered on an empty stomach aqueous solution of the drug in the stomach with a syringe with a metal probe in doses: 1000, 2000, 3000, 4000, 5000 mg/kg body weight. Large doses of the drug were administered in two doses with an interval of 1 hour. Study of multiple gastric drug action “Chitosan with furacillin” and its cumulative properties were conducted on white rats weighing 130–140 grams for 1 month. The drug was administered as an aqueous suspension intragastrically 3rd group of experienced white rats: the first group of 100 mg/kg, the second group – 50 mg/kg, and 3-D group of 10 mg/kg, the fourth group



served as a control. Animals were monitored hourly during the first day of the experiment in the laboratory and in the future in the dynamics within 2–3 weeks.

Account of the appearance and behavior of the animals, the state of the coat and visible mucous membranes, the ratio of food, mobility, rhythm and breathing rate. Pay attention to the time of occurrence and the nature of intoxication assessed its severity, reversibility, to the date of death of animals. The data obtained by the static method of processing V.B. Prozorovskiy were calculated LD50 values [4]. In assessing the toxicity of the drug were considered the maximum-tolerance and absolutely lethal dose. Calculation errors LD50 were conducted by one of the most common methods proposed by Miller and Teytnerom, through determining LD84 and LD16. The difference between the two doses is equal to the mean square error. The sixth group of animals served as a control. All experimental animals were kept in the same conditions at the vivarium balanced diet on the content of protein, fat and carbohydrates, with free access to food and water. Results of the research were subjected to statistical treatment.

**Results and Discussion.** The studies were conducted two formulations of the drug, “Chitosan with furacillin”. Our experiments have shown that animals have one’s group after injection at a dose of 1000 mg/kg body weight of the animals’ changes in behavior and functional status were observed. However, with increasing dose animals became listless, inactive, and quick to respond to external stimuli: loud, banging on the table, the irritation of the tail. Appetite in animals disturbed, some of them refused to eat; animal species became unkempt, disheveled hair. The death of animals comes from respiratory failure. Table 1 shows animals death time duration on the drug dose administered “Chitosan with furacillin” (gel). Mid-lethal dose (LD50) of the drug, “Chitosan with furacillin” (powder) – 3300 (3353÷3246.96) mg/kg and “Chitosan with furacillin” gel 3120 (3165.9÷3074.1). Consequently, the classification of medicines for acute toxicity intragastric drug administration “Chitosan with furacillin” refers to low-toxic substances, and the powder and gel formulation for the acute toximeters are bioequivalent.

Table 1. – The dependence of the timing of animal deaths on the dose administered drug (“Chitosan with furatsilin” gel)

| Dose in mg/kg, m.t | Number of animals in the group | Duration of death time |                   |                    | Total death | Percentage of deaths |
|--------------------|--------------------------------|------------------------|-------------------|--------------------|-------------|----------------------|
|                    |                                | During the 1st day     | During the 3 days | In subsequent days |             |                      |
| 1000               | 10                             | 0                      | 0                 | 0                  | 0           | 0                    |
| 2000               | 10                             | 1                      | 1                 | –                  | 2           | 20                   |
| 3000               | 10                             | 2                      | 3                 | –                  | 5           | 50                   |
| 4000               | 10                             | 3                      | 4                 | –                  | 7           | 70                   |
| 5000               | 10                             | 4                      | 5                 | 1                  | 10          | 100                  |

In assessing the cumulative properties and Chronic Toxicity The low toxicity of the drug, set in the acute experiment, and estimated duration of treatment, so the timing of the chronic experiment 1 month (according to the guidelines for preclinical safety study of medicines). During the experiment the general condition of the experimental animals is not compromised, toxic symptoms have been identified however the death of animals were not. On the skin of local change is not detected, sites of focal alopecia and ulcers were noted. Animals were neat and the coat’s was smooth, shiny, happy eating food, active and adequately respond to external stimuli. While statistically significant delays

weight gain, «mink reflex» in all treated animals compared with control animals has been established. The obtained results allowed making conclusion that the drug “Chitosan with furacillin” has no effect on the activity of alkaline phosphatase, AST and ALT, bilirubin and direct bilirubin in serum total, as statically significant changes in the animals of the experimental group compared with control individuals is not established. Hexenal sleep duration in white after repeated gastric effects of the drug “Chitosan with furacillin” in different doses characterizes the state of hepatotoxic effects of the test substances. The results showed no statistically significant change in the experimental and control groups.



We have obtained positive results related biological properties of chitosan. Forming many hydrogen bonds, Chitosan binds a large number of water-soluble organic substances, including bacterial toxins formed in the large intestine during digestion. Due to the same hydrogen bonds Chitosan is poorly soluble in water, because the relationships between the molecules are stronger than those between the chitosan molecules and water. However, Chitosan swells and dissolves in organic acids – acetic, citric, oxalic, succinic. Moreover, the swelling it can securely hold the structure in a solvent, and the dissolved and suspended matter in it. Chitosan also binds saturated hydrocarbons, fats and fat-soluble compounds by hydrophobic interactions and network structure, which brings him to the sorption mechanisms with cyclodextrins. Splitting up of chitin and chitosan D-glucosamine and N-acetyl-D-glucosamine is the action of microbial enzymes – chitinase and hitobiaz, so they are completely

biodegradable perishable and do not pollute the environment [1; 7; 9]. Thus, our range of toxicological, physiological and biochemical studies suggests that chronic intragastric exposure during the month drug “Chitosan with furacillin” in different doses (100.0 mg/kg bw, 50.0 mg/kg bw and 10.0 mg/kg bw) did not have a negative impact on the body of experimental animals.

**Conclusions.** 1. The drug “Chitosan with furacillin” with a single intragastric administration refers to the low-toxic drug, powder and gel formulation for the acute toximeters bioequivalent.

2. “Chitosan with furacillin” has no cumulative effect.

3. With long-term intragastric administration “Chitosan with furacillin” has no effect on the behavior and dynamics of animal body weight.

4. The drug has no toxic effect on biochemical parameters of liver function, as well as adverse effects on the morphology of organs and tissues.

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## **THE EFFICACY OF COMPLEX TREATMENT OF VIRAL EYE LESIONS**

**Abstract:** antiviral and antioxidant efficacy of the preparation actipol was studied in complex treatment of adenoviral conjunctivitis. The high efficacy of proposed complex treatment in combination with preparation actipol was detected: reduction of treatment term, significant improvement of the patient's condition even in the first days of treatment.

Study of biochemical parameters of blood and lachrymal liquid showed that complex therapy of viral eye diseases with inclusion of the preparation actipol more significantly suppresses the expression of gene of inducible form of syntheses nitric oxide on the local level, which appears with the reduction of the final level of its metabolites.

**Keywords:** viral diseases of eyes, adenoviral conjunctivitis, severity index inflammation, lachrymal fluid, nitric oxide.

**Topicality.** In the last decades the character of infectious pathology of an eye has been significantly changed. Today the most important viruses which have a special place take the group of adenoviruses. Significant and widespread of viral eye lesion, more severe clinical course is universally accepted fact [8; 12; 14; 15].

Polymorphism of ophthalmological symptomatology with viral lesion of visual organ, the absence of clear clinical symptoms, pathognomonic for certain agent, similarity of clinical manifestations in inflammation, which caused by different infectious agents doesn't allow to establish the etiology of inflammatory lesion of an eye in time and to carry out adequate etiotropic treatment [9; 10; 13].

It is necessary to mark the decrease of products of interferon – the most important factor of non-specific antiviral resistance taking into consideration of common regularities of the diseases, caused by specimen of the family of adenovirus. Interferon-is glycoprotein cytokine, having antiviral, immunomodulator, antiproliferative properties [1; 6; 7].

Another significant meaning the fact, that inflammation caused by viruses is accompanied by complex system progress, famous as acute phase response. One of components of such responses is activation the free radical oxidation (FRO) – process, which exists in all tissues of human organism [2; 4]. The process of FRO was balanced strongly in norm and it depends on the condition of the system, generating free-radicals and utilizing them into different stages of chain reactions (antioxidant protection system). It is necessary to consider the pathogenetic valid therapy while choice [3; 5; 11].

**The aim of study.** Clinical-laboratorial estimation of complex treatment efficacy of adenovirus conjunctivitis with including the preparation actipol.

**Materials and methods of study.** The complex treatment was carried out in 52 patients (104 eyes) with adenoviral conjunctivitis (AVC). The age – 18–80 (28 men and 24 women).

Two similar patient groups were revealed according to performed treatment: control – 26 patients (52 eyes) and main – 26 patients (52 eyes).

The patients were treated by the following methods:

– the patients of control group were treated by traditional therapy: leucocytic interferon (by 2 drops 6–8 times in a day), 0.25% chloramphenicol (by 2 drops 4 times in a day) into conjunctival sac;

– the patients of the main group in contrast to the control group were prescribed actipol instead of interferon (by 2 drops 6 times in a day).

All patients were prescribed general therapy: intramuscular administration 12.5% cycloferon by scheme, antihistaminic preparations (suprastin by 1 tablet 1 time a day), vitamins of B group (vitamin B complex by 2.0 i/m).

The preparation «Actipol» (0.007% eye drops, international and chemical name a pair – benzaminic acid) – is related to the inductor of interferon that it is considered to be one of the mechanisms of specific antiviral effect, it has antioxidant, immune modulator, radio protector effect and it accelerates the regeneration of cornea.

All patients received the general ophthalmological methods of diagnostics.

The severity degree of inflammation was revealed by the methods of intensity degree of estimation of clinical signs by three grading system. (Maychuk Yu. F. and Vaxova E. S., 1994).

The disease was verified by the data of anamnesis, clinical signs, and the results of microbiological analysis, which excluded the secondary infection.

Biochemical investigation of nitric oxide in lachrymal fluid and in blood serum was performed in twenty examined patients in the central research laboratory of TMA.

**Results and discussion.** The indexes of initial of visual acuity in both groups with adenovirus conjunctivitis ranged from 0.7 to 1.0 with corrections.

According to our data, it should be noted that the ratio of visual acuity in both groups comparability and made up relatively, the acuity of vision is lower than 0.9 was observed in 82.9% and 86.2% cases. The acuity of vision within 0.9–1.0 was observed in 17.1% and 13.8% cases, correspondingly in control and the main groups.

The estimation of objective indexes of the main symptoms of inflammation in patients with adenovirus conjunctivitis showed that the main symptoms of disease in both groups were reddening of skin eyelid, hyperemia of conjunctiva (in 100% cases), watering, feeling of burning, itching and made up correspondingly to 88.6% and 93.1%; the presence of serous discharging were in 94.3% and 86.2% cases. the presence of follicles in conjunctiva were marked in 85.7% cases of control group and 89.6% cases in the main group of patients.

Before the treatment the severity index of inflammation in the control group patients made up 19.4 in the grading system. The severity index of clinical symptoms of inflammation in the main group of patients made up 19.7 in the grading system ( $P > 0.05$ ).

According to the dynamics of data of visual sharpness of patients with AVC in the process of treatment in the group of patients who were treated by traditional method the efficacy was observed only in 91.7% cases, but in the group of patients who were treated by using the actipol preparation, the efficacy was 98.2%.

The increase of visual sharpness until 0.8–0.9 happened in the control group of patients in 25% against 8.6% of the main group. On the background of high increase of visual acuity until 1.0 happened in the control group only in 66.7% cases, whereas the index made up 88.6% in the main group.

On the third day of treatment the severity index of inflammation in the main and control groups made up in the average 12.2 and 16.5 grades ( $P < 0.05$ ), correspondingly; on the 7<sup>th</sup> day –  $3.9 \pm 0.24$  and  $8.3 \pm 0.27$  grades ( $P < 0.05$ ). By the 10<sup>th</sup> day the index in the control group was equal to  $2.0 \pm 0.25$  grades, the signs of inflammation was absent in the main group.

The efficacy of complex treatment was confirmed by shortening of term of reduction of the main symptoms of inflammation in patients with AVC.

Received data showed that disappeared symptoms of disease in the main group of patients with AVC occurs on average in 1,4 times faster than in the control group (table 1).

The patients of control and the main group the determination of syntheses nitric oxide content were conducted. Before the treatment the indexes of oxide in blood serum of patients with AVC statistically reliably decreased. Thus, the content of stable nitric oxide metabolites made

up  $5.05 \pm 0.60$  and  $5.55 \pm 0.36$   $\mu\text{mol/l}$  (norm- $7.12 \pm 0.55$   $\mu\text{mol/l}$ ). i. e. in 1.4 and 1.3 times lower the norm ( $P < 0.01$  and  $< 0.05$ ).

In lachrymal fluid of patients the level of stable metabolites of nitric oxide, on the contrary it increased until  $7.35 \pm 0.74$ .

Table 1. – Comparative estimation of treatment results on term of reduction of symptoms of inflammation and duration of treatment, patients with adenovirus conjunctivitis

| Groups  | Number | Severity degree of inflammation | Clinical criteria of recovery (terms in days) | Duration of treatment (in days) |                  |                                 |                  |                            |
|---------|--------|---------------------------------|---|---------------------------------|------------------|---------------------------------|------------------|----------------------------|
|         |        |                                 | Hyperemia of conjunctiva                      | Feeling of burning and itching  | Watering         | Reddening of the skin of eyelid | Tears            | Disappearance of follicles |
| control | 52     | $19.2 \pm 0.25$                 | $6.3 \pm 0.16$                                | $5.2 \pm 0.15$                  | $5.7 \pm 0.16$   | $5.9 \pm 0.16$                  | $4.5 \pm 0.15$   | $6.3 \pm 0.16$             |
| main    | 52     | $19.5 \pm 0.26^*$               | $4.5 \pm 0.17^*$                              | $3.3 \pm 0.16^*$                | $3.7 \pm 0.15^*$ | $4.2 \pm 0.20^*$                | $3.8 \pm 0.17^*$ | $4.5 \pm 0.17^*$           |

Note: \* – significantly by comparing with the data of control group ( $P < 0.05$ )

Complex treatment of patients with using the actipol preparation did not only stopped the inflammatory process in the eye but also brought the content of stable metabolites of nitric oxide to the norm (table 2).

So, the initial level of these combination in blood serum in the process of treatment the patients with AVC increased to 34,1, but in lachrymal fluid decreased in 1.4 times. However, the studied indexes

were not normalized, that it obviously shows the necessity of prolongation of treatment term. In patients blood serum with AVC the content of stable metabolites nitric oxide somewhat exceeded the normal meaning. In lachrymal fluid their level of significantly exceeded the norm to 44.6, which manifested on the background of more rapid reduction of inflammatory process.

Table 2. – The content of stable metabolites of nitric oxide ( $\mu\text{mol/l}$ ) in blood serum and lachrymal fluid of patients with viral diseases of eye ( $M \pm m$ )

| Groups              |         | Blood serum            |
|---------------------|---------|------------------------|
| Practically healthy |         | $7.12 \pm 0.55$        |
| AVC                 | Main    | $5.05 \pm 0.60^*$      |
|                     |         | $6.77 \pm 0.41^\wedge$ |
|                     | Control | $5.25 \pm 0.71^*$      |
|                     |         | $6.14 \pm 0.34$        |
|                     |         | $6.33 \pm 0.31^\wedge$ |

Note: 1) in the numerator presented numbers before treatment, in the denominator – after treatment; 2) \* – reliable with respect to indexes of practically healthy people (\* –  $P < 0.05$ , \*\* –  $P < 0.01$ , \*\*\* –  $P < 0.001$ ), ^ – with respect to initial level ( $^\wedge$  –  $P < 0.05$ ,  $^\wedge^\wedge$  –  $P < 0.01$ ,  $^\wedge^\wedge^\wedge$  –  $P < 0.001$ )

Thus, on the basis of received data we can say that the viral diseases of eye are expression of gene of inducible form of syntheses nitric oxide on local level. Their direction and expression depend on the severity of pathology and also investigated bio-samples for blood serum-with the decrease of stable metabolites of nitric oxide, in the lachrymal fluid with sharply increasing. The complex therapy of viral disease of eye with using the actipol preparation more clearly suppresses the expression of gene of inducible form of syntheses nitric oxide on local level, which appears with decreasing final level

of its metabolites, therefore positive side of dynamics of clinical functional manifestations of diseases and reduction of recovery term of patient.

**Conclusion.** 1. The use of actipol preparation in complex treatment of adenoviral conjunctivitis decreases the course of disease in 1.4 times.

2. In viral eye lesion the observed reduction level of metabolites of nitric oxide in blood and its increase in lachrymal fluid is reliably changed after the using antioxidant therapy: in blood serum the level of metabolites increases to 34.1%, but in lachrymal fluid it decreases to 1.4 times.



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## **THE RELATIONSHIP BETWEEN BODY POSTURE AND BALANCE IN YOUTH AND ADOLESCENTS**

**Abstract:** body posture is an individual characteristic, it shows great differentiation – especially in people during their progressive development. Postural balance is the ability to keep the body in equilibrium. The aim of this paper was to review the latest literature regarding the relationship between body posture and balance in adolescents. We searched in PubMed. More research studies should address the contribution on the relationship between body posture and balance in earlier ages to prevent the future spinal problems.

**Keywords:** Posture, Balance, Adolescents.

### **Introduction**

Body posture is an individual feature, which shows a great differentiation, especially at the age of puberty. Puberty is accompanied by major maturational physical alterations in body shape and dimensions, and substantial brain changes [1; 2]. Because of development variability and lack of physical activity, body posture defects appear in children and youths [3; 4]. Cieszkowski S [5] Miałkowska J [6] found that schoolchildren with body posture defects had significantly lower levels of power dynamic, static strength and endurance, and interestingly presented a higher level of flexibility. This fundamental motor skill is learned at an early age and represents an essential basic for daily routine tasks and athletic activities [7]. Postural balance is the ability to keep the body in equilibrium and to regain balance after the shift of body segments [8].

Postural change occurs continuously throughout the entire time of ontogenesis, with critical periods at school age and puberty. Large cohort studies analyzing children and adolescents reported reference values of spinal and pelvic sagittal parameters [9–14]. Other studies have characterized the changes in sagittal plane alignment

during growth [15; 16]. External pelvic motion has a critical role in maintaining the balance of the spinopelvic axis: varying rotational position (pelvic tilt) and antero-posterior translation are well documented [17; 18].

One of the main spinal deviation in adolescents is scoliosis, which is a three-dimensional (3 D) deformation of the spine and rib cage resulting in a prominent trunk distortion. Its more common form is adolescent idiopathic scoliosis (AIS) usually affects young girls [19]. Most studies describe the differences between scoliotic and non-scoliotic girls and focus primarily on a single set of parameters derived from spinal and pelvis morphology [20], posture [21; 22] or standing imbalance [23; 24]. Few addressed a combination of different types of parameters, for instance, curve type and postural sway [25] or body posture and standing stability [26] in AIS. Fewer reported differences in untreated adolescent idiopathic scoliosis of different severities for standing balance [27; 28] and pelvis morphology asymmetries [29]. Often studies include more than a single curve type [22] or combine different form of scoliosis such as adolescent idiopathic scoliosis infantile idiopathic scoliosis

and scoliosis associated with another condition and back problems [30]. Correlations between the Cobb angle and radiographic, morphologic, postural and standing balance parameters met mitigated successes [31]. Attempts have been made to link standing balance to body posture [32; 33], to morphology [34], and to curve type [25], or to associate scoliotic severity to standing imbalance [35]. These studies confirm that scoliosis and its progression are related to more than a single type of biomechanical factors. Simoneau M [36], advocate a sensory integration hypothesis to explain balance control problems observed in AIS. This concept is based on the dynamic regulation of sensorimotor integration by the inappropriate weighting of sensory inputs. They conclude that AIS girls have difficulty in reweighing sensory inputs following a brief period of sensory deprivation. Bruyneel AV [36], also attribute the variability in ground reaction forces during forward and lateral step initiation to the ontogenesis of adaptive strategies. In opposition, a biomechanical hypothesis gives importance to trunk shape posture adjustments. [29], who have observed a significant correlation between the Cobb angle and pelvic abnormal growth, support this. Others like Burwell RG [38], Goldberg CJ [30], and Ramirez L [39], found strong relationships between spinal deformity and asymmetrical postures reinforcing the biomechanical concept. The included curve types (single or double), number of different curve types, location of curves (thoracic and lumbar), and/or Cobb angles vary considerably between studies, and all of these factors individually have been shown to influence postural balance. For example, patients with single lumbar curves showed poorer postural balance than those with double major curves [25] and greater Cobb angles were also associated with poorer postural balance [27; 28]. Based in all this datas and different discussion on this topic we thought that it will with great interest to underwent a review study focusin on the latest paper dealing with body posture and and his relationship with balance.

### Objectives

The main objective of this paper was to review the latest literature regarding the possible relationship between body posture and balance in adolescents.

### Methodology

The search was made in PubMed, for studies focusing on Body Posture and Balance in Adolescents. The

main key words used were; *Posture, Balance, and Adolescents*. Selection criteria were: Article type: Clinical Trial, Randomized clinical trial: Text availability: Free full text. Publication dates: Last 10 years.

### Results and Discussion

From 125 studies, only six papers fulfilled the criterias. The selected studies were:

1. Dolphens. M et al., – 2011.
2. Dalleau G et al., – 2012.
3. Stylianides A. G et al., – 2013.
4. Lizis P & Walaszek R., – 2014.
5. Schimmel JP. J et al., – 2015.
6. Ludwig O., – 2017.

Dolphens. M et al., 2011 study aim was to document the correlations between sagittal standing posture parameters in a pre-peak height velocity (pre-PHV) cohort. Study included 639 pre-PHV boys (age 12.6 [SD, 0.54] years) and 557 pre-PHV girls (age 10.6 [SD, 0.47] years). Gross body segment orientations and spinopelvic orientation/shape indexes were quantified using a clinical screening protocol. Pearson's correlation coefficients were determined for all sagittal standing plane alignment parameters, and a postural model was used to analyze the correlations between parameters.

Results Both at the gross body segment and spinopelvic level, an interdependence was found between postural parameters. No correlations were observed between 'global' parameters related to the pelvis, trunk or body anteroposterior translation postures and 'local' spinopelvic geometries.

In Dalleau G et al., 2012 study the first objective was to test if there were differences in some parameters between pre-braced AIS girls with a right thoracic scoliosis of moderate (less than 27u) and severe (more than 27u) deformity. The second objective was to identify which of these parameters are related to the Cobb angle progression either individually or in combination of thereof. Forty-five scoliotic girls, randomly selected by an orthopedic surgeon from the hospital scoliosis clinic, participated in this study. Parameters related to pelvis morphology, pelvis orientation, trunk posture and quiet standing balance were measured. Generally moderate pre-brace idiopathic scoliosis patients displayed lower values than the severe group characterized by a Cobb angle greater than 27u. Only pelvis morphology and trunk posture were statistically different between

the groups while pelvis orientation and standing imbalance were similar in both groups. Statistically significant Pearson coefficients of correlation between individual parameters and Cobb angle ranged between 0.32 and 0.53. Collectively trunk posture, pelvis morphology and standing balance parameters are correlated with Cobb angle at 0.82. The results suggest that spinal deformity progression is not only a question of trunk morphology distortion by itself but is also related to pelvis asymmetrical bone growth and standing neuromuscular imbalance.

The purpose of Stylianides A. G et al., 2013 study was to determine how pelvic morphology, body posture, and standing balance variables of scoliotic girls differ from those of able-bodied girls, and to classify neurobiomechanical variables in terms of a lower number of unobserved variables. Twenty-eight scoliotic and twenty-five non-scoliotic able-bodied girls participated in this study. 3D coordinates of ten anatomic body landmarks were used to describe pelvic morphology and trunk posture using a Flock of Birds system. Standing balance was measured using a force plate to identify the center of pressure (COP), and its anteroposterior (AP) and mediolateral (ML) displacements. A multivariate analysis of variance (MANOVA) was performed to determine differences between the two groups. A factor analysis was used to identify factors that best describe both groups. Statistical differences were identified between the groups for each of the parameter types. While spatial orientation of the pelvis was similar in both groups, five of the eight trunk postural variables of the scoliotic group were significantly different than the able-bodied group. Also, five out of the seven standing balance variables were higher in the scoliotic girls. Approximately 60% of the variation is supported by 4 factors that can be associated with a set of variables; standing balance variables (factor 1), body posture variables (factor 2), and pelvic morphology variables (factors 3 and 4). Pelvic distortion, body posture asymmetry, and standing imbalance are more pronounced in scoliotic girls, when compared to able-bodied girls. These findings may be beneficial when addressing balance and ankle proprioception exercises for the scoliotic population.

Lizis P & Walaszek R., 2014 study aim was to evaluate the relations between correct body posture parameters, measured with the photogrammetric method, with some of the somatic features and motor abilities of boys

at the age of 14. The study included 133 boys aged 14 attending junior secondary schools in the Kraków area of Poland. Only boys with the correct body posture were examined. Posture was examined by the Moire method, through which six parameters were obtained in the sagittal plane, seven in the frontal plane, and one in the transverse plane. The somatic measurements included basic parameters, such as body weight and body height. The measurements of motor features included: marching balance test, speed movement test of the arms and their functional strength. To evaluate the relationships between correct body posture with the characteristics of somatic and motor abilities, the Spearman rank correlation was used. The lowest level of statistical significance was accepted at  $p \leq 0,05$ . No correlations were noted between some of the correct body posture features and the somatic features, and some of the motor abilities of the examined boys at the level of  $p \leq 0.05$  and  $p \leq 0.01$ .

In Schimmel JP. J et al., 2015-study purpose was to determine whether AIS patients have defective postural balance compared to a healthy age-matched control group and whether potential deficits are similar between patients with single and double curves. The second purpose was to delineate the effects of corrective posterior spinal fusion on postural balance in the same group of patients with AIS. Postural balance was tested on a force plate, in 26 female subjects with AIS (12–18 years old; preoperative Cobb-angle: 42–71°; single curve  $n = 18$ , double curve  $n = 6$ ) preoperatively, at 3 months and 1 year postoperatively. We also conducted a balance assessment in 18 healthy age-matched female subjects. Subjects were tested during quiet double-leg standing in four conditions (eyes open/closed; foam/solid surface), while standing on one leg, while performing a dynamic balance (weight shifting) task and while performing a reaching task in four directions. According to the results, AIS subjects did not demonstrate greater COP velocities than controls during the double-leg standing tasks. In the reaching task, however, they achieved smaller COP displacements than healthy controls, except in the anterior direction. AIS patients with double curves had significantly greater COP velocities in all test conditions compared to those with a single curve ( $p < 0.05$ ). For the AIS group, a slight increase in COP velocities was observed in the foam eyes closed and right leg standing condition at 3 months post surgery. At 1-year post surgery,



however, there were no significant differences in any of the outcome measures compared to the pre-surgery assessment, irrespective of the curve type.

In Ludwig O., 2017 paper the purpose was to examine possible interrelationships between postural sway and posture parameters in children and adolescents with a particular focus on posture weakness. 308 healthy children and adolescents (124 girls, 184 boys, aged  $12.3 \pm 2.5$  years) participated in the study. Posture parameters (posture index, head protrusion, trunk inclination) were determined based on posture photos in the sagittal plane. Postural sway was measured during 20 seconds on a force plate. The Pearson's product-moment correlation coefficients between the anthropometric and posture parameters and the sway path length (SPL) were calculated, as well as the coefficient of determination  $R^2$ . Study results showed that there is a weak but significant correlation between age or body mass index of the test subjects and the SPL. There is no statistically significant correlation between posture parameters and the SPL. Children and adolescents with posture weakness do not exhibit a changed SPL.

### Conclusions

Based on the reviewed studies we can conclude that there are few studies focusing on the relationship between body posture and balance in adolescents.

According to Dolphens. M et al., 2011 study conclusions reveal that the sagittal standing balance in normal pre-PHV subjects, and describes a scheme of correlations in the framework of the segmental theory of postural organization. Generally, the pattern and strength of correlations was similar between both genders, showing a similar interdependence between orientation and shape parameters at both the gross body segment and spino-pelvic level. According to Dalleau G et al., 2012 study conclusions, generally moderate pre-brace idiopathic scoliosis patients displayed lower values than the severe group characterized by a Cobb angle greater than  $27^\circ$ . Only pelvis morphology and trunk posture were statistically different between the groups while pelvis orientation and standing imbalance were similar in both groups. Statistically significant Pearson coefficients of correlation ranged between 0.32 and 0.53 and were within the reported values. Also Stylianides A. G et al., 2013 study has shown that pelvic distortion, body posture asymmetry, and standing imbalance of scoliotic girls are more pronounced when compared to a comparable able-bodied

group. Upright stance in able-bodied girls is mostly characterized by the control they exercise to maintain balance since there is little pelvic distortion and their posture is relatively erect. Untreated scoliotic girls were shown to have an abnormal pelvic morphology combined with body posture asymmetries. Their ability to maintain balance is also perturbed, but it could be a compensatory mechanism or one that develops or manifests itself in the later stage of the scoliotic progression.

In Lizis P & Walaszek R., 2014 study conclusions was showed that regarding photogrammetric posture, somatic and motor features revealed the following: The angle of tilt of the trunk correlated with body weight, and the difference in the height of the anterior superior iliac spine correlated with body height. This means that heavier persons are often predisposed to a round back, and that lean people frequently have an asymmetrical pelvis; The thoracic kyphosis angle, depth of the kyphosis, and fixing of the triangles of the waist determine marching balance. Thus, worse body posture accompanies worse marching balance;

The compensation ratio correlates with the speed of the upper limbs (knocking on the circle, tapping in the rings). This means that better eye-movement coordination accompanies better body posture; The correlation between the maximum leaning of the line of the spine from the upright position C7-S1 in the frontal plane and functional strength (overhang – arms bent) means that systematical exercises on muscle strength should be used at children with body posture defects, especially defects of the spine.

In Schimmel JP. J et al., 2015 study conclusions is showed that the postural balance in the current cohort of 26 AIS patients with large curves is the same as in an age matched healthy control group. After surgery, in which a substantial part of the spine is made rigid by spinal fusion, some variables slightly deteriorated for a short period, but after one year, the patients' postural balance had recovered to preoperative values. This suggests that disturbed motor-sensory integration does not play a role in the development of a spinal malalignment in AIS. These findings also suggest that postural balance in AIS is neither affected by the trunk asymmetry, nor by spinal fusion.

Also after reviewing all these studies we can conclude that more research studies should address the contribution on the relationship between body posture and balance in earlier ages in order to better prevent the future

spinal problems and also to orientate the children involving in the wright and proper physical activity programs foocusing in prevntion and also in the improvement of pastural problem and in the same time balance problems.

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## PECULIARITIES OF CLINICAL CURRENCY OF JUVENILE RECOVERING PAPILOMATOSIS OF LARYNX

**Abstract:** In the manifestation of laryngeal papillomatosis, external factors, in particular respiratory infection, are important, so in our studies in 81.7% of cases the manifestation of the disease was associated with a transferred cold, during which the virus actively penetrates through the microtraumas and sites of inflammation into the basal cells of the epithelium, where it begins active replication with the development of intraepithelial neoplasia (hyperplasia).

**Keywords:** Papillomatosis, larynx, children, relapse.

Papillomatosis of the larynx (PL) was first described in the 1800s, but until the 80s of the last century there was no clear concept of the disease and explanations of its recurrence, when finally for the first time there were convincing data on the indisputable dominant role of human papillomavirus (HPV) in development of this disease [1; 4]. There is still no clear classification. Juvenile PL and PL adults are distinguished, which differ not only in time of manifestation, but also in clinical features of the development of the disease. The prevalence of PL varies depending on the age, the gradation of the country and the socio-economic status of the population, and usually range from 1 to 4 per 100,000 population [2; 3].

Despite the low prevalence, the economic and social burden of PL is severe, and given the numerous surgical procedures and possible consequences in the form of cicatricial changes in the larynx and persistent irreversible voice changes, the PL problem remains one of the important unresolved sections of both otorhinolaryngology and virology.

Numerous studies have shown that the main way of transferring HPV from PL from mother to child during labor during infection of the respiratory tract. The exception is adult patients, whose infection is associated with sexual contact. Although Caesarean section can prevent HPV infection during labor, its effectiveness in preventing PL is controversial and the procedure carries an increased risk of complications [4; 5].

**The aim** of the study was to study the clinical course of juvenile papillomatosis of the larynx.

**The material and methods** of the study were carried out in the department of the 3th of the Tashkent Academy clinic, which includes a study since 1998, a time span of 20 years. Our study included 186 children from 6 months to 18 years. The manifestation of the disease to 8 years, the average age of the manifestation was  $3.2 \pm 0.8$  years. Of the 186 patients, 102 patients were male and 84 female. The observation period was from 2 years to 18 years. The conducted studies included: a questionnaire, endoscopic examination of the larynx, identification of HPV (PCR diagnostics), morphological study.

**Results of the study and discussion.** Examination of patients with PL revealed that in 80.6% of patients the manifestation of the disease and the main period of recurrence were at the age of up to 7 years, with a considerable percentage of them being children of early age (up to 3 years) – 39.2%, which is accompanied by severe clinical manifestations of respiratory failure associated with narrowing of the glottis. Children with PL in the senior school age are not found often – up to 18.3% (34), and there were only two patients 16 and 17 years old.

The first symptom of the debut of PL in all patients was hoarseness of the voice, which had an increasing character, without intervals of “enlightenment”. At the same time, this symptom remained the only one in 67.2% (125) of children during the year, and 8.1% (15) for six months.

Analyzing the age when hoarseness first appeared, it is worth noting that the beginning of the disease in the majority of patients falls to the age of one to three years – the period of active growth and development of the immune system, as well as the period of active contact of

children with airborne infection, which amounted to 133 (71.5%) patients, the lowest was in the year to 9.1%, which was 17 (9.1%) patients, with 7 (41.2%) patients who had a disease onset before age 6 months, the minimum age of the patient with the appearance of hoarseness was 3 months. When collecting anamnesis on the

question of what was associated with the onset of the disease in 34 (18.3%) cases, the parents did not associate the onset of hoarseness with anything, in 87 (46.8%) associated with the transferred cold, in 65 (34.9%) with a child's infection, a large proportion of which was measles and chicken pox – 51 (78.4%) case (table 1.).

Table 1. – Characteristics of the age composition and sex by the appearance of the first clinical signs (dysphonia)

| Sex   | Up to 1 year 1 |      | 3 years 3 |      | 5 years Total |      | Up to 1 year 1 |      |
|-------|----------------|------|-----------|------|---------------|------|----------------|------|
|       | abs            | %    | abs       | %    | abs           | %    | abs            | %    |
| Boys  | 11             | 64.7 | 79        | 59.4 | 12            | 33.3 | 102            | 54.8 |
| Girls | 6              | 35.3 | 54        | 40.6 | 24            | 66.7 | 84             | 45.2 |
| Total | 17             | 9.1  | 133       | 71.5 | 36            | 19.4 | 186            | 100  |

Analyzing the history of the disease of patients with PL and having studied the anamnesis, they found that the diagnosis of PL took about a year in the group of patients from 1 to 3 years, in the group up to 1 year, 3–6 months, in the older age group (3–5 years) up to 3 months, which corresponds to the data of the literature [3], that on average, from the time of the onset of the first symptoms to the establishment of a clinical diagnosis in children is about 1 year [1].

The second most frequent symptom of debut is a different degree of respiratory failure, while it is of an inspiratory nature. 132 (71%) patients initially received respiratory failure without a diagnosis. Of these, 74 (56.1%) had primary respiratory failure, 49 (37.1%) with a second degree and 9 (6.8%) patients with severe 2–3 degrees of respiratory failure, with three of them transferred from a specialized laryngitis department, where the stenosing laryngotracheitis was urgently delivered (table 2.).

Table 2. – Characteristics of patients by respiratory failure

| Symptom                     |               | Number of Patients |      | Total |      |
|-----------------------------|---------------|--------------------|------|-------|------|
|                             |               | abs                | %    | abs   | %    |
| Respiratory failure         | I degree      | 74                 | 56.1 | 132   | 71.0 |
|                             | II degree     | 49                 | 37.1 |       |      |
|                             | II–III degree | 9                  | 6.8  |       |      |
| Without respiratory failure |               | 54                 | 29   |       |      |

No swallowing disorders were observed in any of the patients we observed either during the initial admission (in the anamnesis) or in the subsequent it was not revealed.

When collecting anamnesis, we found that 169 (90.8%) of the children we examined were first born, and 17 children (9.2%) were born as the second child in the family. In this case, the mothers of the examined first-born children became pregnant in the first year after the first contact with the sexual partner, which corresponds to the literature data that the activation and increased reproduction of the virus with clinical manifestations in the form of papillomas and condylomas occurs within up to 24 months (on average 6–12 months) with self-healing or transition to a

chronic form [1], in which the virus ceases to be determined, available at the present time, by diagnostic methods. Also these data are confirmed by the data of a survey of mothers of children with PL: 56 mothers were examined – gynecologist's consultation with taking HPV scraping (6, 11, 16, 18 types) – no examination of condyloma and papilloma was detected in any mother. In cervical scrapes, 11 and 16 types of HPV DNA were detected, which is 1.8% of the case of HPV detection. At the same time, the skin manifestations of HPV in adult family members in the form of multiple papillomas of the skin of the neck, back and other parts of the body were detected in 137 families (from the parents), which amounted to 73.7%, attributable to the unfavorable «family background» of HPV infection.

By the nature of the growth of papillomas in the respiratory tract, a widespread form of PL was primarily detected in 117 children (62.9%), in 5 cases spread to the oropharynx, 2 in the esophagus, in 2 children, the growth of papillomas was observed in the trachea. In 69 cases, a limited form of PL was observed, which amounted to 37.1%. However, we consider this separation impractical, since it is associated with the period of detection or diagnosis of the laryngeal papillomatosis. In fact, in the absence of definite treatment and with concomitant factors (infection, a decrease in the immunoreactivity of the organism, or in the event of circumstances contributing to a decrease in local immunity), the growth of papillomas was widespread, which was particularly pronounced in patients with PL after the infection (measles, chickenpox) cases in children with a primarily restricted form of PL after infection, active papillomatosis progressed to the oropharynx and esophagus.

The study showed that the larynx of the larynx is associated with various immune disorders. In 4 children, there was a deficiency of the T-cell link of immunity, manifested by a decrease in peripheral blood of T-lymphocytes (CD3 +) below 25%. In addition, these children, against a background of a general decrease in T-lymphocytes, also had a deficit of T-helpers (CD4 +). In 2 children, on the contrary, CD4 + lymphocytes prevailed in the peripheral blood (43% and 47%, respectively), which led to an increase in the CD4/CD8 ratio (respectively, 2.4 and 2.6). Thus, it can be assumed that some autoimmune clones may be stimulated in some patients with PL [4].

In 17 (9.1%) children (examined), immune disorders were associated with an increase in the peripheral blood of immunoglobulin E up to 126 ng/ml and circulating immune complexes to 0.100 conv. units. These data show the significance of atopy and infectious allergies in the course of the underlying disease.

The obtained results confirm the literature data on the leading significance in the formation of PL associated immunopathology. So, Bergler W. F. (2000) indicated that 70% of children with PL had allergies to cow's milk proteins. Aaltonen L. M. (2001) noted the importance of a deficit of antibodies to papillomatosis viruses in the development of PL [6].

In our studies, we found that the frequency of recurrence was of great importance for the characterization of the disease, which could be affected both by the state of the immune status of the child's organism, and the concomitant pathology and virulence of the papilloma-virus itself.

Thus, according to the frequency of recurrence, the patients surveyed are divided into the following groups: a continuously recurring course, when during the PL there was a period with virtually uninterrupted growth of the papilla with at least 3 operations per year; often a relapsing group – relapses at least once a year, but not more than 3 times; rarely relapsing group – relapses no more than 1 time per year; non-recurring group – during the period of observation, a single growth was observed after removal, of which no growth of papillomas was observed (tabl 3).

Table 3. – Characteristics of patients with a recurrence rate

| Number of relapses            | Up to 3 years 3 |      | 6 years 7 |      | 18 years Total |      | Up to 3 years 3 |       |
|-------------------------------|-----------------|------|-----------|------|----------------|------|-----------------|-------|
|                               | abs             | %    | abs       | %    | abs            | %    | abs             | %     |
| Continuously recurring course | 30              | 68.2 | 13        | 29.5 | 1              | 2.3  | 44              | 23.7  |
| 1–3 times a year              | 23              | 53.5 | 14        | 32.6 | 6              | 13.9 | 43              | 23.1  |
| 1 time per year               | 18              | 23.4 | 33        | 42.9 | 26             | 33.7 | 77              | 41.4  |
| no                            | 2               | 9.1  | 17        | 77.3 | 3              | 13.6 | 22              | 11.8  |
| Total                         | 73              | 39.2 | 77        | 41.4 | 36             | 19.4 | 189             | 100.0 |

When analyzing this table, it can be stated that in most PL is a disease with recurrence at least once a year, which is a greater specific gravity 164 (88.1%). At the same time, the continuously recurring group was not so unimportant, amounting to 44 (23.7%) of patients,

which indicates an unfavorable immunological status of patients. Considering the age structure of this group with the prevalence of children under 6, most of them 40 (90.9%) patients had signs of respiratory failure requiring urgent measures and worsening both the course



of the disease and the results of subsequent therapy. In our observations, the relapsing group was rarely the most numerous, its specific gravity was 77 (41.4%) patients, in which pre-school children (3–6 years) prevailed – 42.9% [4]. The smallest non-recurring group was 22 (11.8%) patients, who were mainly children of pre-school age. Such a division of patients along the flow is considered conditional, since the process of recurrence, as already mentioned above, is more influenced by the state of the organism itself, which is highly susceptible to fluctuations in different age periods. Therefore, we did not exclude children with a single growth of papillomas from the studies, since many cases of PL have been described in the literature, under adverse conditions, manifested by recurrent growth of papillomas [3]. Thus, we believe that a prolonged absence of growth should not be seen as a recovery, should be considered a stable remission of PL. In addition, the course of PL is more influenced by the immunological stability of the patient

rather than the age, for the confirmation of which it is necessary to conduct an extended immunological study taking into account the clinical course and the age composition of the patients.

#### Conclusions

1. The obtained data testify to a high incidence of infection of children of first-borns (90.8%) from a mother with HPV infection in 73.7% of families with an unfavorable “family background” for papillomavirus infection;

2. The initial clinical symptom of PG is persistent hoarseness of the voice, the duration of which is isolated for about 1 year, 67.2% (125) children and half a year in 8.1% (15) children;

3. In our study, juvenile papillomatosis of the larynx in 46.8% occurred frequently and continuously in relapsing forms, which indicates an unfavorable immunological status and a high incidence of acute respiratory infection, a factor contributing to the recurrence of papillomavirus infection.

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## EFFECT OF ECDISTEN ON THE CONDITION OF THE NITROGEN OXIDE SYSTEM IN THE DEVELOPMENT OF ALLOXANE DIABETES

**Abstract:** The effect of ecdystene on the nitric oxide system in experimental alloxan diabetes is evaluated in the article. The results obtained showed that ecdystene, in contrast to glucocorticoid and retabolil, causes a more pronounced decrease in the content of nitric oxide, especially during treatment during the 21<sup>st</sup> day. Such a change in the content of nitric oxide occurs due to a change in the activity of synthases involved in their formation.

**Keywords:** alloxan diabetes; blood serum; system of nitric oxide; ecdystene.

In recent years, the prevalence and incidence of diabetes mellitus continues to increase, according to WHO experts, by 2025 there will not be 300 million diabetics worldwide, as predicted in 1999, but 380 million [1]. All this points to the need to intensify scientific research aimed at clarifying the mechanisms underlying the pathogenesis of both diabetes mellitus and its complications.

The role of the nitric oxide system in the pathogenesis of diabetes is not well understood. The data obtained in experimental type 1 diabetes, caused by streptozotocin or alloxan, indicate both activation [2–4] and inhibition of the activity of this system [5; 6].

It is known that alloxan is a toxic analog of glucose, penetrating into cells with the help of GLUT2 glucose transporter, activates free radical processes in them with the formation of superoxide anions and hydroxyl radicals, which cause pancreatic  $\beta$ -cell death [3; 7]. It is obvious that oxidative stress caused by alloxan in  $\beta$ -cells is also accompanied by hyperglycemic activation of these processes in the body [9]. Metabolic disorders in alloxan diabetes (AD), including damage to  $\beta$ -cells, prevent antioxidants [3; 9]. Elimination of hyperglycemia and reduced mortality due to L-NNA in rats with diabetes

suggests that this blocker prevents the death of insulin-containing cells caused by alloxan. It is most likely that this L-NNA effect is due to the fact that the blocker by inhibiting NO synthase prevents excessive formation of NO and, accordingly, toxic products of reactive oxygen species, which causes the protection of  $\beta$ -cells and the body from alloxane damage.

It was found that one of the mechanisms of NO-synthase activation in diabetes is mediated by the nuclear transcription factor NF- $\kappa$ B (nuclear transcription factor  $\kappa$ B) [10]. Thus, in mice it was shown that the level of NF- $\kappa$ B in the pancreas increases only 30 minutes after the injection of alloxan [3]. Oxygen radicals in excess formed in hyperglycemia activate this factor [3], which, as shown, can directly activate iNOS [11], which leads to hyperproduction of NO. Thus, the increased activity of the NO system increases the vulnerability to diabetic factors, namely, alloxan.

**Objective:** To study the state of the nitric oxide system and evaluate the effect of ecdystene on the nitric oxide system in experimental alloxan diabetes.

**Material and methods of investigation.** To solve the goal, the experiments were carried out on 70 male

rats weighing 130–150 g, which are on a standard diet. The experiments were guided by the “European Convention for the Protection of Vertebrates, which are used for experiments and other scientific purposes” (Strasbourg, 1985). To reproduce the model of diabetes 60 rats after the quarantine were administered alloxane in a dose of 13 mg per 100 g of body once. The development of diabetes was judged by the glucose level in the blood, which was determined on a biochemical analyzer using a set of glucose oxidase test from the firm of Lahem. Seven days after the reproduction of the diabetes, the animals were divided into 4 groups of 15 individuals each: 1st (control) – rats with blood pressure, which received orally distilled water 0.5 ml per 100 g of body weight; The 2<sup>nd</sup> group (the main group) – rats with blood pressure, who received ecdystene at a dose of 0.143 mg per 100 g of weight intragastrically; 3<sup>rd</sup> group – rats with blood pressure, who received the drug of comparison glucofazh at a dose of 4.28 mg per 100 g of weight; The 4<sup>th</sup> group – rats with blood pressure, who received a drug of comparison retabolil in a dose of 0.0714 mg per 100 g of mass. 10 rats made up an intact group.

The preparations were administered for 14 days, the animals were sacrificed on the 14<sup>th</sup> and 21<sup>st</sup> days from the beginning of the experiment. The choice of comparator drugs is justified by the fact that glucofrage is practically the only antidiabetic drug that reduces the risk of dying from diabetes and its serious complications. It reduces the rate of absorption of carbohydrates in the

small intestine, increases the sensitivity of peripheral tissues to insulin, inhibits the processes of gluconeogenesis and glycogenolysis in the liver and reduces systemic hyperinsulinemia. The choice of retabolil is justified by its anabolic effect.

The state of the NO – ergic system in blood serum was assessed by the concentration of the main stable metabolites NO<sub>x</sub> (NO<sub>2</sub> and NO<sub>3</sub>) according to the method of P. P. Golikova [11], the activity of endothelial (eNOS) NO-synthase (NOS) – according to V. V. Sumbaev, I. M. Yasinskaya [12], inducible (iNOS) – by the method of N. W. Kooy et al. [13] in the modification of R. K. Azimova, A. S. Komarina [14]. The level of peroxynitrite (ONOO –) after its oxidation with hydroxylamine (NH<sub>2</sub>O) was determined by the method modified by R. K. Asimov, A. S. Komarin.

The obtained results were processed with the help of the application programs Statistica 6, Biostat. The data are presented as mean arithmetic meanings (*M*) and standard deviations (*m*). To compare the samples, Student’s t-test was used. The significance level was considered reliable at  $P < 0.05$ .

**Results of the study and their discussion.** As can be seen from (Table 1), the NO content in the blood serum increases throughout the study period. On the 7<sup>th</sup> and 21<sup>st</sup> days, this indicator increased 2.8 and 3.2 times, respectively, compared to the control, and the highest was on the 14<sup>th</sup> day, exceeding the control by 4.05 times.

Table 1. – Indicators of the nitro system in the dynamics of alloxan diabetes

| Term of study, days. | alloxan diabetes |                   |                   |               |
|----------------------|------------------|-------------------|-------------------|---------------|
|                      | NO, мкмоль/л     | eNOS, мкмол/мин/л | iNOS, мкмол/мин/л | ONOO, мкмол/л |
| Control group        | 15.2 ± 0.72      | 8.28 ± 0.89       | 0.122 ± 0.01      | 0.06 ± 0.001  |
| 7 <sup>st</sup>      | 43.9 ± 3.38      | 3.3 ± 0.3         | 0.34 ± 0.03       | 0.67 ± 0.01   |
| 14 <sup>st</sup>     | 61.6 ± 3.4       | 4.6 ± 0.13        | 0.62 ± 0.15       | 0.79 ± 0.02   |
| 21 <sup>st</sup>     | 49.53 ± 5.24     | 2.4 ± 0.08        | 0.44 ± 0.07       | 0.83 ± 0.03   |

Note. In all cases,  $p < 0.05$

An increase in serum peroxynitrite levels in the dynamics of alloxan diabetes was also established. On the 7<sup>th</sup> day of the experiment, in comparison with the control, this indicator increased by 11.1 times. Most expressed its content increased by the 14<sup>th</sup> and 21<sup>st</sup> day of the experiment, respectively, 13.2 and 13.8 times higher than that of intact animals.

It has been established that NO plays a role not only in the stress reaction, but also can be involved in the mechanisms of specific damage. Depending on the nature of the acting factor, these lesions may be due to either hypo – or hyperproduction of NO. Thus, for example, the NO production can occur under the influence of high glucose concentrations [13] and contribute to the development of diabetes mellitus.

Table 1. – Parameters of the serum nitric oxide system at experimental BP in animals receiving ecdysten and comparators,  $M \pm m$ 

| Indicator                    | Intact group | AD + H <sub>2</sub> O |        | AD + ecdysthene |        | AD + glucophage AD |           | AD + retabolyl |         |
|------------------------------|--------------|-----------------------|--------|-----------------|--------|--------------------|-----------|----------------|---------|
|                              |              |                       |        |                 |        |                    |           |                |         |
| NO, $\mu\text{kmol/l}$       | 15.2 ±       | 43.9 ±                | 61.6 ± | 49.53 ±         | 36.3 ± | 25.84 ±            | 42.26 ±   | 40.36 ±        | 29.75 ± |
|                              | 0.72         | 3.38                  | 3.4    | 5.24            | 5.273  | 2.59               | 2.82      | 4.932          | 2.692   |
| eNOS, $\mu\text{kmol/min/l}$ | 8.28 ±       | 3.3 ±                 | 4.6 ±  | 2.4 ±           | 6.2 ±  | 7.0 ±              | 5.1 ± 0.3 | 5.5 ±          | 6.1 ±   |
|                              | 0.89         | 0.3                   | 0.13   | 0.08            | 0.18   | 0.74*              |           | 0.36           | 0.008   |
| iNOS, $\mu\text{kmol/min/l}$ | 0.122 ±      | 0.34 ±                | 0.62 ± | 0.44 ±          | 0.31 ± | 0.27 ±             | 0.41 ±    | 0.48 ±         | 0.39 ±  |
|                              | 0.01         | 0.03                  | 0.15   | 0.07            | 0.04   | 0.005              | 0.007     | 0.007          | 0.002   |
| ONOO, $\mu\text{kmol/l}$     | 0.055 ±      | 0.67 ±                | 0.79 ± | 0.83 ±          | 0.74 ± | 0.69 ±             | 0.75 ±    | 0.77 ±         | 0.73 ±  |
|                              | 0.012        | 0.06                  | 0.04   | 0.03            | 0.053  | 0.048              | 0.071     | 0.064          | 0.061   |

Note. \* –  $p > 0.05$  compared with the control

Inadequate production or accelerated decomposition of NO lead to dysregulation of endothelial function, a pathological increase in vascular tone and arterial pressure. This is facilitated by glycosylation products, severe and chronic hypoxia and reactive oxygen species [14]. The decrease in the activity of antioxidant defense enzymes and the intensification of oxidation processes lead to the interaction of nitric oxide (NO) and superoxide radical of the radical with the formation of peroxynitrite, which induces apoptosis, blocks prostacyclin synthesis, enhances the production of leukotrienes and thromboxane, and activates the oxidation of low density lipoproteins. The cause of NO deficiency can be a number of factors, including a decrease in the content of L-arginine, suppression of expression of endothelial NO synthase (eNOS), an increase in endogenous inhibitors of eNOS [15].

The results of our studies indicate a multidirectional change in the activity of NO-synthases in the development of alloxan diabetes. Thus, the activity of ENOS decreases during all periods of the study, but is most pronounced on the 21<sup>st</sup> day – 3.45 times compared to that of intact animals.

At the same time, the activity of iNOS is increasing in all terms of the study. This indicator on the 7<sup>th</sup> and 21<sup>st</sup> days of development of blood pressure in comparison with intact animals increased by 2.8 and 3.6 times, respectively. And on the 14<sup>th</sup> day of the development of alloxan diabetes, iNOS activity increased 5.1-fold.

Thus, on the 14<sup>th</sup> and 21<sup>st</sup> days of the development of blood pressure in the nitric oxide system, there are changes that are characterized by a marked increase in the level of nitric oxide and peroxynitrites and the induction of iNOS.

One of the most important areas of medical and biological research is the search for the possibility of targeted treatment of endothelial dysfunction (ED). Of great importance are the data on the effect of various drugs on the functional characteristics of the endothelium. Currently, there are no preparations for specific correction of ED. The medicines used can only exert an indirect influence on the functions of endothelial cells. These properties are possessed by the following pharmacological groups: 1) hypoglycemic agents; 2) antioxidant and metabolic regulators: antihypertensive, lipid-lowering and enhancing nitric oxide products, vitamin derivatives and endogenous antioxidants.



Used in the treatment of diabetes hypoglycemic agents, in addition to the main hypoglycemic effect, can affect the functional state of the vascular endothelium. Thus, endothelium-dependent and endothelium-independent vasodilation was significantly improved with insulin therapy. The drug from the group of sulfonurea derivatives of the third generation of amaryl increased the production of NO by endotheliocytes of the coronary arteries, which was subsequently confirmed in the clinic using positron emission tomography [16].

The effect of hyperglycemia on atherogenesis in the vascular wall is realized with the help of generalized vascular endothelial dysfunction and rapid enhancement of oxidative stress [17].

Treatment of experimental animals with ecdystene for 14 and 21 days resulted in a decrease in the NO content by 2.03 and 2.5 times, respectively, compared with untreated rats (Table 2). Despite this, the NO content was 2.0 and 1.3 times higher, respectively, than the data of intact animals. Compared with ecdystene, glucocorticoid and retabolil less expressed decrease the NO content, which remained higher than in untreated animals, respectively, in 1.4 and 1.5; 1.6 and 1.66 times.

The content of peroxynitrite during treatment with ecdystene for 14 days does not change significantly, after 21 days compared to untreated group it decreases by 16.9%. Comparison preparations of glucofrage and retabolil during treatment for 14 and 21 days do not cause significant changes in the content of peroxynitrites compared to the untreated group.

Treatment with ecdystene for 14 and 21 days increases the activity of eNOS compared to the untreated group by 1.3 and 2.9 times, respectively. In the treatment with glucofrage and restabolol for 21 days, the activity of this enzyme increases significantly, respectively, in 2,4 and 2,5 times.

The activity of iNOS after treatment with ecdystene for 14 and 21 days compared to the untreated group of experimental animals with blood pressure decreases by 2 and 1.6 times, respectively. Treatment with glucofrage and restabolol for 14 days led to a significant decrease in this indicator, respectively, in 1.5 and 1.3 times.

**Conclusion.** Ecdystene, in contrast to glucocorticoid and retabolil, causes a more pronounced decrease in the content of nitric oxide, especially during treatment during the 21<sup>st</sup> day. Such a change in the content of nitric oxide occurs due to a change in the activity of synthases involved in their formation.

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## **THE RESULTS OF SURGICAL TREATMENT OF LONG BONE FRACTURES WITH MULTIPLE AND ASSOCIATED INJURIES**

**Abstract:** For multiple and combined injuries against the background of anti-shock measures and stabilization of hemodynamic indicators, urgent and delayed surgical interventions on the damaged limbs should be performed depending on the severity of the injury and the patient's condition.

From 2011 to 2016, here were conducted operative and conservative treatment of 125 patients with open and closed fractures of long bones with multiple and combined injuries. The average age varied from 25 to 72 years. Of these, men – 78 (62.4%), women – 47 (37.6%). The majority of patients, which comprised 109 patients (87.2%), were persons of working age.

According to the type of damage, the distribution was carried out according to the AO-ASIF classification as follows: A1–32; A2–15; A3–2; B1–8; B2–6; C1–26; C2–28; C3–8. In this case, fractures of the femur were observed in 56 patients; In 69 patients there was a fracture of the shin bones.

Patients were divided into 2 groups: basic and control. The main group consisted of 47 (37.6%) patients who received early stable osteosynthesis of long bone fractures in the first three days after the trauma. The control group consisted of 78 (62.4%) patients who had osteosynthesis in a delayed and planned manner.

When studying the long-term results in the two groups the following results were obtained. In the main group: good results were found in 34 (91.5%) patients, satisfactory results – in 3 (6.4%), poor – in 1 (2.1%) patient. In the control group: good results were found in 47 (85.45%) patients, satisfactory results – in 3 (5.45%), poor – 5 (9.1%) patients.

When choosing the timing and scope of surgical treatment, the "damage control" requirements must be taken into account. It is also mandatory to perform massive intensive care and give preference to low-injury external fixation devices.

Early intervention reduces mortality and complications in patients with combined and multiple injuries of the musculoskeletal system.

**Keywords:** polytrauma, early osteosynthesis, external fixation apparatus.

### **Relevance**

Year by year, due to the population urbanization, the emergence of high-speed mechanisms and increase of vehicles, increasing the number of patients with multiple and associated trauma is an important task of

traumatology, orthopedics, because of the severity of her condition, compounded by a combination of bone fractures of extremities with other anatomical structures. These injuries are very hard for victims who are bedridden, which is one of the main causes of early and late

complications (hypostatic pneumonia, pressure ulcers, phlebitis, cardiovascular and respiratory failure, non-fracture, false joints, etc.) [1; 2; 3].

For multiple and combined injuries against the background of anti-shock measures and stabilization of hemodynamic indicators, urgent and delayed surgical interventions on the damaged limbs should be performed depending on the severity of the injury and the patient's condition. However, conducting an operation creates additional difficulties for multiple and combined injuries when performed according to vital indications, where the time factor plays a big role in saving the patient's life. This is due to the fact that with multiple and combined injuries, the severity of the condition of the affected is determined by shock, internal damage, bleeding and traumatic brain injury. That is why various authors believe that first of all, it is necessary to perform surgical interventions to save the life of the patient (stop bleeding, surgery on damaged internal organs, etc.) [4; 5]. In such cases, some authors [6] propose their own design, preventive immobilization by the EFD-PI rod apparatus. After stabilization of hemodynamics of the victim, he is transferred to medical immobilization.

The problem of treating victims with multiple and combined injuries, over the past decades has become the most urgent task of traumatology and orthopedics. This is due to high rates of mortality, disability and long rehabilitation periods [7]. Also, the issue of determining the timing of surgical treatment for multiple and combined injuries remains unresolved [8; 9].

Foreign authors, in order to reduce the lethality, recommend a stage treatment "damage control", which allows to obtain good results [11]. In case of severe general condition, according to the "damage control" law, the treatment measures performed should be minimally traumatic, rapid stabilization in severe hemodynamically unstable victims, allows to stabilize the general and local condition, providing subsequent reconstructive treatment [17].

According to the results of A. V. Bondarenko, OA Gerasimova and A. G. Goncharenko, carrying out osteosynthesis in combination with trauma in the first three weeks after trauma, is the optimal time and significantly reduces hospital mortality, which allows early activation of patients [10]. The primary treatment procedure should be minimally traumatic and short-term, so as to minimize the effect on the general condition of the

patient, as well as on the condition of the injured limb [16; 19]. The main cause of complications is the hypodynamic state of patients caused by the trauma itself and the method of its treatment [15; 16].

Currently, in the treatment of patients with polytrauma, significant progress has been made. Osteosynthesis by rod devices is less traumatic, the risk of damage to the vascular nerve trunks is reduced due to their one-sided arrangement. Rod devices have a rigid fixation of bone fragments, they are compact, easier to install and install and significantly reduce the time of surgery. In addition, rod devices create optimal conditions for fracture healing [12; 13; 19]. Stabilization of fractures with polytrauma, contributes to early activation and prevention of secondary complications, which is of great importance for patients [15; 18].

**The purpose of research:** analysis of the results of surgical treatment of fractures of long bones, depending on the duration and severity of injury in multiple and associated injuries.

#### **Material and methods of investigation**

For the period from 2011 to 2016, we performed operative and conservative treatment in 125 patients with open and closed fractures of long tubular bones with multiple and combined injuries. The age of the patients ranged from 25 to 72 years. The men were 78 (62.4%), women – 47 (37.6%). Among the total number, 109 patients (87.2%) were persons of working age. According to the mechanism of injury, the patients were distributed as follows: households – 25 (20%), industrial – 11 (8.8%), street – 4 (3.2%), as a result of road accidents – 78 (62.4%), Katatrauma – 4 (3.2%) and in sports – 3 (2.4%). Closed fractures accounted for 82 cases (65.6%), open fractures – 43 (34.4%). Femoral fractures were observed in 56 patients, in 69 patients there was a fracture of the shin bones. According to the type of damage, the distribution was carried out by the classification of AO-ASIF [14] as follows: A1–32, A2–15, A3–2, B1–8, B2–6, C1–26, C2–28, C3–8 cases. In 69 patients fractures were combined with craniocerebral trauma, fracture of pelvic bones in 13 patients, thoracic organs damage in 12 patients, abdominal organs in 30 patients, peripheral nerve injuries of upper extremities in 1 patient. 62 injured (49.6%) had a traumatic shock of varying degrees.

Patients distribution criterion was the scale of assessment of the severity of injuries of the TS (1981) and

assessment of severity of the Glasgow Coma Scale of traumatic brain injury (1974). The severity of the condition was as follows: 3–7 points in 13 patients (10.4%), in 28 patients (22.4%), the severity of the injury was estimated at 8–10 points, 11–15 points in 37 (29.6%) and 16 points in 47 (37.6%) patients. It should be noted that 41 patients (32.8%) had a serious and extremely serious condition when they were admitted. The state of severity of the victims with multiple and combined injuries was aggravated by fractures of bones, degrees of traumatic shock and the magnitude of blood loss.

To provide emergency assistance, a team of specialists consisting of a traumatologist, a surgeon, a neurosurgeon and an intensive care specialist was involved, temporary immobilization of the damaged limbs with plaster bandages or standard tires was carried out, the severity of the patient's condition and the severity of the injury were assessed and, based on this, the tactics of the medical and diagnostic measures were planned. The question of the time and amount of the operative intervention was decided, depending on the severity of the trauma and the severity of the patient's condition. The examination included radiography of the skull, chest and pelvic bones, ultrasound examination (ultrasound) of the abdominal organs. If necessary, magnetic resonance imaging (MRI) or multispiral computed tomography (MSCT) was used for additional information. When deciding on the method of fixing fractures, the nature of the fracture and the number of damaged segments were taken into account. Patients were divided into 2 groups: primary and control. The main group consisted of 47 patients (37.6%) who received early stable osteosynthesis of fractures of long bones in the first three days after the trauma. The control group consisted of 78 patients (62.4%) who had osteosynthesis in a delayed and planned manner.

### Results and its discussion

Patients of the main group in the first 3 days, against the background of anti-shock measures and condition severity of the injury TS 10–16 points, held a variety of surgical procedures. In the first 6 hours 12 patients (25.5%) on a background therapy of antishock and 13 patients (27.7%) after the infusion, transfusion therapy, stabilization of hemodynamics and general condition, produced osteosynthesis of long bones external fixation devices (EFD) Extramedullary osteosynthesis by the plate, intramedullary osteosynthesis, including blocking intramedul-

lary osteosynthesis (BIN). In 12 patients (25.5%) with concomitant damage to the abdominal organs and limbs, the operation performed by two teams surgery – laparotomy with stitching breaking parenchymatous organs and stabilization of bone fractures rod device or compression-distraction osteosynthesis device of Ilizarov. Due to the severity of the condition (the degree of injury of TS 3–7 points) 10 patients (21.3%) with fractures in the first day the treatment was conducted conservatively, including 8 patients after stabilization of hemodynamic parameters, and general condition, held preventive surgery. In the intensive care unit, in the absence of acute surgical interventions on the organs of the abdominal cavity and head, a rod apparatus was used to fix the injured extremities. In a combined trauma with fractures of the pelvic bones, six patients underwent spinal-osteosynthesis. After the exit of patients from the critical condition, the final osteosynthesis was carried out with the help of the stem apparatus in 4 patients (8.51%), bone osteosynthesis was performed by 2 patients (4.25%), BIN – 2 patients (4.25%). In 2 cases (4.25%), due to the severity of the injury on the 3–5 days, lethal outcome was observed.

We have developed rod device (patent FAP 00737 08.06.2012). Time to impose the device took 20–30 minutes and did not require a special operating room. The application of the External Fixation Device (EFD) has the following positive aspects: facilitating the care of severe and comatose patients, monitoring the skin condition, preventing bedsores and painful syndrome of damaged limbs. In addition, the use of EFD is a prophylaxis of complications observed in skeletal traction, such as heart overload, increased central venous pressure, high diaphragm standing and reduced excursion, general hypokinesia, immobilization of the injured limb.

The control group mainly used methods of conservative treatment. Severity of TS trauma patients was estimated at 8–16 points. In 18 patients (23.1%) with combined abdominal injury, laparotomy was performed with suturing the rupture of parenchymal organs, thoracocentesis was performed in 16 cases (20.5%). Damaged limbs were fixed with plaster bandages. Since the moment of the injury in case of open fractures, produced primary surgical treatment of wounds with the osteosynthesis rod device in 7 cases (8.97%), compression-distraction osteosynthesis Ilizarov – 5 cases (6.41%), with needles – 7 Of patients (8.97%). In delayed-routinely produced extramedullary



osteosynthesis plate in 17 cases (21.79%), intramedullary osteosynthesis – 11 (14,1%), BIN (Blocked intramedullary nailing) – in 17 cases (21.79%). Also, a needle-shaft apparatus was applied to the pelvic bone in 7 patients. In 8 patients (12.3%) continued conservative treatment, because On the control radiography the standing of the bone fragments was satisfactory. In 1 case, with a fractured fracture of the head of the right humerus with traumatic separation of the vessels and brachial plexus, autovenous plastic of the brachial artery was performed. Also in 1 case with a fracture of the femur with femoral artery damage, according to vital indications, the right lower limb was

amputated at the level of the upper third of the thigh. Mortality despite the intensive intensive care measures was 6 cases (7.69%). The cause of death was an extremely difficult condition for admission of patients, instability of hemodynamics complicated by ARDS, thrombotic and fat embolism, cardiovascular and respiratory insufficiency.

To illustrate, there is given a clinical example. Patient H., 28 years old, catatrauma. At admission, the following is diagnosed: Combined trauma. CCSI. Concussion of the brain. An open comminuted fracture with/3 bones of the left shin with a mix of k/o (according to the AS/ASIF classification – 42.A2.3) (Fig. 1).

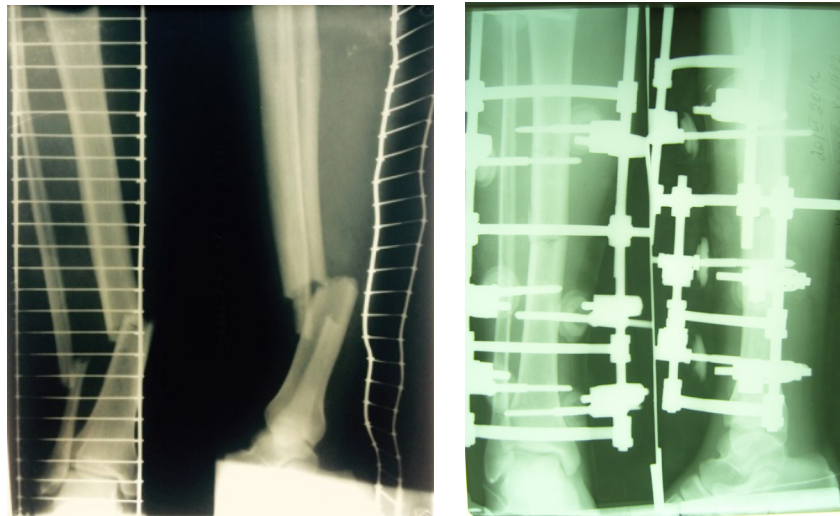


Figure 1. X-ray image at the admission. Figure 2. The X-ray after the operation

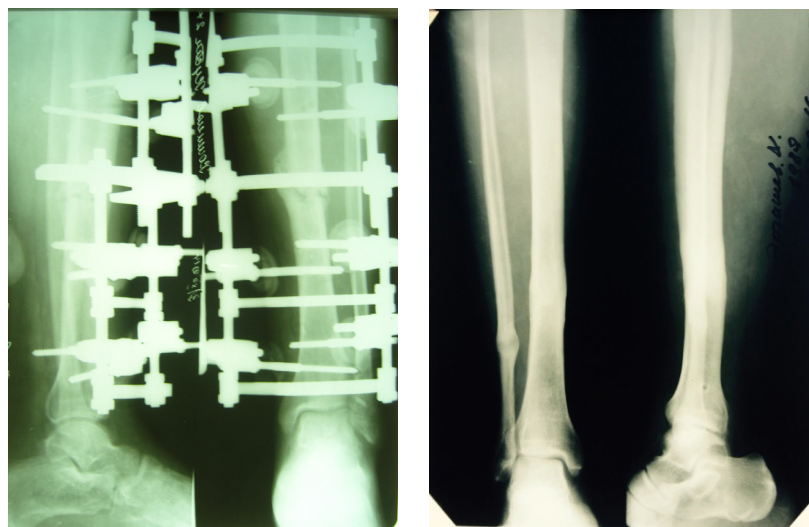


Figure 3. The X-ray image after 16 weeks. Figure 4. The X-ray image of the patient after 2 years

After the preoperative preparation, the Initial Surgical D-bridement of the wound with osteosynthesis of the bones of the left calf with the stern apparatus

of the clinic was performed 12 hours after the injury (Fig. 2). The residual displacement of the fragments, revealed on the control radiograph, was eliminated at



subsequent stages. On the 3rd day after the trauma the patient started the course of rehabilitation measures. The postoperative period was uneventful, which allowed the patient to be discharged from the hospital in satisfactory condition on day 10. After 16 weeks, bone fragments were fused (Figure 3), after which the apparatus was dismantled. At a control examination after 2 years on the roentgenogram (Figure 4), complete consolidation of fractures of the shin bones was noted, walking does not show any complaints, movement in the knee and ankle joints in full, a good anatomical and functional result is noted.

The analysis of literature sources showed that the main cause of complications is the hypodynamic state of patients caused by the trauma itself and the method of its treatment, which was confirmed in our studies.

To assess the outcome of treatment outcomes, the evaluation system of the ER was used. Long-term results of treatment were studied in 93 patients in terms of 12 to 26 months. When studying the long-term results in the two groups the following results were obtained. In the main group: good results were established in 34 patients (91.5%), satisfactory – in 3 (6.4%), unsatisfactory – in 1 (2.1%) patients. In the control group revealed good results in 47 cases (85.45%), satisfactory – in 3 (5.45%), poor – in 5 cases (9.1%) ( $p < 0.05$ ).

### Conclusion

Patients in the control group experienced complications against the background of an acute period of traumatic disease, hemorrhage, hypovolemic shock and multiple organ failure. Severe complications such as thrombotic and fatty embolism were noted in 6 patients (7.69%) and only in 2 cases (4.25%) in the main group. In 2 patients (4.25%) of the main group and 6 (7.69%) in the control group were noted infectious complications. Hypostatic pneumonia was observed in 4 patients (8.5%) from the main group and in 10 patients (12.8%) from the control group. Sacral bedsores, heel and shoulder area of the main group were only observed in 1 case (2.1%), while in the control group, 7 patients (8.97%).

In the study of dynamics observation remote results in the two groups the following results were obtained. In the main group: good results were established in 34 patients (91.5%), satisfactory – in 3 (6.4%), unsatisfactory – in 1 (2.1%) patients. In the control group revealed good results in 47 cases (85.45%), satisfactory – in 3 (5.45%), poor – in 5 cases (9.1%) ( $p < 0.05$ ).

When choosing the timing and scope of surgical treatment, the “damage control” requirements must be taken into account. Also a must is to conduct a massive and intensive care to give preference to low-invasive external fixation devices.

Conducting the early surgery reduces mortality rates and the number of complications in patients with combined and multiple injuries of the musculoskeletal system.

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## **INTERMITTING HORMONAL THERAPY IN PATIENTS WITH COMMON PROSTATE CANCER**

**Abstract:** Intermittent androgen deprivation can lead to a prolonged decrease in serum testosterone, but the choice of regimens and tactics for this therapy for prostate cancer (PCA) remains relevant for oncologists. The purpose of this study was to improve the treatment outcomes and the quality of life of patients with advanced PCA by choosing the optimal regimen of hormone therapy depending on the prognostic factors. The study included 186 patients with advanced prostate cancer (PCA) treated at the City Cancer Dispensary in Tashkent. It was found that the advanced age of patients with PCa ( $75.46 \pm 0.66$  years), the prevalence of the tumor process of stages T2–3, the presence of bone metastases, retroperitoneal and iliac lymph nodes are not limiting factors in the appointment of hormone therapy. In the process of treatment of advanced prostate cancer with criteria for the appointment and withdrawal of hormonal drugs, we determined the dynamics of clinical symptoms of cancer, the level of PSA and testosterone, the severity of complications of hormone therapy from the cardiovascular system and liver.

Resistance of malignant neoplasms of the prostate to hormone therapy remains the main problem when choosing a therapy in such patients. We determined the optimal regimen of hormone therapy, which led to better treatment outcomes and quality of life for patients with advanced PCA.

**Keywords:** prostate cancer, hormonal therapy, limiting factors, luteinizing releasing hormone agonists.

**Introduction.** Neoadjuvant therapy for prostate cancer (PKD) is used to reduce the frequency of the positive surgical edge and possibly improve the results of radical prostatectomy. A number of randomized trials have demonstrated that neoadjuvant therapy reduces the frequency of the positive surgical margin for a clinically localized stage; data for a locally advanced disease are less convincing [1; 2; 3].

The goal of adjuvant therapy is to act on residual microscopic cancer foci after local primary treatment. Patients who received therapy immediately after surgery showed a significant advantage in all cases and a better cancer-specific survival rate compared with those who received delayed treatment (62 vs 71%,  $p < 0.001$ ). These

results are similar to those obtained in patients with metastatic prostate cancer [4].

Recently, studies have focused on the study of intermittent hormonal blockade in order to assess the decrease in side effects following androgen deprivation, improvement in the quality of life in a common process, and delay in the development of hormonal refractoriness [5]. These studies are based on the assumption that intermittent androgen deprivation can lead to a prolonged decrease in serum testosterone levels.

The purpose of this study was to improve the treatment outcomes and the quality of life of patients with advanced PCa by choosing the optimal regimen of hormone therapy depending on the prognostic factors.

**Material and methods.** The study included 186 patients with advanced prostate adenocarcinoma treated at the City Oncology Dispensary in Tashkent. The mean age of patients was  $75.46 \pm 0.66$  years. In 59 patients ( $31.7 \pm 3.41\%$ ) the extent of the tumor process was T2NxMx, in 102 ( $54.8 \pm 3.64\%$ ) – T3NxMx, in 25 ( $13.4 \pm 2.50$ ) – T3NxMx. In 37 patients ( $19.9 \pm 2.92\%$ ) metastases were found in the bones of the skeleton, retroperitoneal and iliac lymph nodes.

All patients received treatment in the mode of intermittent therapy with the agonist LHRH-goserelin acetate 3,6 mg as a depot injection once a month, and with the injection form of anti-androgen cyproterone acetate 300 mg twice a month in combination with bisphosphonates. Patients who received drugs from the group

of bisphosphonates – zoledronic acid, daily received 500 mg of calcium as a food supplement and vitamin D in tableted form (500 IU). Admission of these drugs reduced the compensatory increase in the level of parathyroid hormone (PGH) in the serum, which occurs in response to transient hypocalcemia caused by the introduction of a bisphosphonate. The duration of treatment was 12 months. Objective evaluation was performed before the start of treatment and after 6 months. In the evaluation, data from digital rectal examination, PSA level, morphological examination, ultrasound, computed tomography, skeletal scintigraphy, and necessary radiographic and radiological studies were taken into account.

**Results and discussion.** In Fig. 1 shows the results of the determination of PSA before and after treatment.

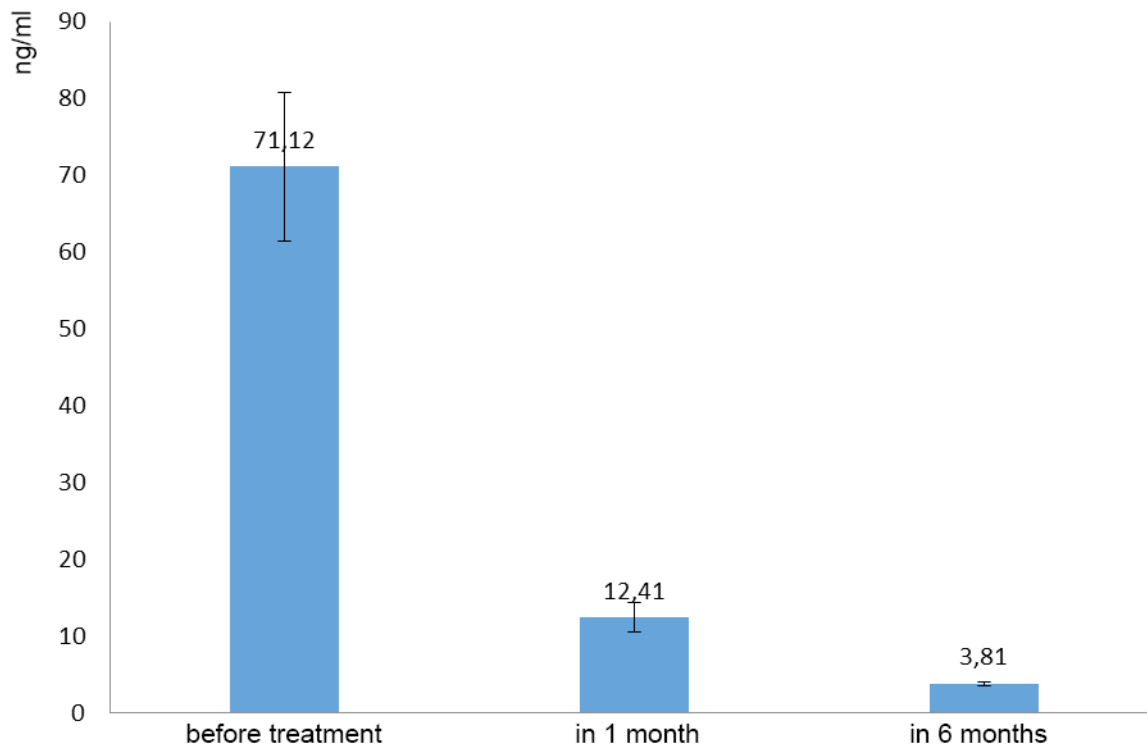


Figure 1. Results of the definition of PSA before and after treatment in patients with PCA

As seen from the results of the PSA determination, before the treatment, the marker level in patients with PCA significantly exceeded the concentration of this protein in the norm ( $<4.0$  ng/ml). Conducting therapy for 1 month allowed to reduce this figure to  $12.41 \pm 1.94$  ng/ml. When planning intermittent therapy, we weekly monitored the level of PSA: if it was more than 20 ng/ml and as a result of treatment it decreased to less than 4 ng/ml, a new cycle of hormone therapy was pre-

scribed until the PSA concentration was 10–20 ng/ml, while “biochemical relapse”, possible after the 1 stage of treatment, was taken into account.

Six months after the start of treatment, in patients with PCA, the PSA level in the blood averaged  $3.81 \pm 0.30$  ng/ml, which corresponds to the norm for a healthy person. The maximum testosterone concentration was 30 ng/dL, i. e. was less than the castration level of the hormone (50 ng/dL).

In the process of hormone therapy of advanced prostate cancer, the following criteria for the appointment and withdrawal of hormonal drugs were used: the dynamics of clinical symptoms of cancer, the level of PSA and testosterone, the severity of complications of hormone therapy from the cardiovascular system and the liver. At the same time, the important advantage of the chosen treatment tactics was noted: improving the quality of life of patients with PCa by reducing the side effects of hormone therapy.

At the first admission of prescribed drugs, agonists LHRH caused a temporary release of the pituitary luteinizing hormone. This was accompanied by an increase in plasma levels of testosterone to concentrations far exceeding the values prior to treatment (flash phenomenon). A similar effect of hormone therapy for PCA was previously noted by researchers for locally advanced PCA [6]. In the case of treatment of advanced prostate cancer, we encountered a significant increase in testosterone

concentrations and conducted a short-term parallel assignment of antiandrogens. On average, after 3–4 weeks, the pituitary LHRH receptors became insensitive, which led to a decrease in serum testosterone concentrations to the castration level of 50 ng/dl. In this regulation, two factors play a key role: (1) constant, and not as in the natural conditions, cyclic, the intake of the LHRH agonist; and (2) hyperstimulation of the receptors with the development of insensitivity due to the stable maintenance of the LHRH agonist concentration in the blood > 100 pg/ml [7].

In (Fig. 2) presents the results of determining the tumor size before and after treatment in patients with advanced PCA. The dynamics of a decrease in tumor volume after hormone therapy shows good results of treatment. One month after the administration of drugs, the tumor volume in patients with prostate cancer decreased by an average of 17.9%. In the next 6 months, the chosen tactics of treating patients allowed.

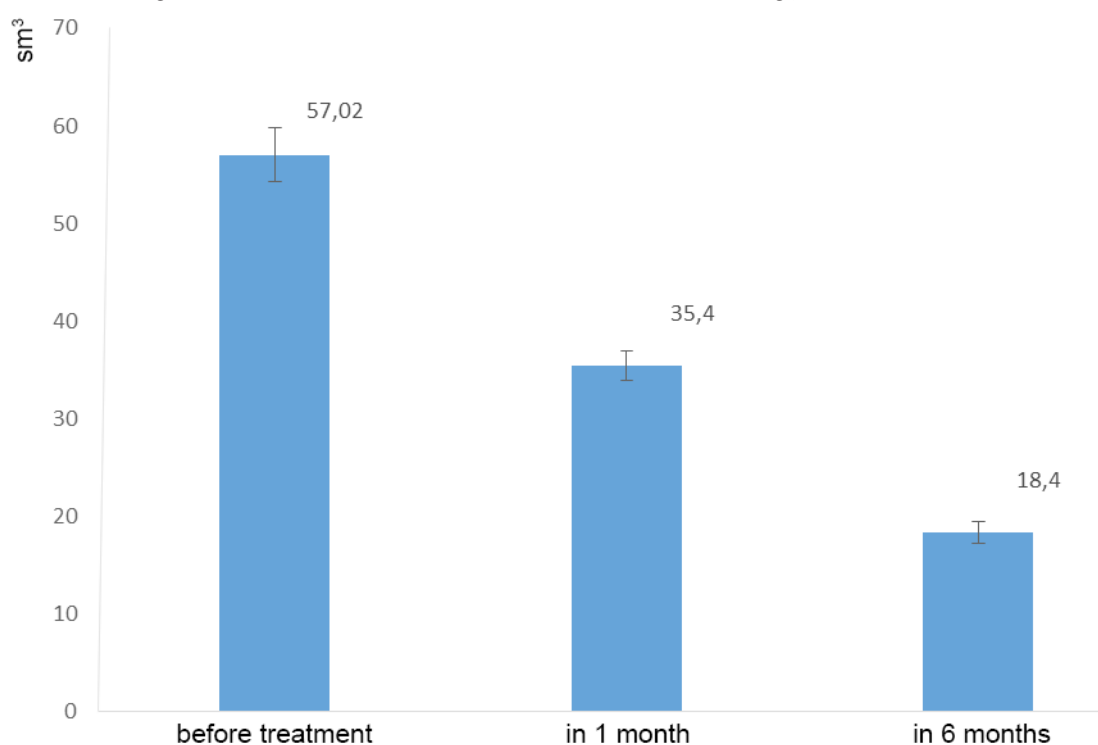


Figure 2. The results of determining the tumor volume (cm<sup>3</sup>) before and after treatment in patients with PCA. inhibit the tumor process — the antitumor effect was 67.7%

We attribute these results to a decrease in the synthesis of growth factors due to inhibition of testosterone production. It is known that testosterone produced by Leydig cells circulates through the systemic circulation

to other organs, including the prostate gland. In prostate cells, testosterone is converted by 5 $\alpha$ -reductase to dihydrotestosterone (DHT). DHT has a higher affinity for the intracellular androgen receptor than testosterone.



After the binding of DHT to the androgen receptor of the cell nucleus, a complex is formed, which eventually leads to protein synthesis of the specific antigen of the prostate (PSA) and growth factors [8].

Thus, the choice of optimal therapy for suppressing the synthesis of testosterone leads to an effective suppression of the production of prostate-specific growth-inducing factors, which demonstrates the results of a decrease in tumor volume in patients with PCA.

**The conclusion.** The resistance of malignant neoplasms of the prostate to hormone therapy remains the main problem in the choice of therapy in patients with advanced PCA. We determined the ways of choosing the optimal regimen of hormone therapy depending on the prognostic factors, which led to better treatment outcomes and quality of life for patients with advanced PCA. Standard primary treatment of a common disease is based on a decrease in the level of circulating androgens and inhibition of their effect on the tumor. In

patients with advanced prostate cancer, LHRH analogs can be used in monotherapy or in combination with antiandrogens. The use of first-line drugs allows assessing the hormone sensitivity of the tumor. Positive clinical and biochemical (reduction in PSA) dynamics after 3 months of treatment with LHRH analogues confirms the hormonal sensitivity of the tumor. The advanced age of patients with PCA ( $75.46 \pm 0.66$  years), the prevalence of the tumor process of stages T2–3, the presence of bone metastases, retroperitoneal and iliac lymph nodes is not a limiting factor in the appointment of the hormone therapy that we have chosen.

In the process of hormone therapy of advanced prostate cancer, the authors defined the following criteria for the appointment and withdrawal of hormonal drugs: the dynamics of clinical symptoms of cancer, the level of PSA and testosterone, the severity of complications of hormone therapy from the cardiovascular system and liver.

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## Section 5. Mechanics

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### **DEFINITION OF KINEMATIC AND DYNAMIC PARAMETERS OF HYDRO-HINGED SYSTEM OF A TRACTOR OF HIGH LOAD-CARRYING CAPACITY**

**Abstract:** In article the kinematics of mounted hydraulic system of energetically saturated tractor with use of a method of the closed vectors is considered. The system consists from flat lever seven links the mechanism with rotating kinematic steams of links and copes the power hydro cylinder informed with a hydro drive of a tractor and the mathematical model of dynamic calculation of tractor mounted hydraulic system of the high load-lifting capacity is offered. The received results qualitatively close describe real process of work of mounted hydraulic system.

**Keywords:** universal plough tractors, hydro-hinged system, hydraulic cylinders, kinematic, dynamic, method.

Modern universal plough tractors are equipped with diesel engines of increased power. In this regard, the hydro-hinged system (HHS) of power tractors should have a high load-carrying capacity. This condition is provided by the use of a lever seven-link mechanism with rotating kinematic pairs of links, which is controlled by a power cylinder coupled to the hydraulic drive of a tractor.

The HHS is controlled by a separate-aggregate hydraulic drive of a tractor. The HHS of modern energy universal plough tractors should provide a load-carrying capacity of 3.0, 3.5 tons, (30 kN, 35 kN) or more. The effective work of the HHS of a tractor essentially depends on the correct calculation of lifting force, the definition of necessary and sufficient number

and types of hydraulic cylinders to be installed, as well as the substantiation of their main parameters. For this purpose it is necessary to carry out dynamic calculation of the HHS. In this paper, the dynamic calculation of the HHS is considered.

Consider the kinematics of the HHS (Fig. 1) and determine the displacement, velocity and acceleration of the angles of its links.

When pressure acts on the piston of hydraulic cylinder, the rod, i. e. the link  $l_2$ , becomes longer or shorter, as a result, the link 13 rotates by an angle  $\varphi_3$ . Using the well-known technique [1; 2], we write the closure condition of the vectors for  $\triangle ABS$  (Fig. 1):

$$\vec{l}_1 + \vec{l}_2 = \vec{l}_3.$$

The projection on the XOY coordinate axis gives:

$$\begin{cases} l_1 \cos \phi_1 + l_2 \cos \phi_2 = l_3 \cos \phi_3 \\ l_1 \sin \phi_1 + l_2 \sin \phi_2 = l_3 \sin \phi_3 \end{cases} \quad (1)$$

Excluding from (1),  $\varphi_3$  and  $\varphi_2$ , respectively, we obtain:

$$l_1^2 + l_2^2 + 2l_1 l_2 \cos(\phi_1 - \phi_2) = l_3^2,$$

$$\phi_2 = \phi_1 - \arccos\left(\frac{l_3^2 - l_1^2 - l_2^2}{2l_1 \cdot l_2}\right)$$

$$l_3^2 + l_1^2 - 2l_1 l_3 \cos(\phi_3 - \phi_1) = l_2^2,$$

$$\phi_3 = \phi_1 + \arccos\left(\frac{l_3^2 + l_1^2 - l_2^2}{2l_1 \cdot l_3}\right)$$

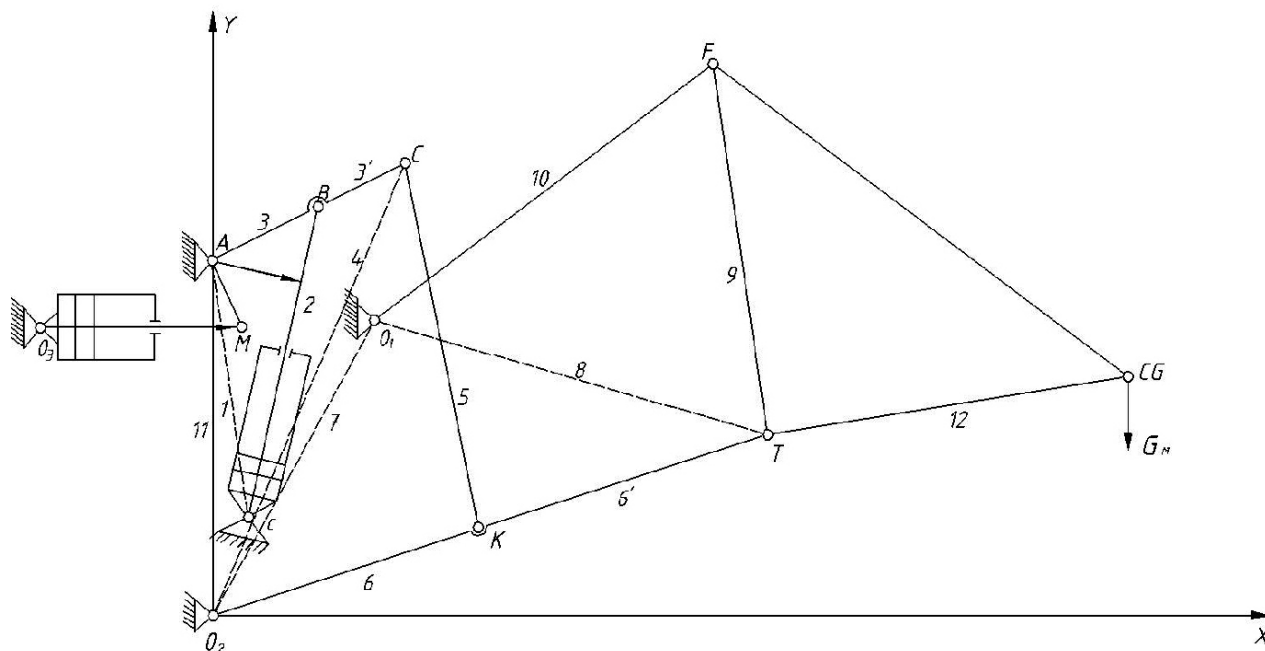


Figure 1. Kinematic scheme of the HHS. 2, 3, 5, 6, 9, 10, 12 – are the links of the lever mechanism; 1, 4, 7, 8 – artificially introduced links of the lever mechanism

$G_M$  – load weight.

To define the angular velocity the derivative from (1) is taken.

$$\begin{cases} -l_1 \sin \phi_1 \omega_1 - l_2 \sin \phi_2 \omega_2 + \dot{l}_2 \cos \phi_2 = -l_3 \sin \phi_3 \omega_3 \\ l_1 \cos \phi_1 \omega_1 + l_2 \cos \phi_2 \omega_2 + \dot{l}_2 \sin \phi_2 = l_3 \cos \phi_3 \omega_3 \end{cases} \quad (2)$$

As  $\phi_1 = \text{const}$ ,  $\omega_1 = 0$ .

Excluding from (2),  $\omega_2$  and  $\omega_3$  respectively, we obtain:

$$\omega_2 = \frac{\dot{l}_2}{l_2} \text{ctg}(\phi_2 - \phi_3), \quad \omega_3 = \frac{\dot{l}_2}{l_3 \sin(\phi_2 - \phi_3)}.$$

To define the angular acceleration, the derivative from (2) is taken.

$$\begin{cases} -l_2 \cos \phi_2 \omega_2^2 - l_2 \sin \phi_2 \varepsilon_2 + \ddot{l}_2 \cos \phi_2 - 2\dot{l}_2 \sin \phi_2 \omega_2 + l_3 \cos \phi_3 \omega_3^2 + l_3 \sin \phi_3 \varepsilon_3 = 0 \\ -l_2 \sin \phi_2 \omega_2^2 + l_2 \cos \phi_2 \varepsilon_2 + \ddot{l}_2 \sin \phi_2 + 2\dot{l}_2 \cos \phi_2 \omega_2 + l_3 \sin \phi_3 \omega_3^2 - l_3 \cos \phi_3 \varepsilon_3 = 0 \end{cases} \quad (3)$$

Excluding from (3),  $\varepsilon_2$  and  $\varepsilon_3$  respectively, we obtain:

$$\varepsilon_2 = \left( \frac{\ddot{l}_2}{l_2} - \omega_2^2 \right) \operatorname{ctg}(\phi_2 - \phi_3) - \frac{2\dot{l}_2}{l_2} \omega_2 + \frac{l_3 \omega_3^2}{l_2 \sin(\phi_2 - \phi_3)}, \quad \varepsilon_3 = \frac{l_2 \omega_2^2}{l_3 \sin(\phi_3 - \phi_2)} - \frac{\ddot{l}_2}{l_3 \sin(\phi_3 - \phi_2)} - \omega_3^2 \operatorname{ctg}(\phi_3 - \phi_2).$$

Introduce an artificial link  $O_2 C$ , its length denoted as  $l_4$ . Its value can be found by calculating the coordinates of points  $O_2$  and  $C$ .

Define the coordinates of the point  $C$ :

$$\left. \begin{aligned} X_c &= l_{21} \cos \phi_2 \\ Y_c &= l_{11} + l_{21} \sin \phi_2 \end{aligned} \right\},$$

where  $l_{31} = l_3 + l_3'$ ,  $l_{11}$  – is the length of the segment  $O_2 A$ .

As  $O_2 (0, 0)$ , define:  $l_4 = \sqrt{X_c^2 + Y_c^2} = \sqrt{l_{31}^2 \cos^2 \phi_3 + (l_{11} + l_{31} \sin \phi_3)^2}$ . For  $\Delta O_2 AC$  write:  $\vec{l}_{11} + \vec{l}_{31} = \vec{l}_4$ .

Projecting this equation on the  $XOY$  coordinate axes, we obtain

$$\begin{cases} l_{11} \cos \phi_{11} + l_{31} \cos \phi_3 = l_4 \cos \phi_4 \\ l_{11} \sin \phi_{11} + l_{31} \sin \phi_3 = l_4 \sin \phi_4 \end{cases} \quad (4)$$

Taking into account that  $\phi_{11} = 270^\circ$ , from the first equation we define:

$$\phi_4 = \arccos \left( \frac{l_{31} \cos \phi_3}{l_4} \right).$$

To define  $\omega_4$ ,  $\varepsilon_4$ ,  $\dot{l}_4$  and  $\ddot{l}_4$ , we take the derivative from (4) and with  $\omega_{11} = 0$ , we obtain

$$\begin{cases} -l_{31} \sin \phi_3 \omega_3 = -l_4 \sin \phi_4 \omega_4 + \dot{l}_4 \cos \phi_4 \\ l_{31} \cos \phi_3 \omega_3 = l_4 \cos \phi_4 \omega_4 + \dot{l}_4 \sin \phi_4 \end{cases} \quad (5)$$

Excluding from (5)  $\dot{l}_4$  and  $\omega_4$ , respectively, we obtain:

$$\omega_4 = \frac{l_{31} \omega_3}{l_4} \cos(\phi_3 - \phi_4), \quad \dot{l}_4 = l_{31} \omega_3 \cos(\phi_3 - \phi_4).$$

Next, we take the derivative from (5)

$$\begin{cases} -l_{31} \cos \phi_3 \omega_3^2 - l_{31} \sin \phi_3 \varepsilon_3 = \ddot{l}_4 \cos \phi_4 - 2\dot{l}_4 \sin \phi_4 \omega_4 - l_4 \cos \phi_4 \omega_4^2 - l_4 \sin \phi_4 \varepsilon_4 \\ -l_{31} \sin \phi_3 \omega_3^2 + l_{31} \cos \phi_3 \varepsilon_3 = \ddot{l}_4 \sin \phi_4 + 2\dot{l}_4 \cos \phi_4 \omega_4 - l_4 \sin \phi_4 \omega_4^2 + l_4 \cos \phi_4 \varepsilon_4 \end{cases} \quad (6)$$

Excluding from (6)  $\ddot{l}_4$  and  $\varepsilon_4$ , respectively, we obtain:

$$\begin{aligned} \varepsilon_4 &= \frac{l_{31}}{l_4} \varepsilon_3 \cos(\phi_3 - \phi_4) - \frac{l_{31}}{l_4} \omega_3^2 \sin(\phi_3 - \phi_4) - \frac{2\dot{l}_4}{l_4} \omega_4, \\ \ddot{l}_4 &= l_4 \omega_4^2 - l_{31} \omega_3^2 \cos(\phi_3 - \phi_4) - l_{31} \varepsilon_3 \sin(\phi_3 - \phi_4). \end{aligned}$$

Consider  $\Delta O_2 CK$ :  $\vec{l}_4 + \vec{l}_5 = \vec{l}_6$ .

Like the above-mentioned sequence, carrying out the corresponding calculations, we obtain

$$\begin{aligned}\phi_5 &= \phi_4 - \arccos\left(\frac{\ell_6^2 - \ell_4^2 - \ell_5^2}{2\ell_4 \cdot \ell_5}\right), \quad \phi_6 = \phi_4 + \arccos\left(\frac{\ell_6^2 + \ell_4^2 - \ell_5^2}{2\ell_6 \cdot \ell_4}\right), \\ \omega_5 &= \frac{-\omega_4 l_4 \sin(\phi_6 - \phi_4) - \dot{l}_4 \cos(\phi_6 - \phi_4)}{l_5 \sin(\phi_6 - \phi_5)}, \quad \omega_6 = \frac{-\omega_4 l_4 \sin(\phi_5 - \phi_4) - \dot{l}_4 \cos(\phi_5 - \phi_4)}{l_6 \sin(\phi_6 - \phi_5)}, \\ \varepsilon_5 &= \frac{(\omega_4^2 l_4 - \ddot{l}_4) \cos(\phi_6 - \phi_4) - (\varepsilon_4 l_4 + 2\dot{l}_4 \omega_4) \sin(\phi_6 - \phi_4) - \omega_5^2 l_5 \cos(\phi_6 - \phi_5) - \omega_6^2 l_6}{l_5 \sin(\phi_6 - \phi_5)}, \\ \varepsilon_6 &= \frac{(\omega_4^2 l_4 - \ddot{l}_4) \cos(\phi_5 - \phi_4) - (\varepsilon_4 l_4 + 2\dot{l}_4 \omega_4) \sin(\phi_5 - \phi_4) - \omega_6^2 l_6 \cos(\phi_6 - \phi_5) + \omega_5^2 l_5}{l_6 \sin(\phi_6 - \phi_5)}.\end{aligned}$$

Introduce the artificial links  $O_2 O_1$  and  $O_1 T$ , and denote them by the numerals 7 and 8, respectively (see Fig. 1). The length of the links is determined by the coordinates of points  $O_2$ ,  $O_1$  and  $T$

The coordinates of the point  $T$  are:

$$\left. \begin{aligned} X_T &= l_{61} \cos \phi_6 \\ Y_T &= l_{61} \sin \phi_6 \end{aligned} \right\}'$$

where  $l_{61} = l_6 + l_6$ .

Since the coordinates of the points are

$O_2(0,0), O_1(X_{01}, Y_{02})$ , the length of a link  $O_2 O_1$  will be:

$$l_7 = \sqrt{X_{01}^2 + Y_{01}^2},$$

and the length of a link  $O_1 T$ :

$$l_8 = \sqrt{(X_T - X_{01})^2 + (Y_T - Y_{01})^2}.$$

From  $\Delta O_2 O_1 T$  we obtain:  $\vec{l}_7 + \vec{l}_8 = \vec{l}_{61}$ .

Projecting this equation on XOY coordinate axes, we obtain

$$\begin{cases} l_7 \cos \phi_7 + l_8 \cos \phi_8 = l_{61} \cos \phi_6 \\ l_7 \sin \phi_7 + l_8 \sin \phi_8 = l_{61} \sin \phi_6 \end{cases} \quad (7)$$

Excluding from (7)  $\phi_6$ , we obtain:  $\phi_8 = \phi_7 - \arccos\left(\frac{\ell_{61}^2 - \ell_7^2 - \ell_8^2}{2\ell_7 \cdot \ell_8}\right)$ .

Define  $\omega_8, \varepsilon_8, \dot{l}_8$  и  $\ddot{l}_8$ , similar to the link  $O_2 C$

$$\omega_8 = \frac{l_{61} \omega_6}{l_8} \cos(\phi_6 - \phi_8), \quad \dot{l}_8 = l_{61} \omega_6 \cos(\phi_6 - \phi_8),$$

$$\varepsilon_8 = \frac{l_{61}}{l_8} \varepsilon_6 \cos(\phi_6 - \phi_8) - \frac{l_{61}}{l_8} \omega_6^2 \sin(\phi_6 - \phi_8) - \frac{2\dot{l}_8}{l_8} \omega_8,$$

$$\ddot{l}_8 = l_8 \omega_8^2 - l_{61} \omega_6^2 \cos(\phi_6 - \phi_8) - l_{61} \varepsilon_6 \sin(\phi_6 - \phi_8).$$

Further, from  $\Delta O_1 FT$  we obtain:  $\vec{l}_8 + \vec{l}_9 = \vec{l}_{10}$ .

Like the above sequence, conducting the appropriate calculations, the following is obtained:



$$\phi_9 = \phi_8 - \arccos\left(\frac{\ell_{10}^2 - \ell_8^2 - \ell_9^2}{2\ell_8 \cdot \ell_9}\right),$$

$$\omega_9 = \frac{-\omega_8 l_8 \sin(\phi_{10} - \phi_8) - \dot{l}_8 \cos(\phi_{10} - \phi_8)}{l_9 \sin(\phi_{10} - \phi_9)}, \quad \omega_{10} = \frac{-\omega_8 l_8 \sin(\phi_9 - \phi_8) - \dot{l}_8 \cos(\phi_9 - \phi_8)}{l_{10} \sin(\phi_{10} - \phi_9)},$$

$$\varepsilon_9 = \frac{(\omega_8^2 l_8 - \ddot{l}_8) \cos(\phi_{10} - \phi_8) - (\varepsilon_8 l_8 + 2\dot{l}_8 \omega_8) \sin(\phi_{10} - \phi_8) - \omega_9^2 l_9 \cos(\phi_{10} - \phi_9) - \omega_{10}^2 l_{10}}{l_9 \sin(\phi_{10} - \phi_9)},$$

$$\varepsilon_{10} = \frac{(\omega_8^2 l_8 - \ddot{l}_8) \cos(\phi_9 - \phi_8) - (\varepsilon_8 l_8 + 2\dot{l}_8 \omega_8) \sin(\phi_9 - \phi_8) - \omega_{10}^2 l_{10} \cos(\phi_{10} - \phi_9) + \omega_9^2 l_9}{l_{10} \sin(\phi_{10} - \phi_9)}.$$

(Fig. 2) shows the results of numerical calculation of the change in angles, angular velocities and angular accelerations of the 2, 3 and 6 links of the HHS. In calculation, the following values of the links are taken:  $l_1 = 0.415$  m,  $l_2 = 0.447$  m,  $l_3 = 0.2$  m,  $l_3' = 0.158$  m,  $l_{31} = 0.358$  m,  $l_5 = 0.599$  m,  $l_6 = 0.49$  m,  $l_6' = 0.5$  m,  $l_{61} = 0.99$  m,  $l_7 = 0.558$  m,  $l_9 = 0.61$  m,  $l_{10} = 0.711$  m,  $l_{11} = 0.574$  m,  $l_{12} = 1.22$  m,  $X_{01} = 0.292$  m,  $Y_{01} = 0.476$  m,  $\varphi_1 = -83^\circ = -1.448$  rad,  $\varphi_7 = 58^\circ = 1.012$  rad.

Thus, the obtained dependences of the change in angles, angular velocities and angular accelerations of the links could be used for dynamic calculation of the HHS.

The HHS of a tractor is controlled by a power cylinder connected with the tractor hydraulic drive. The load force of the HHS is calculated by successively defined forces and moments of the force couple in the link joints under given load located at the conditional point (CG) of the kinematic scheme of the mechanism (Fig. 1).

We will compose the equations of motion by the method of reduced mass and resistance force to a specific link. Let the link of the reduction is a rod of hydraulic cylinder (Fig. 1), i. e. a link  $l_2 = l_2(t)$ . Then the dynamics of the hydraulic cylinder is described by the following system of differential equations [1]

$$\begin{cases} \frac{d(m_{dr} v_2^2 / 2 + j_{dr} \omega_2^2 / 2)}{dt} = P_d - k_v v_2 - P_{fr} \text{sign } v_2 - P_f \\ \frac{d p_1}{dt} = \frac{E_c (Q_1 - v_2 F_1)}{V_{01} + l_2 F_1} \\ \frac{d p_2}{dt} = \frac{E_c (v_2 F_2 - Q_2)}{V_{02} + (l_{max} - l_2) F_2} \end{cases} \quad (8)$$

where

$$m_{dr} = \sum_{i=2}^n m_i (v_i / v_2)^2 + j_i (\omega_i / v_2)^2,$$

$$j_{dr} = \sum_{i=2}^n m_i (v_i / \omega_2)^2 + j_i (\omega_i / \omega_2)^2,$$

$$P_d = p_1 F_1 - p_2 F_2,$$

$$P_f = \sum_{i=2}^n P_i v_i \cos \phi_i / v_2 + M_i \omega_i / v_2$$

$m_{dr}, j_{dr}$  – are the masses and moments of inertia of the moving parts, driven to the rod of hydraulic cylinder;  $l_2, v_2, \omega_2$  – displacement, velocity and angular velocity of hydraulic cylinder;  $k_v$  – coefficient of viscous friction;  $P_{fr}$  – coefficient of dry friction;  $P_d$  – the driving force acting on the piston of hydraulic cylinder;  $P_f$  – resistance forces driven to the rod of hydraulic cylinder;  $p_1, p_2$  – pressure in head and discharge cavities of the hydraulic cylinder;  $F_1, F_2$  – effective areas in head and discharge cavities;  $V_{01}, V_{02}$  – initial volume of fluid in head and discharge cavities;  $m_i$  – the mass of the  $i$ -th link;  $j_i$  – the moment of inertia of the  $i$ -th link about the axis passing through the center of mass;  $v_i$  – velocity of the center of gravity of the  $i$ -th link;  $\omega_i$  – angular velocity of the  $i$ -th link;  $P_i, M_i$  – the values of the active forces and moments acting on the links;  $\phi_i$  – the angle between the directions of forces  $P_i$  and the velocity  $v_i$ ;  $l_i$  – length of the  $i$ -th link.

The coordinates of the center of mass of the considered device can be determined by formula

$$\left. \begin{aligned} x_c &= \sum G_i x_i / \sum G_i \\ y_c &= \sum G_i y_i / \sum G_i \\ i &= 2 \dots 12 \end{aligned} \right\} \quad (9)$$

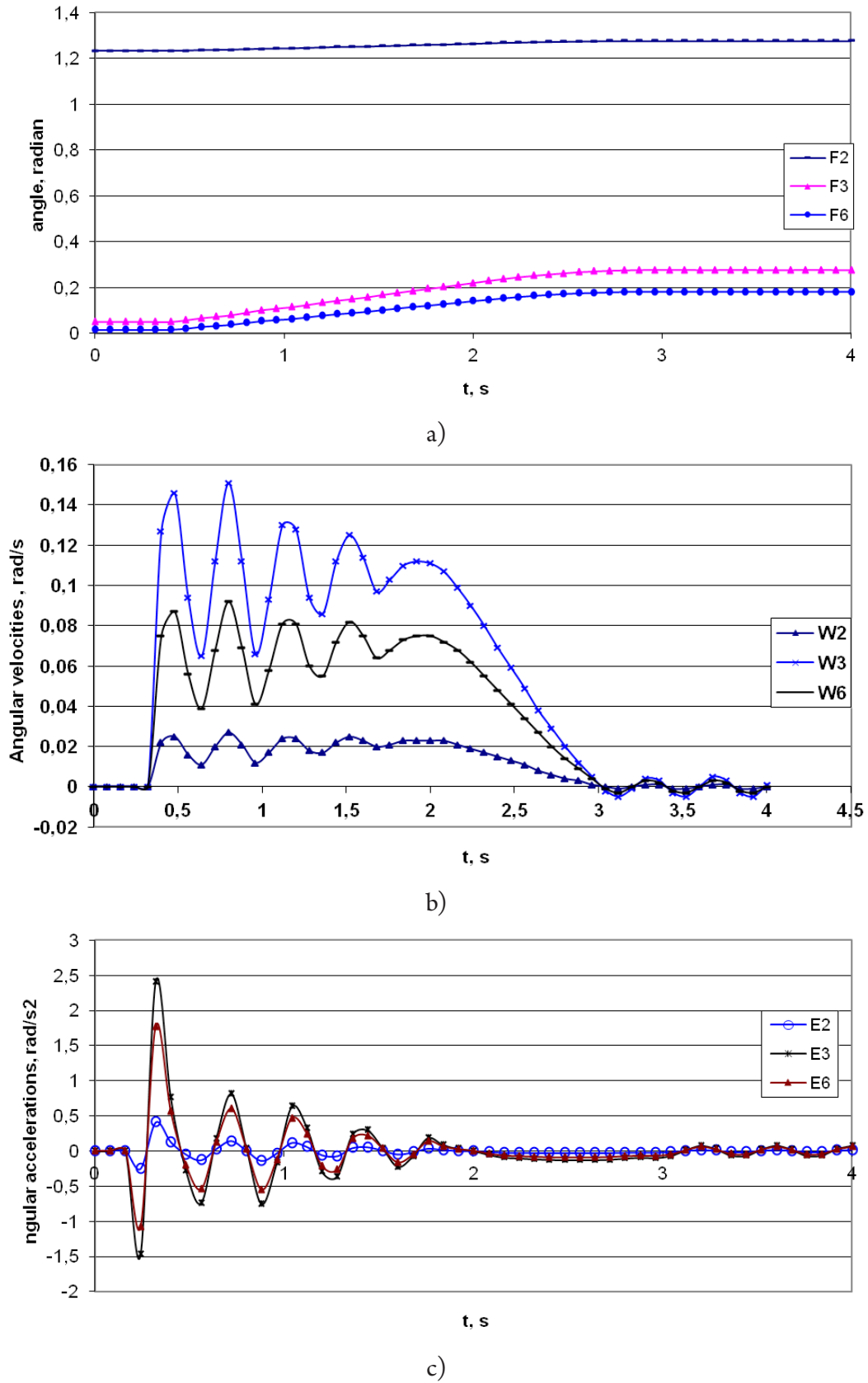


Figure 2. The dependence of the change in angles; a) angular velocities b) angular accelerations; c) of the 2, 3 and 6 links of the HHS

The velocity and moment of inertia of the links are determined by the formulas

$$v_i = l_i \omega_i / 2, \quad (10)$$

$$j_i = m_i \left[ (x_c - x_{ic})^2 + (y_c - y_{ic})^2 \right], \quad i = 2 \dots 12 \quad (11)$$

where  $x_{ic}, y_{ic}$  – are the coordinates of the center of gravity of the  $i$ -th link.

To study the flow of fluid in a pipeline, a model is chosen where the fluid is assumed to be compressible and concentrated in one or two bulks of small length (a system with lumped parameters, taking into account the compliance of hydraulic system elements). In this model, there is a possibility to take into account the compressibility of undissolved air bubbles [3].

$$\rho l \frac{d^2 x}{dt^2} + 27,5 \frac{\ell \mu}{f} \frac{dx}{dt} + (0,443 \frac{k_\varepsilon \mu}{\sqrt{f}} + 0,5 \zeta \rho) \left( \frac{dx}{dt} \right)^2 \text{sign} \frac{dx}{dt} + p_{\text{out}} = p_{\text{in}} \quad (12)$$

$$\frac{dp}{dt} = \left( \frac{E_f \delta_{pip} E_{pip}}{E_{pip} \delta_{pip} + d_{pip} E_f} \right) \frac{(Q_{\text{in}} - Q_{\text{out}})}{V_f} \quad (13)$$

where  $\text{sign} \frac{dx}{dt} = \begin{cases} 1 & v > 0 \\ -1 & v < 0 \end{cases}$ ,  $p_{\text{in}}, Q_{\text{in}}$  – are the

pressure and flow rate in the inlet of a pipeline;  $p_{\text{out}}, Q_{\text{out}}$  – pressure and flow rate in the outlet of a pipeline;  $t$  – time;  $\rho$  and  $E_f$  – the density and the bulk modulus of the fluid;  $d_{pip}, E_{pip}, E_{pip}$  – the diameter, wall thickness and the bulk modulus of pipeline material, respectively;  $k_\varepsilon$  – the coefficient of the approximation, its value depending on the relative roughness  $\varepsilon$  of hydraulic lines;  $\zeta$  – the local resistance coefficient;  $f$  and  $l$  – the area and length of the pipeline;  $V_f$  – the volume of fluid in a pipeline;  $\mu$  – the dynamic viscosity of the fluid.

The flow rate through the distributor is determined by the dependence [3]:

$$Q_p = \eta_p f_p(y) \sqrt{2 |p_p - p_{\text{in}}| / \rho} \quad (14)$$

where  $p_p$  – is the pressure created by the pump,  $f_p(y)$  – the area of flow section,  $\eta_p$  – flow rate coefficient.

The flow section of the distributor can be approximated by the following characteristic:

$$f_p(y) = \begin{cases} 0, & \text{in } t < \tau \\ \pi d_y^2 (t - \tau) / (4(t_k - t)), & \text{in } \tau \leq t \leq t_k, \\ \pi d_y^2 / 4, & \text{in } t > t_k \end{cases}$$

where  $d_y$  – is a conditional passage,  $\tau$  – the lag time,  $t_k$  – time of full opening of the passage.

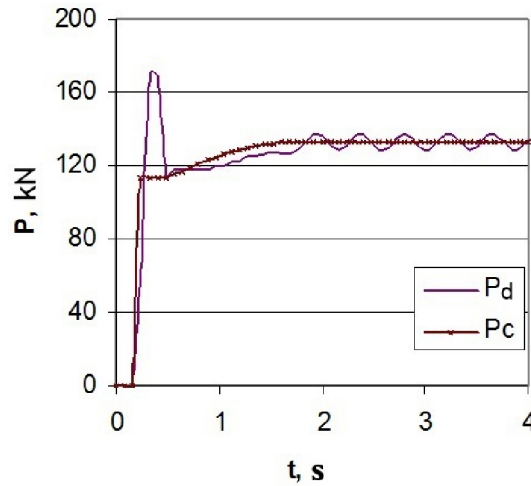


Figure 3. Dependences of the change in driving force (Pd) and resistance force (Pc) on the hydraulic cylinder rod versus time

The system of equations (8) – (14), with initial and boundary conditions, is a mathematical model of dynamic calculation of the HHS of a tractor with increased loading capacity. To solve the mathematical model, a computer program was developed in DELPHI algorithmic language.

Figure 3 shows the results of numerical calculation of the change in driving force and resistance force on the rod of the hydraulic cylinder (3<sup>rd</sup> – link, Fig. 1). In calculation, the following values of links and the initial data are taken:  $l_1 = 0.415$  m,  $l_2 = 0.447$  m,  $l_3 = 0.2$  m,

$l'_3 = 0.158 \text{ m}$ ,  $l_{31} = 0.358 \text{ m}$ ,  $l_5 = 0.599 \text{ m}$ ,  $l_6 = 0.49 \text{ m}$ ,  
 $l'_6 = 0.5 \text{ m}$ ,  $l_{61} = 0.99 \text{ m}$ ,  $l_7 = 0.558 \text{ m}$ ,  $l_9 = 0.61 \text{ m}$ ,  
 $l_{10} = 0.711 \text{ m}$ ,  $l_{11} = 0.574 \text{ m}$ ,  $l_{12} = 1.22 \text{ m}$ ,  $m_2 = 14.2 \text{ kg}$ ,  
 $m_3 = 6.98 \text{ kg}$ ,  $m_5 = 6.84 \text{ kg}$ ,  $m_6 = 19.1 \text{ kg}$ ,  $m_9 = 1.52 \text{ kg}$ ,  
 $m_{10} = 2.14 \text{ kg}$ ,  $m_{12} = 3028.9 \text{ kg}$ ,  $P_2 = 142 \text{ N}$ ,  $P_3 = 69.8 \text{ N}$ ,  
 $P_5 = 68.4 \text{ N}$ ,  $P_6 = 191 \text{ N}$ ,  $P_9 = 15.2 \text{ N}$ ,  $P_{10} = 21.4 \text{ N}$ ,  
 $P_{12} = 30289 \text{ N}$ ,  $t = 0$ ,  $\tau = 0.2$ ,  $t_k = 2$ ,  $p_p = 12 \text{ MPa}$ ,  $p_{in} = Q_{in} =$   
 $= p_{out} = Q_{out} = l_2 = v_2 = \omega_2 = p_1 = p_2 = 0$ .

Analysis of the graphs shows that when the distributor is switched on with account of delay at  $t = 0.2$

... 0.65 seconds, the driving force sharply increases to about 170 kN, then it decreases to the value which is the resistance force. Further to the value of complete opening of the distributor at  $t = 0.65 \dots 2$  seconds, the value of the driving force increases monotonically according to the resistance force. When the value of complete opening of the distributor is reached, the driving force begins to oscillate and eventually decays.

Results of numerical calculation obtained qualitatively closely describe the actual process of the HHS operation.

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## Section 6. Agricultural sciences

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### **WAYS OF MINIMIZING IRRIGATION WATER LOSSES IN THE ARID AREAS OF SYRDARYA AND JIZZAK REGIONS OF UZBEKISTAN**

**Abstract:** The article summarizes the results of experiments on water conservation methods and improving efficiency of water use at the level of irrigation systems and farms. This research aimed to solve the problem of improving the efficiency of water use for crop irrigation in Uzbekistan. Existing water conservation methods currently used in irrigated agriculture were analyzed during the course of the research. It has been established that at present there is an acute need for the development of low-cost but effective soil and water conservation methods that include introduction of water saving methods into agricultural practices, improving application efficiency of irrigation systems and use of drip irrigation.

**Keywords:** water resources, efficiency, irrigation method, application efficiency, irrigation method, irrigation method, water shortage, Syrdarya River basin.

#### **Introduction**

Countries located in arid areas tend to have constant shortage of water for irrigation. This deficit particularly aggravates under conditions of global warming. Thus, in the plains of the Republic of Uzbekistan, relative humidity level in the summer months reaches 14–16 per cent. The moisture deficit, which reflects the difference between the measured evapotranspiration and effective precipitation, for the growing season varies between 844.2 and 996 mm. Taking into account its insignificant amount, the contribution of precipitation to soil moisture is insufficient. Under these conditions, the development of the national economy, and especially the agricultural sector, is impossible without improving water use efficiency. It is worth to mention that over the last decades demand for water resources has exceeded (especially in low water years) the available supply in the Syrdarya and Amudarya rivers.

In light of this, the only way to reduce the gap between supply and demand for water use is to manage demand for water resources by using water saving technology.

Uzbekistan's agriculture is dominated by surface irrigation, which is prone to certain conveyance losses from the water source to a specific farm.

**Materials and methods.** The data on the Syrdarya River regime is obtained from the observations of the Hydrometeorological Service of Uzbekistan and Syrdarya Basin Water Organization. Retrospective data was obtained from the archive materials of the Ministry of Agriculture and Water Resources, Central Asian Research Institute of Irrigation (SANIIRI) and other organizations. These materials were supplemented by the results of expedition and field studies performed on irrigated fields of Syrdarya region. Analysis and interpretation of data was done through the use of hydrological calculations, water and salt balance, as well as statistical analysis.



### Results and discussion

Irrigation system application efficiency, a performance criterion, plays a key factor in reducing water loss. At the same time, the higher the application efficiency, the higher the water availability of the territory. In recent years, due to aging and obsolescence of the irrigation systems built back in the 1960s, their efficiency has gradually decreased. Thus, the efficiency of inter-farm canals in the Hungry Steppe (Uzbekistan) decreased from 0.73 in 2000 to 0.69 in 2014. Studies show that at this value of the application efficiency, the total water loss in the Hungry

Steppe reaches 30% or 1.0–1.2 billion m<sup>3</sup> per year (for Syrdarya and Jizzakh regions).

Estimation methods are derived from the works of the authors cited below [1; 2; 3] showed that increasing the application efficiency from 0.65 to 0.8 through technological improvement of the entire system (including irrigation efficiency and inter-farm and main canals), allows to reduce water loss by 20%, ensuring a reduction in gross water requirement (for cotton by various hydromodule areas) to the calculated values (Table 1).

Table 1. – Reduction of (gross) irrigation water requirement under improved application efficiency scenarios

| Calculated cotton water requirements,<br>m <sup>3</sup> /ha | Gross water requirement (m <sup>3</sup> /ha) under improved efficiency |        |        |        |
|---|--|--------|--------|--------|
|   | 0.65   | 0.70   | 0.75   | 0.80   |
| 6.000   | 9.230  | 8.570  | 8.000  | 7.500  |
| 7.640   | 11.750   | 10.910 | 10.910 | 9.550  |
| 8.930   | 13.745   | 12.760 | 11.910 | 11.170 |

An equally important factor for increasing the efficiency of water use is widespread introduction of water conservation methods and technologies.

Our estimations show that with application of drip irrigation and optimization of furrow irrigation in Jizzak and Syrdarya regions (Hungry Steppe), water deficit during the growing season can be reduced by about 918 million m<sup>3</sup> (Table 2).

Table 2. – Calculation of possible water use requirement reduction in the Hungry Steppe under new water conserving technologies

| Region                  | Drip irrigation area (1,000 ha) | Furrow irrigation area (1,000 ha) | Volume of saved water, mln.m <sup>3</sup> /year |                         |
|-------------------------|---------------------------------|-----------------------------------|---|-------------------------|
|                         |                                 |                                   | Under drip irrigation                           | Under furrow irrigation |
| Syrdarya                | 10.0                            | 272.2                             | 25.0  | 423.3                   |
| Jizzak                  | 20.4                            | 259.2                             | 51.0  | 419.4                   |
| Total for Hungry Steppe | 30.4                            | 531.4                             | 76.0  | 842.0                   |

**Conclusions.** 1. Unstable water management situation in the Syrdarya river basin complicates the long-term river flow regime, which leads to greater risks of flooding during the vegetation period. This, in turn, makes it difficult to regulate the environmental and reclamation processes and damages crop yields.

2. In such circumstances, there arises the need to develop inexpensive and effective soil and water conservation methods.

3. The proposed measures include the introduction of water conservation methods, improving the efficiency of irrigation systems, use of drip irrigation, etc.

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## Section 7. Technical sciences

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### HYDRAULIC PARAMETERS OF THE VEINSING FLOW IN HYDRO TRANSPORT

**Abstract:** In article offers the New methods of the determination hydraulic parameter and critical velocity alluvium flow.

**Keyword:** Hydra transport. Alluvium flow. Concentration hydraulic friction factor. Hydraulic dimensions critical velocity.

Hydro-transport is characterized by a joint movement of liquid and solid particles, which in the mixture form two or multiphase flows different in physical-mechanical properties. One of the main tasks of hydro-transport is to study the throughput capacity of pipelines, where taking into account the distribution of their concentration along the section of the pipeline formed under the action of gravitational force is of great importance in describing the nature of the two-phase flow.

The pressure-weighted flows in hydro-transport systems are usually characterized by high volumetric concentrations and wide ranges of particle sizes and densities. The weighted flows are more complex in structure than the turbulent flows of homogeneous liquids in the pipes. Therefore, the methods for calculating these flows are much more complicated than the usual methods of hydraulics for pressure flows of homogeneous liquids.

The differential equations of one-dimensional motion of a two-phase mixture in a cylindrical coordinate system can be written in this form [1; 2; 3]:

$$\begin{aligned} f_n \frac{\partial p}{\partial z} &= \frac{\mu_n}{r} \frac{\partial}{\partial r} \left( r f_n \frac{\partial u_n}{\partial r} \right) + \frac{\mu_n}{r^2} \frac{\partial}{\partial \phi} \left( f_n \frac{\partial u_n}{\partial \phi} \right) + K(u_{2n} - u_n) + \rho_n F_n \\ f_n \frac{\partial p}{\partial r} &= 0 \\ f_n \frac{\partial p}{\partial \phi} &= 0 \end{aligned} \quad (1)$$

there  $\frac{\partial \rho}{\partial r}$ ,  $\frac{\partial \rho}{\partial \phi}$  and  $\frac{\partial \rho}{\partial z}$  – pressure drop across the axes;

$u_{nr}$ ,  $u_{n\phi}$  and  $u_{nz}$  – components of the vector velocity of each phase;

$f_n$  – distribution of the concentration of each phase;

$\alpha_n$  – viscosity coefficient of the phases;

$F_{nr}$ ,  $F_{n\phi}$ ,  $F_{nz}$  – projections of mass forces;

$K$  – coefficient force of interaction between phases.

From the last two equations (1) obtained:

$$\frac{d\rho}{dr} = 0, \quad \frac{d\rho}{d\phi} = 0$$

According to this the pressure drop is a function of the  $z$  coordinate and it does not depend on  $r$  and  $\phi$ , ie:

$$\frac{\partial \rho}{\partial z} = \frac{d\rho}{dz}.$$

To differential equations of motion (1) we add the relation concentrations of phases

$$f_1 + f_2 = 1 \quad (2)$$

boundary adherence conditions for  $r = R$ :

$$\begin{aligned} u_1 &= 0, \\ u_2 &= 0, \end{aligned} \quad (3)$$

and the symmetry condition along the vertical axis ( $y$ ), i. e. at  $\varphi = 90^\circ$  and

$$\varphi = 270^\circ \quad \frac{\partial u_1}{\partial \varphi} = 0, \quad \frac{\partial u_2}{\partial \varphi} = 0 \quad (4)$$

The distribution of concentration is expressed as [2; 5]:

$$f_2 = f_{20} \exp \left[ \left[ -\frac{3(\rho_r - \rho)g}{\rho_r u_i^2} - \frac{3}{2} \rho C_0 \frac{S_r W_r^2}{m_r u_i^2} \right] (R + r \sin \varphi) \right] \quad (5)$$

It is seen from the differential equation of motion (1) that the velocity of phase of the mixture depends on distribution of concentration  $f_2$  and interaction coefficient  $K$ . At the same time these parameters depend on distribution of velocities of the mixture.

With using well-known methods of hydromechanics [1; 4; 5], with adding the equation (1) term by term for each phase, we obtain the equation of motion of the slurry, with those for concentration of the second phase being taken  $f_2 = s$ .

With integrating all the parts of equation with cross-sectional area of the flow, for the steady-state flow in a one-dimensional formulation from Eq. (1), we have the following [1; 2; 4]:

$$\frac{dP}{dz} = \rho g i - \frac{\lambda_{cr} \rho Q^2}{2d\omega^2} - \frac{s\pi d}{\omega} \tau_0 \quad (6)$$

With generalizing equation of motion for the density and velocity of the slurry (dispersoid), the following value was adopted:

$$\rho = (1-s)\rho_1 + s\rho_2 \quad (7)$$

$$g = \frac{(1-s)\rho_1 g_1 + s\rho_2 g_2}{(1-s)\rho_1 + s\rho_2} \quad (8)$$

there:  $s$  – volume concentration of solid components;  $\rho_1$  u  $\rho_2$  – density of liquid and solid particles;  $Q$  – consumption slurry;  $\omega$  – area of cross-sectional pipeline;  $g_1$  and  $g_2$  – averaged velocities of the liquid and the solid particle over the cross section of the pipeline;  $i$  – slope of the stream;  $P$  – hydrodynamic pressure;  $\chi$  – perimeter of the pipeline;  $\tau_0$  – initial resistance of the mixture;  $\lambda_{cr}$  – coefficient of hydraulic friction.

Calculating equation (6) with taking account of boundary conditions (for  $z=0, P=P_1$  and for  $z=L, P=P_2$ ) one can obtain:

$$\frac{\lambda_{cr} \rho}{2d\omega^2} Q^2 = \frac{P_2 - P_1}{L} + \rho g i - \frac{s\pi d}{\omega} \tau_0 \quad (9)$$

Flow rate is determined by the expression:

$$Q = \sqrt{\frac{2d\omega^2}{\lambda_{cr} \rho} \left( \frac{P_1 - P_2}{L} + \rho g i - \frac{s\pi d}{\omega} \tau_0 \right)} \quad (10)$$

There  $P_1 - P_2 = \Delta P$  – pressure drop which created by the pumping system.

For  $i = 0$ :

$$Q = \sqrt{\frac{2d\omega^2}{\lambda_{cr} \rho} \left( \frac{\Delta P}{L} - \frac{s\pi d}{\omega} \tau_0 \right)} \quad (11)$$

The condition, which the mixture begins to move can write as:

$$\frac{P_1 - P_2}{L} > \frac{s}{R} \tau_0 \quad (12)$$

Consequently, it is necessary to create a difference of pressure  $\Delta P$ , which would exceed the value  $\frac{s}{R} \tau_0$ .

With a suspended flow in pipelines with a negative slope  $i < 0$ , we have:

$$Q = \sqrt{\frac{2d\omega^2}{\lambda_{cr} \rho} \left( \frac{P_1 - P_2}{L} - \rho g i - \frac{s\pi d}{\omega} \tau_0 \right)} \quad (13)$$

Thus the condition, which the mixture begins to move one can write as:

$$\frac{P_1 - P_2}{L} > \rho g i + \frac{s}{R} \tau_0 \quad (14)$$

The maintance of the approach is that, here the influence of the slope of the pipeline is taken into account additionally to the main factors which characterizing the movement of the suspended flow:

$$\Delta P > \rho g i + \frac{s}{R} \tau_0. \quad (15)$$

The regularity of distribution of the concentration of solid particles along the vertical diameter of a cylindrical tube depends on average speed of flow.

With a gradual decreasing of this speed approaching the critical, the weighting capacity of a stream containing a predetermined amount of solid material decreases continuously, which leads to complete siltation of the pipelines, saturation of the lower layers of the stream with solid particles, and reaches an almost maximum value [1; 2].

In average speed of mudflow which less than  $v_{kp}$ , the weighing capacity of the stream decreases accordingly, and the solid particles in the stream are gradually precipitate.

Thus, the critical regime of hydro-transportation – boundary regime of the movement of slurry

through pipes. In this regime must be satisfied, the maximum dynamic equilibrium between the mixture as a whole and the continuous flow of solid particles.

Consider the condition that determines the limiting dynamic equilibrium between the moving layer of solid particles and the flow as a whole on the basis of the following considerations: Let and be the average tangential stress on the bottom wall of the pipe and the voltage of the average frictional force of sliding of the solid material. With an increase in the average flow velocity above critical, an increasing number of solids are entrained in the flow and in these regimes always  $\tau_1 > \tau_A$ . This corresponds to clearly stable modes of hydrotransportation.

Thus, the only condition that defines the limit regime is as follows:

$$\tau_0 = \tau_A \quad (16)$$

It expresses the ultimate dynamic equilibrium between the weighted flow as a whole and the continuous flow of solid particles moving in the pipeline.

Denoting through  $g_2$  the average velocity of the motion of the slurry, for  $\tau_0$  we have:

$$\tau_0 = \rho_0 \frac{\lambda_A g_2^2}{8}; \quad (17)$$

At certain speeds, it is possible to fully weigh solid particles of a certain size, which we call the optimum diameter. In the works [1; 2]. The following dependence was proposed for determining the optimum diameter as a function of the flow velocity:

$$d_0 = \sqrt{\frac{18 \cdot v \frac{1}{\rho_0 g} \frac{dP}{dz}}{g(\rho_2 - \rho_0)}} \quad (18)$$

From the analysis of works it is known, that existing average speed in the flow which particles of a given hydraulic size begin to be transported with the speed of carrier fluid.

Thus,  $\left(\frac{dp}{dz}\right)_{:@}$  the partial gradient of pressure must be

determined from the condition of a stable regime of movement of the slurry in the pipeline.

Then, according to (4),  $\left(\frac{dp}{dz}\right)_{:@}$  equation will define as follows:

$$\left(\frac{dp}{dz}\right)_{:@} = \left(\frac{w}{g_2}\right) g \quad (19)$$

there,

$$w = K \frac{d^2 \cdot g(\rho_2 - \rho_1)}{\rho_1} \quad (20)$$

$w$  – hydraulic size of suspended particles.

$K$ - coefficient which depends to the regime of motion of a solid particle in the liquid flow and it determined by the formulas [2; 4].

Thus, with bringing (5) and (3) to (7) for the determination of the critical speed, we obtain:

$$g_{kp} = \sqrt[3]{\frac{2gDw}{\rho_0 \cdot \lambda_0}}; \quad (21)$$

Thus, a new relationship is proposed for determining the critical speed of the slurry in the suction pipe. Differing from the equation (7) there are taken into account a number of factors which characterizing hydro-transport of river sediments. Analysis of this formula is significant and it can be recommended for practical use on the basis of specially set experiments.

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## RATIONAL WAY OF DISPOSAL OF CHRYSOTILCEMENT WASTE IN THE MANUFACTURE OF THE PORTLANDCEMENT

**Abstract:** An efficient method of utilizing wet chrysotile cement wastes for Portland cement production has been developed and proposed for industrial application. The expediency of their thermal activation by supplying hot clinker to the layer leaving the rotary kiln of clinker production with a temperature of 1000–1100 °C, followed by milling of the cooled clinker with additive – additive in the presence of gypsum stone. Portland cement from such clinker is used for the production of chrysotile cement products.

**Keywords:** chrysotile cement waste, secondary raw materials, utilization, thermal activation, additive to clinker, additional cement for chrysotile cement products, physical and mechanical properties, pilot-industrial tests.

**Formulation of the problem.** The intensive accumulation of a large amount of chrysotile cement waste during the filtration of the chrysotile cement mass on the sheet-forming machine leads to environmental contamination. Neutralization and disposal of these wastes are associated with great labor and financial costs, which negatively affects the cost of the main products. Taking into account the above, the solution of the problem of developing the technology of utilization of CCW by obtaining on their basis building materials and products of a wide range of purposes is topical.

The composition of “wet” chrysotile cement wastes is mainly represented by hydrated minerals of Portland cement clinker and fine chrysotile fibers that, when properly processed, exhibit astringent properties and can be a high-quality raw material for the manufacture of building materials and products, since they have high potential hydraulic activity [2]. An effective way to open it is a correctly selected heat treatment of solid waste. In this case, hydrate neoplasms and tiny particles of chrysotile will be

subjected to destructuring, and anhydrous products with hydraulic activity accumulate in the chrysotile-cement mixture [2–4]. Therefore, it becomes urgent to develop rational methods for processing chrysotile cement waste and their use in the production of building materials and products. With this in mind, the present work is devoted to the development of a method for utilization of chrysotile cement waste in relation to the production conditions of JSC “Kizilkumcement” taking into account the technical and technological capabilities of the enterprise.

**Materials research methods, equipment and instruments.** In the work, clinker, two-water gypsum and wet chrysotile cement waste (CCW) of JSC “Kizilkumcement” were used as raw materials. They were submitted by two samples with an average moisture content of 80 and 35%, respectively. From dried to constant mass components (clinker and chrysotile cement waste at a temperature of 105–110 °C, gypsum – at 40 °C, medium samples were taken by quartering, which after grinding until complete passage through a No. 008 sieve according to



GOST (State Standard) 6613 was subjected to chemical analysis in compliance with the requirements of GOST

5382–91 “Cements and materials of cement production, methods of chemical analysis” (Table 1).

Table 1. – Chemical composition of raw materials

| Material                | loss on ignition | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaO   | MgO  | Na <sub>2</sub> O | K <sub>2</sub> O | SO <sub>3</sub> |
|-------------------------|------------------|------------------|--------------------------------|--------------------------------|-------|------|-------------------|------------------|-----------------|
| Clinker*                | 0.75             | 20.54            | 5.19                           | 3.56                           | 62.04 | 3.60 | 0.97              | 1.07             | 2.62            |
| Gypsum                  | 2.2              | 1.52             | 0.13                           | 0.14                           | 33.04 | 0.20 | 0.10              | 0.10             | 43.5            |
| Chrysotile cement waste |                  |                  |                                |                                |       |      |                   |                  |                 |
| Sample 1                | 1.90             | 23.41            | 5.90                           | 4.93                           | 55.71 | 7.12 | –                 | –                | 1.32            |
| Sample 2                | 1.77             | 24.41            | 6.03                           | 5.21                           | 54.27 | 6.80 | –                 | –                | 1.38            |

\* Calculated mineralogical composition of clinker, %:  $C_3S = 56.52$ ;  $C_2S = 17.12$ ;  $C_3A = 7.74$ ;  $C_4AF = 10.82$ .

The essence of the method of activation of chrysotile cement wastes was their heat treatment by contact method according to which a dosage portion of waste with natural moisture is supplied to a layer of hot Portland cement clinker leaving the furnace and going to the refrigerator for cooling. In laboratory conditions, this scheme was simulated in this way: the bowl with clinker was placed in an electric muffle furnace in which, at a temperature of 1000 °C, it was kept for 30 minutes, after which the bowl with a hot clinker was extracted from the furnace, and the clinker was poured into a metal container into which the dosed 3, 5, 10% of the chrysotile cement waste, and the waste was thoroughly mixed with the hot clinker. After cooling under natural conditions, the charge “Portland cement clinker + chrysotile cement waste” was milled in the presence of 5% double-water gypsum. The fineness of grinding the obtained cements was characterized by the remainder on the screen No. 008 (12–14)%. Cement with additive (3, 5, 10)% of thermally activated (TCCW) chrysotile cement wastes were tested for compliance with the requirements of GOST (State Standard) 10178–85 “Portland cement and slag Portland cement. Technical specifications” and O’z DSt (State Standard of the Republic of Uzbekistan) 913–98 “Portland cement for the production of asbestos-cement

products. Technical conditions”, according to the methods of GOST 310.1–310.4 “Cements. Methods of testing”.

**Results and its discussion.** It was established that the experimental Portland cement with an addition of 3, 5, 10% heat-treated chrysotile cement waste after 60 min. The grinds had a residue on a No. 008 screen of 10, 9, 13%, respectively. Experimental cements at 28 days of age of normal hardening have compressive strength in the range of 34.6–43.2 MPa. For the comparative analysis of the test results, the tensile strength of the additive cement was determined, which at the age of 28 amounted to 41.2 MPa at compression, which was assumed to be 100%. Experimental cements with the addition of 3, 5% of chrysotile cement waste, according to the requirements of GOST 10178–85, are marked 400. An increase in the content of the additive to 10% leads to a sharp decrease to 15% of the strength of cement (Table 2). It is noted that cements with thermally activated additives have an increased water demand (0.45–0.46). Therefore, the scope of such cements may be somewhat limited, that is, these cements can be recommended for the production of chrysotile cement products, the molding of which involves the preparation of a chrysotile-cement slurry with a large amount of water (60–92)%.

Table 2. – Physical and mechanical properties of Portland cement and their compliance with the requirements of GOST 10178 “Portland cement and slag Portland cement. Specifications”

| Cements | Composition of cement, % |        |                                  | Fineness of cement grinding on the remainder on a sieve No. 008, % | Strength limit at 28 d, MPa, at: |             |
|---------|--------------------------|--------|----------------------------------|--|----------------------------------|-------------|
|         | Clinker                  | Gypsum | Thermally activated cement waste |  | bending                          | compression |
| PC D0   | 95                       | 5      | –                                | 15   | 6.28                             | 41.2        |
| TPC D3  | 90                       | 5      | 3                                | 10   | 5.99                             | 41.6        |
| TPC D5  | 85                       | 5      | 5                                | 9  | 6.05                             | 43.2        |
| TPC D10 | 80                       | 5      | 10                               | 13   | 5.82                             | 35.0        |

According to the requirements of O'z DSt 913–98, the strength indices of cement during bending and compression of 3- and 7-day normal hardening should have

a value not less than, MPa: for bending –  $R_3 = 3.2$  MPa;  $R_7 = 4.2$  MPa; for compression –  $R_3 = 20.0$  MPa;  $R_7 = 27.0$  MPa.

Table 3. – Physico-mechanical properties of experienced Portland cement and their compliance with O'z DSt 913 requirements

| Cements       | Composition of cement, % |          |                                  | Setting time, h – min |             | Strength limit, MPa, aged, d |             |             |             |
|---------------|--------------------------|----------|----------------------------------|-----------------------|-------------|------------------------------|-------------|-------------|-------------|
|               | Clinker                  | Gyp-sum  | Thermally activated cement waste | Start                 | End         | bending                      |             | compression |             |
|               |                          |          |                                  |                       |             | 3                            | 7           | 3           | 7           |
| PC D0         | 95                       | 5        | –                                | 2–30                  | 4–00        | 4.33                         | 4.90        | 20.2        | 27.8        |
| <b>TPC D3</b> | <b>90</b>                | <b>5</b> | <b>3</b>                         | <b>2–05</b>           | <b>3–40</b> | <b>2.68</b>                  | <b>4.20</b> | <b>20.8</b> | <b>28.0</b> |
| <b>TPC D5</b> | <b>85</b>                | <b>5</b> | <b>5</b>                         | <b>2–15</b>           | <b>3–30</b> | <b>2.98</b>                  | <b>4.24</b> | <b>21.8</b> | <b>30.0</b> |
| TPC D10       | 80                       | 5        | 10                               | 2–25                  | 3–10        | 2.65                         | 4.13        | 17.9        | 24.8        |

It is established that the values of the strength limit for bending and compression, as well as the setting time, cements with an addition of 3–5% of thermally activated waste meet the requirements of O'z DSt 913–98. The highest strength parameters of cements are also provided at a dosage of 3–5% of a thermoactivated chrysotile cement additive.

Pilot-industrial tests for the production of batch of clinker with additive-additive of chrysotile cement waste and Portland cement from modified clinker were carried out at JSC “Kizilkumcement”. Heat treatment of wet chrysotile cement wastes occurred in contact with a heated Portland cement clinker having a temperature of 1000–1100 °C at the exit from the rotary kiln. Then clinkers with additives of thermally activated chrysotile cement waste are fed to the grid of the grate cooler and cooled to a temperature of 20–40 °C, moving along the refrigerator, fed to the grate screen and then to the clinker warehouse or through the bunker to the cement mill. Proceeding from positive test results, JSC “Kizilkumcement” under this scheme has constructed a technological line providing supply and dosing of chrysotile cement waste to the hot clinker layer for clinker production with a thermally activated additive.

In the conditions of JSC “Kizilkumcement” with the use of a pilot batch of cement with thermally activated chrysotile cement waste, an experimental-industrial batch of eight-wave chrysotile cement sheets of profile 40/150 was produced. In the process of their manufacture deviations from the established technological regime were not observed. The physical and

mechanical tests showed their compliance with the requirements of GOST 30340. The development includes a technological instruction for the process of thermal activation of chrysotile cement waste and their use for the production of Portland cement for chrysotile cement products, a technological scheme for the production of portland cement with the addition of chrysotile cement waste, the standard of organization (Ts) for clinker with additive- a thermally activated additive. The proposed method does not require large investments for the installation of additional equipment and will reduce the consumption of clinker part in the Portland cement, which will lead to a decrease in the cost of production.

**Conclusion.** An energy-efficient method of thermal activation of chrysotile cement waste by contact method was developed by feeding them to a layer of hot Portland cement clinker leaving the rotating furnace. Heat treatment of chrysotile cement waste in this way increases the grindability of the clinker, and Portland cement is obtained with improved physical and mechanical properties. Experimental cements with additives (3, 5)% of thermoactivated chrysotile cement waste for construction and technical properties comply with the requirements of GOST 10178–85 and O'z DSt 913–98, therefore they are recommended for serial production of portland cement intended for the production of chrysotile cement products at JSC “Kizilkumcement” which in the future will be directed to the production of chrysotile cement products.

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## ABOUT AGROTECHNICAL PASSABILITY AND STABILITY OF THE 4-WHEELED UNIVERSAL-ROW TRACTOR

**Abstract:** The article presents the results of the investigation of the influence of the position of the clearance on the stability of the tractor. Researches have shown that change of clearance of the tractor with low-clearance on high-clearance leads to deterioration in both longitudinal, and cross stability of the tractor. Whereas change of clearance of the tractor, on the contrary, with high-clearance on low-clearance leads to improvement of both longitudinal, and cross stability of the tractor. At the same time static stability of the tractor increases: cross up to 9,42%, and longitudinal on a bias up to 6,25% and on rise up to 26,39%.

**Keywords:** tractor, agrotechnical gleam, clearance, wheel, front axle, rear axle, gravity, lifting, gradient, angle of heel, stability, controllability.

Increased agrotechnical patency of the 4-wheeled universal tractor can be achieved by changing the low clearance for high ground clearance. However, our researches have shown [1, 46–50] that changing the clearance of the front and rear bridges leads to change not only in the agrotechnical clearance, but also length of the base and the parameters of the coordinates of the center of gravity of the universal tractors.

Change of parameters of coordinates of the center of gravity of any tractor, including 4-wheeled universal row leads tractors to change and loss of its stability, therefore, to a spontaneous deviation from the set direction, to side sliding or capsizing.

To capsizing there corresponds such rising of wheels over a basic surface at which the angle of heel of a skeleton reaches extreme value and its further movement in the direction of a list by gravity and inertia becomes irreversible. Such phenomenon occurs in case

$$M_{on} \geq M_{cma6} \quad (1)$$

where,  $M_{on}$  – the overturning moment, Nm;

$M_{cma6}$  – the moment from forces seeking to return the tractor to a starting position, Nm.

The main criteria of stability 4-wheeled universal row tractors against capsizing are characteristics of his geometrical parameters and the arrangement of the center of mass of rather basic wheels defining limits of static stability. And limits of static stability are defined by extreme values of angles of lead, descent and a side list.

The property of the tractor to resist the overturning movement around a cross axis of capsizing is called longitudinal stability of the tractor against capsizing. At the same time capsizing happens because of redistribution of basic reactions on bridges of the tractor and at equality of zero one of them.

To determine the effect of the clearance on the stability of the 4-wheeled universal tractors, we analyze its longitudinal (fig. 1) and transverse (fig. 2) stability in the high-steep (I) and low-lance (II) positions to rollover and to lateral slip.

Insufficient longitudinal and lateral stability when moving 4-wheeled universal tractor either during descent or during the work on a slope can lead tractors on a bias to irreparable consequences, i. e. to its overturning. Therefore in order to avoid undesirable situations carry out calculation on longitudinal and cross stability of the tractor in advance.

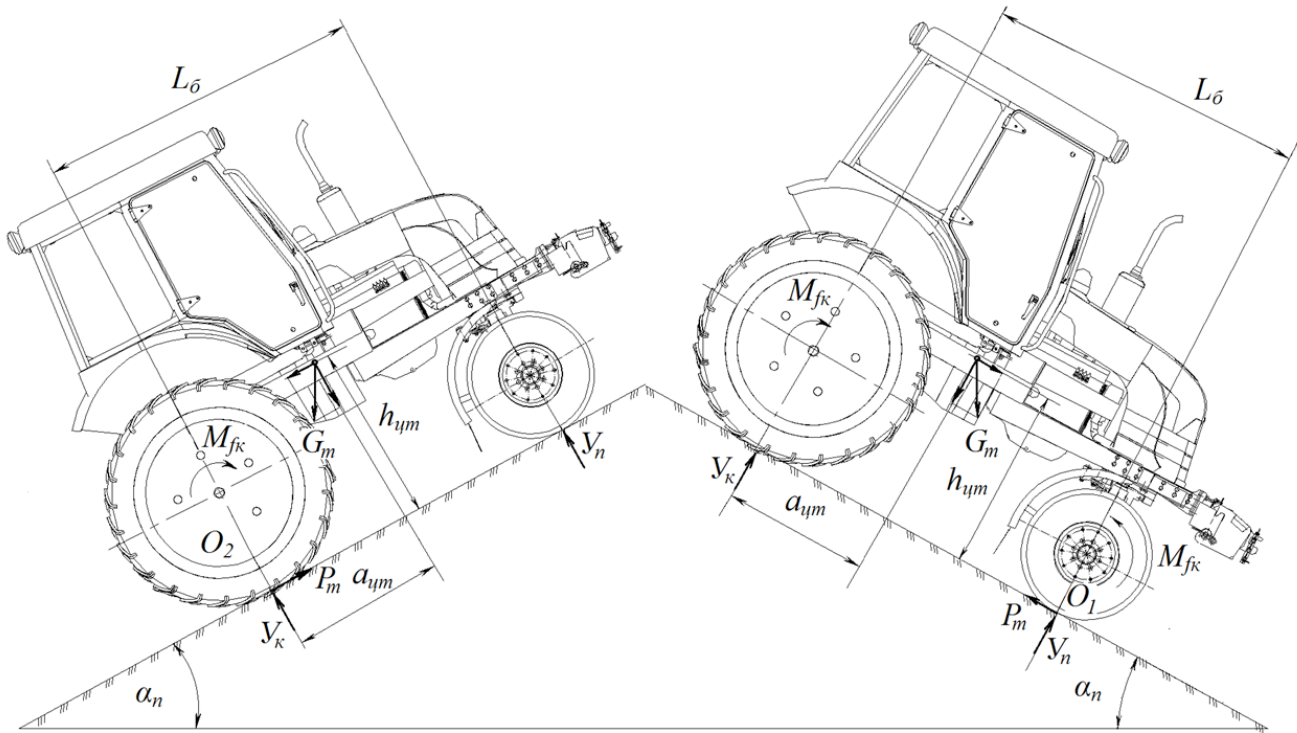


Figure 1. The settlement scheme to definition of longitudinal stability 4 – wheeled universal row tractors

When determining longitudinal stability 4-wheeled universal tractors are accepted the following assumptions:

- resistance of air isn't enough as the speed of the movement of the tractor no more than 30 km/h, therefore,  $P_w = 0$ ;
- the tractor moves evenly at which  $P_i = 0$ ;
- traction loading is absent, i. e.  $P_{kp} = 0$ .

The greatest angle of lead at which the slowed-down tractor can stand, without overturning, call a limit static angle of lead  $\alpha_m$ .

The corner of the beginning of capsizing of the tractor in static situation on rise depending on options of a type of clearance decides on adjustable clearance by expression

$$\alpha_{n\text{pod}}^{I(II)} = \text{arctg} \left( \frac{a_{um}^{I(II)}}{h_{um}^{I(II)}} \right), \quad (2)$$

From fig. 1 it is visible that at a limit static angle of lead if not to consider force of resistance to swing, the vector of gravity passes through an axis of capsizing of  $O_2$ .

Unlike a limit static angle of rise the limit static angle of descent  $\alpha_{ny}$  is determined from expression

$$\alpha_{n\text{pod}}^{I(II)} = \text{arctg} \left( \frac{(L^{I(II)} - a_{um}^{I(II)})}{h_{um}^{I(II)}} \right), \quad (3)$$

where,  $a_{um}^{I(II)}$ ,  $h_{um}^{I(II)}$  – respectively by clearance options the horizontal and vertical coordinate of the center of gravity 4-wheeled universal row tractors, mm;

$L^{I(II)}$  – respectively by clearance options base 4-wheeled universal row tractors, mm.

Further, in view of work [2, 83] we define a corner of the beginning of slipping

$$\alpha_{\phi}^* = \text{arctg}(\phi_c), \quad (4)$$

where,  $\phi_c$  – coefficient of coupling with the soil.

The angle of slipping  $\alpha_{\phi}^{I(II)}$  respectively at the slowed-down back driving wheels is determined by expressions on rise by options of clearance of the tractor

$$\alpha_{\phi}^{I(II)} = \text{arctg} \left( \frac{\phi_c (L^{I(II)} - a_{um}^{I(II)})}{L^{I(II)} - h_{um}^{I(II)} \phi_c} \right), \quad (5)$$

on the slope

$$\alpha_{\phi}^{I(II)} = \text{arctg} \left( \frac{\phi_c (L^{I(II)} - a_{um}^{I(II)})}{L^{I(II)} + h_{um}^{I(II)} \phi_c} \right). \quad (6)$$



Critical angle of an inclination of the road  $\alpha_{\text{кр.ск}}^{I(II)}$  respectively by options of clearance of the tractor under the terms of coupling of buses with a reference surface in case of which sliding of driving wheels can begin, is defined by expression

$$\alpha_{\text{кр.ск}}^{I(II)} = \text{arctg} \left( \frac{\phi_c \cdot (L^{I(II)} - a_{\text{ум}}^{I(II)}) - f \cdot L^{I(II)}}{(L^{I(II)} - h_{\text{ум}}^{I(II)} \cdot \phi_c)} \right), \quad (7)$$

where,  $f$  – coefficient of resistance to self-movement.

Condition of the guaranteed stability of the tractor against tilting [3, P. 338]

$$\alpha_{\text{нпод}}^{I(II)} \geq \alpha_{\text{кр.ск}}^{I(II)} \quad (8)$$

and at sharp braking

$$\alpha_{\text{нпод}}^{I(II)} \geq \phi_c. \quad (9)$$

When calculating cross stability define a corner of the beginning of capsizing and a corner of the beginning of slipping on a slope (fig. 2).

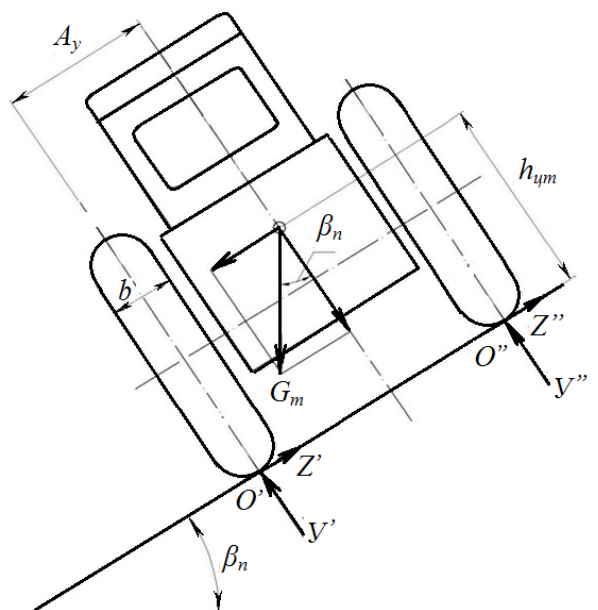


Figure 2. The settlement scheme to definition of cross stability 4 – wheeled universal row tractors

The corner of the beginning of capsizing  $\beta_n$  on a slope depending on options of a type of clearance of the tractor is defined according to work [2, 83] as expression

$$\beta_n^{I(II)} = \text{arctg} \left( \frac{A_y^{I(II)}}{h_{\text{ум}}^{I(II)}} \right), \quad (10)$$

where,  $A_y^{I(II)}$  – a shoulder of stability of the tractor, mm;  
 $h_{\text{ум}}^{I(II)}$  – vertical coordinate of the center of gravity of the tractor.

The corner of the beginning of slipping on a slope according to work [2, 83] can be accepted

$$\beta_\phi = \text{arctg}(0,8 \cdot \phi_c). \quad (11)$$

In the presence of dynamic influences from microroughnesses of the path a dynamic lateral stability angle according to [4, 270]

$$\beta_{\text{дин}}^{I(II)} = (0,4 \div 0,6) \cdot \beta_n^{I(II)}. \quad (12)$$

According to the stated technique it is defined the key parameters estimating longitudinal and cross stability 4-wheeled universal row tractors in two options: in high-clearance and low-clearance, also we enter them in table 1.

Table 1.

| Name of indicators, symbol and unit of measure   | Value of indicators by options |       | Increase (+) or reduction (-),% |
|--|--------------------------------|-------|---------------------------------|
|  | I                              | II    |                                 |
| I  | 2                              | 3     | 4                               |
| 1. Longitudinal stability  |                                |       |                                 |
| Corner of longitudinal static stability (rise) $\alpha_{\text{нпод}}^{I(II)}$ , degree | 32.72                          | 41.35 | 26.38                           |
| Corner of longitudinal static stability (bias) $\alpha_{\text{нпод}}^{I(II)}$ , degree | 47.38                          | 50.34 | 6.25                            |

| <b>1</b>   | <b>2</b>            | <b>3</b>            | <b>4</b> |
|--|---------------------|---------------------|----------|
| Corner of longitudinal stability. The tractor moves evenly on an eddish (rise) $\alpha_{npod}^{I(II)}$ , degree  | 30.67               | 39.52               | 28.85    |
| Corner of longitudinal stability. The tractor moves evenly on an eddish (a bias) $\alpha'_{npod}^{I(II)}$ , degree   | 48.64               | 51.60               | 6.07     |
| Critical angle of an inclination of the road on which sliding of driving wheels under the terms of coupling of buses with a reference surface on an eddish of $\alpha_{sp.c}^{I(II)}$ , degree | 29.73               | 24.63               | -17.15   |
| Condition of the guaranteed stability of the tractor against capsizing on an eddish $\{\alpha_{npod} \geq \alpha_{sp.c}\}$   | done                | done                |          |
| Corner of the beginning of slipping of the $\alpha_{\phi}^*$ , degree  |                     |                     |          |
| on an eddish   |                     | 34.99               |          |
| on the dirt road   |                     | 33.02               |          |
| on a concrete covering   |                     | 37.23               |          |
| An angle gaucherie delayed The tractor of ascension and $\alpha_{\phi}^{I(II)}$ , degree   |                     |                     |          |
| on an eddish   | 36.47               | 31.34               | -14.06   |
| on the dirt road   | 33.21               | 28.63               | -13.79   |
| on a concrete covering   | 40.44               | 34.65               | -14.31   |
| An angle gaucherie delayed the tractor on slope $\alpha'_{\phi}^{I(II)}$ , degree  |                     |                     |          |
| on an eddish   | 23.57               | 16.86               | -28.46   |
| on the dirt road   | 22.06               | 15.99               | -27.51   |
| on a concrete covering   | 25.32               | 17.85               | -29.5    |
| At emergency brake application of the tractor condition $\{\alpha'_{npod} \geq \phi_c\}$   |                     |                     |          |
| on an eddish   | Accomplished (done) | Accomplished (done) |          |
| on the dirt road   | Accomplished (done) | Accomplished (done) |          |
| on a concrete covering   | Accomplished (done) | Accomplished (done) |          |
| <b>2. Cross stability</b>  |                     |                     |          |
| Corner of cross stability of $\beta_n^{I(II)}$ , degree  | 31.58               | 34.55               | 9.42     |
| Corner of the beginning of slipping on a slope (eddish) $\beta_{\phi}$ , degree  |                     |                     |          |
| on an eddish   |                     | 29.25               |          |
| on the dirt road   |                     | 27.47               |          |
| on a concrete covering   |                     | 31.30               |          |
| Dynamic corner of side stability of the $\beta_{\partial_{\mu\mu}}^{I(II)}$ , degree   | 12.63               | 13.82               |          |

Results (tab. 1) of the calculations have shown that in both options of clearance the condition of the guaranteed stability 4-wheeled universal row tractors against rollover is fulfilled. But, despite this, the change in the clearance of the tractor from the low-level to the high stance position leads to a deterioration in the overall picture of both longitudinal, and lateral stability of the tractor. The change in the clearance of the tractor from

the low-level to the high stance position, on the contrary, leads to improvement of both longitudinal, and cross stability of the tractor. At the same time static stability of the tractor increases: cross up to 9,42%, and longitudinal on the slope up to 6,25% and on rise up to 26,38%.

Thus, one of the effective ways of increasing the stability of 4-wheeled universal row tractors, both in longitudinal, and in the cross direction, especially when

performing transport works, is decrease in his center of gravity due to reduction of clearance of the tractor. Whereas when performing interrow processings of tall cultures, for example a cotton, for providing get prettier fits in row-spacings and agrotechnical passability the clearance 4-wheeled universal row tractors has to be high.

Therefore, for carrying out transport and field works by the same 4-wheeled universal tractor, its clearance must be adjustable from low-clearance to high-stance position. Proceeding from this consideration the TRCS TR carries out NI and ROC on the creation of a 4-wheeled universal row tractors with adjustable clearance.

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## **OPTIMAL PLANNING OF SHORT-TERM MODES OF POWER SYSTEMS WITH CONTROL OF LOADS OF ELECTRIC CONSUMERS TAKING INTO ACCOUNT OF NETWORK FACTOR**

**Abstract:** In the article the problem of optimal planning of power system's short-term modes with load control of regulated electric consumers and the network factor are considered. A mathematical model and an algorithm for solving of the problem are given. The results of research of efficiency of the proposed algorithm are presented.

**Keywords:** power system, short-term planning, network factor, power losses, derivative of losses, load schedule, fuel consumption, optimization, control, optimal mode.

### **I. Introduction**

Functioning of many modern power systems is characterized by a sharp non-uniform loading schedules, often changing of electrical network schemes and corresponding complication of electrical power system's (EPS) mode control.

Sharp non-uniformity of loading schedules leads to increase of expenses for production of electricity and corresponding growth of its costs for consumers. It, in particular, is connected with operation in power plants at maximum loadings the less economic equipment, which use power resources not enough effectively, frequent change in the composition of operating units in thermal power plants.

One of the rational ways to ensure the economical operation of such power systems in the short-term planning is alignment of the load schedule through control of power consumption. The alignment of the load schedule can be achieved by involving consumers in optimization process on basis of administrative and economic measures [1, 83–86]. At short-term planning of power system mode for some large consumers non-rigid loads for each time interval are given, but their minimum and maximum possible values while maintaining a constant

power consumption during the planning period under consideration. In such conditions, it become possible to obtain an additional economic effect due to the optimal planning of the power system modes taking into account non-rigid load schedules of consumers. Part of the additional generated economic profit, at the same time, can be spent to stimulate consumers for their participation in optimization process.

A mathematical description and an algorithm for solving of the problem under consideration without taking into account the network factor were proposed by the authors of this paper in [1, 83–84]. Here we discuss mathematical modeling and algorithm of solving of the problem taking into account of network factor.

Taking into account of network factor in planning of power system's short-term modes with optimal load control of electric consumers, generally, can lead to significantly changing of the load schedules of regulated electric consumers and redistribution of the total load of power system between power plants. Here, optimization is reduced to reducing the total fuel costs in power system by reducing losses as a result of choosing rational schedules for loads of regulated electric consumers and power plants.

## II. Theoretical Part

The problem under consideration is formulated mathematically as follows:

to minimize the total fuel cost at the thermal power plants (TPPs) for control cycle  $T$

$$B = \sum_{t \in T} \sum_{i \in N} B_i(P_i^t) \quad (1)$$

subject to restrictions

– on balance of power in power system in each time interval of the control cycle  $T$

$$W_t = \sum_{i \in N} P_i^t - \sum_{j \in M} P_j^t - \pi_t = 0, \quad t \in T, \quad (2)$$

– on electricity balance for control cycle for each of the regulated electric consumers

$$\phi_j = \sum_{t \in T} P_j^t - E_j^T = 0, \quad j \in M, \quad (3)$$

– on capacities of power plants and electric consumers

$$\begin{aligned} P_i^{t,\min} \leq P_i^t \leq P_i^{t,\max}, \quad i \in N, \quad t \in T; \\ P_j^{t,\min} \leq P_j^t \leq P_j^{t,\max}, \quad j \in M, \quad t \in T, \end{aligned} \quad (4)$$

– on power flow on controlled power transmission lines (PTL)

$$P_l \leq \bar{P}_l, \quad l \in L_p, \quad t \in T, \quad (5)$$

where  $N, M$  are sets of TPPs and consumers participated in optimization process, accordingly;  $L_p$  is set of PTL in which power flows are supervised;  $P_i^t, P_j^t$  are loadings of TPP  $i$  and consumer  $j$  in time interval  $t$  of the regulation cycle  $T$ ;  $B_i(P_i^t)$  is fuel cost in TPP  $i$  at loading  $P_i^t$  in time interval  $t$  of the regulation cycle;  $W_t, \phi_j$  are non-balance functions of capacity in time interval  $t$  and electricity for consumer  $j$  for regulation cycle, accordingly.

Decision of the described problem can be found through minimization of function

$$\begin{aligned} L = B + \sum_{t \in T} \mu_t \left( \sum_{i \in N} P_i^t - \sum_{j \in M} P_j^t - \pi_t \right) + \\ + \sum_{j \in M} \lambda_j \left( \sum_{t \in T} P_j^t - E_j^T \right) + \sum_{t \in T} \sum_{l \in L_p} S_l^t, \end{aligned} \quad (6)$$

where  $\mu_t, \lambda_j$  are undefined Lagrange multipliers entered for taking into account the condition of balance of capacity in time interval  $t$  and electricity for consumer  $j$ ;  $S_l^t$  is penalty function considering limitations on power flow in supervised PTL  $l$  in time interval  $t$ .

In general, in optimization process participate also Hydro Power Plants (HPPs) which have water reservoirs [2, 34–56; 5, 1975–1976; 6, 125–127; 7, 405–412]. In the described model HPPs are taken into account in basis of choosing of corresponding Lagrange multipliers and

their reduction, in calculation sense, to equivalent TPPs as in [2, 35–38, 6, 126–127].

Thus, the mathematical model of the problem of power system's short-term mode optimal planning with load control of electric consumers and the network factor consideration is characterized by entering into active power balance equation for each  $t$ -th time interval of control cycle the total active power losses in electrical networks. These losses are complex functions of all the operating parameters and, therefore, can be determined on the basis of calculation of steady-state modes of electrical networks for all the time intervals of the control cycle. The proposed algorithm for solving of this problem is described below.

At optimum values of variables – active capacities of power plants, loads of adjustable electric consumers and indefinite Lagrange multipliers, take place next condition:

$$\left. \begin{aligned} \frac{\partial L}{\partial P_i^t} = b_i^t + \mu_t (1 - \sigma_i^t) + \sum_{l \in L_p} s_{li}^t = 0, \quad i \in N, \quad t \in T; \\ \frac{\partial L}{\partial P_j^t} = -\mu_t (-1 - \sigma_j^t) + \lambda_j + \sum_{l \in L_p} s_{lj}^t = 0, \quad j \in M, \quad t \in T; \\ \frac{\partial L}{\partial \mu_t} = W_t = 0, \quad t \in T; \quad \frac{\partial L}{\partial \lambda_j} = \phi_j = 0, \quad j \in M, \end{aligned} \right\} (7)$$

where  $b_i^t = \frac{\partial B_i}{\partial P_i^t}$  is the relative increase in fuel costs in the  $i$ -th TPP at the load of the  $t$ -th time interval  $P_i^t$ ;  $s_{li}^t, s_{lj}^t$  are derivatives of the penalty function for taking into account of restriction on power flow in  $l$ -th supervised line on power of the  $i$ -th TPP and the  $j$ -th node with load in the  $t$ -th interval of the planning period  $T$ ;  $\sigma_i^t$  is derivative of total losses of active power in electrical networks in  $t$ -th time interval of the power regulation cycle on the power  $i$ -th TPP;  $\sigma_j^t$  is derivative of the total losses of active power in electrical networks in the  $t$ -th time interval of power regulation cycle on the  $j$ -th load node with adjustable electrical consumers in the  $t$ -th interval of the control cycle.

Dividing the first equation in (7) by  $1 - \sigma_i^t$  and the second equation by  $1 + \sigma_j^t$ , and also denoting the network coefficients for  $i$ -th TPP in  $t$ -th time interval of control cycle as  $\eta_i^t = 1 / (1 - \sigma_i^t)$ , for  $j$ -th load in  $t$ -th time interval of the control cycle as  $\eta_j^t = 1 / (1 - \sigma_j^t)$ , the system of equations (7) can be presented in following form:



$$\left. \begin{aligned} \eta_i^t \left( b_i^t + \sum_{l \in L_p} w_{li}^t \right) &= \eta_j^t \left( \lambda_j + \sum_{l \in L_p} w_{lj}^t \right), \quad t \in T \quad (i \in N, j \in M); \\ \sum_{i \in N} P_i^t - \sum_{j \in M} P_j^t - \pi_t &= 0, \quad t \in T; \quad \sum_{t \in T} P_j^t - E_j^T = 0, \quad j \in M. \end{aligned} \right\} \quad (8)$$

The last system, together with simple limitations (4), is a prerequisite for the optimality of covering the load schedule of power system by thermal power plants, taking into account the network factor, while optimally controlled of load of the regulated electric consumers.

Solution of the problem under consideration on the basis of solution of system of equations obtained from (8) is connected with non-reliability of convergence of the iterative calculation process. Therefore, this system can be used only to represent the essence of the optimization problem under consideration taking into account the network factor.

In the algorithm proposed here, the problem of optimal planning of power system's short-term mode with optimization of loads of electric consumers and taking into account the network factor is solved by minimizing the function

$$F = B + \sum_{t \in T} \sum_{l \in L_p} III_l^t \quad (9)$$

with gradient method taking into account all the given constraints. In order to take into account constraints (2) and (3), the optimized capacities of the plants and loads of nodes with regulated electric consumers are divided into two groups – independent and dependent variables. The constraints imposed on independent variables are taken into account by fixing at each iteration variables that went beyond the allowed limits on the violated limit values, verifying the necessity of their detachment in subsequent iterations. Restrictions on the limiting values of dependent variables are taken into account by the penalty function as in [2, 24–27; 3, 2156–2157; 6, 106; 7, 421–422].

In the case of adoption as a dependent variables the active power of the first TPP in all time intervals of control cycle and the power of the loads of nodes with adjustable electrical consumers in the first interval of the control cycle, calculation of the power of plants and loads of nodes taken as independent variables in the regular  $k$  – th iteration is performed according to the following formulas:

$$P_i^{t(k)} = P_i^{t(k-1)} - h_i^{t(k-1)} \cdot \frac{\partial F^{(k-1)}}{\partial P_i^t}, \quad i \in N \quad (i \neq 1), \quad t \in T, \quad (10)$$

$$P_j^{t(k)} = P_j^{t(k-1)} - h_j^{t(k-1)} \cdot \frac{\partial F^{(k-1)}}{\partial P_j^t}, \quad j \in M, \quad t \in T \quad (t \neq 1), \quad (10 a)$$

where the components of gradient of the function are determined as

$$\frac{\partial F^{(k-1)}}{\partial P_i^t} = b_i^{t(k-1)} + s_{li}^{t(k-1)} + (b_1^{t(k-1)} + s_{li}^{t(k-1)}) \cdot (-1 + \sigma_i^{t(k-1)}), \quad (11)$$

$$\frac{\partial F^{(k-1)}}{\partial P_j^t} = s_{lj}^{t(k-1)} + (b_1^{t(k-1)} + s_{li}^{t(k-1)}) \cdot (1 + \sigma_j^{t(k-1)}), \quad (11 a)$$

$s_{li}^{t(k-1)}$ ,  $s_{lj}^{t(k-1)}$  are derivatives from the penalty function introduced in violation of the restriction on the flow of the  $l$ -th power transmission line on capacities of the  $i$ -th TPP and loads of  $j$ -th node in the  $t$ -th interval of the control cycle and in  $k-1$ -th iteration;  $h_i^{t(k-1)}$ ,  $h_j^{t(k-1)}$  – steps in the direction of the antigradient for the independent capacities of the  $i$ -th plant and the load of  $j$ -th node in the  $k-1$ -th iteration, determined by the conditions given in [2, 154–155; 3, 351–352].

The proposed algorithm for taking into account of network factor at optimal planning of power system short-term modes undertake the preliminary reconstruction of dependence of losses derivative on active power of power plants  $\sigma_i(P_i)$  and load nodes  $\sigma_j(P_j)$  which are used at calculation on formulas (11) and (11a). The essence of the algorithm is as follows:

1) the optimal coverage of the total load schedule of the power system by all TPPs with optimal load control of electric consumers without taking into account the network factor is carried out. As a result, optimal schedules of loads of power plants and electric consumers are obtained;

2) for each time interval of the control cycle, calculations of the steady-state modes of electrical systems are performed, total losses in electrical networks, their derivatives at the capacities of power plants and load nodes are determined. In view of non-uniformity of load schedules of power plants and consumers, the dependences of  $\sigma_i(P_i)$  and  $\sigma_j(P_j)$  are obtained;

3) the optimal planning of the power system mode with the control of the load of regulated electric consumers for the period under consideration is carried out as

without taking into account the network factor. At this stage, when calculating the components of the gradient on formulas (11) and (11a) the, the dependences of  $\sigma_i(P_i)$  and  $\sigma_j(P_j)$  are used.

Calculation of derivative of losses in the proposed algorithm is carried out on the basis of solution of following system of linear algebraic equations obtained from conditions

$$\begin{bmatrix} \frac{\partial P}{\partial \delta} & \frac{\partial Q}{\partial \delta} \\ \frac{\partial P}{\partial U} & \frac{\partial Q}{\partial U} \end{bmatrix} x \begin{bmatrix} \sigma_p \\ \sigma_q \end{bmatrix} = \begin{bmatrix} \frac{\partial \pi}{\partial \delta} \\ \frac{\partial \pi}{\partial U} \end{bmatrix} \quad (12)$$

as in [2, 101–103; 3, 350–351; 4, 2157–2158]. In (12)

$\sigma_p = \frac{\partial \pi}{\partial P}$ ,  $\sigma_q = \frac{\partial \pi}{\partial Q}$  are determined vectors of the loss

derivatives on active and reactive powers of nodes;  $\frac{\partial P}{\partial \delta}$ ,  $\frac{\partial Q}{\partial \delta}$ ,  $\frac{\partial P}{\partial U}$ ,  $\frac{\partial Q}{\partial U}$  are sub matrixes of partial derivatives of active and reactive powers of nodes on angles and modules of complex voltages of nodes;  $\frac{\partial \pi}{\partial \delta}$ ,  $\frac{\partial \pi}{\partial U}$  are the vectors of loss derivative on angles and modules of complex voltages of nodes.

### III. Experimental Part

Efficiency of the proposed algorithm was evaluated in the example of optimal coverage of the load schedule of power system by four TPP with following fuel consumption characteristics (in tones of conditional fuel in hour – t. c.f./h.):

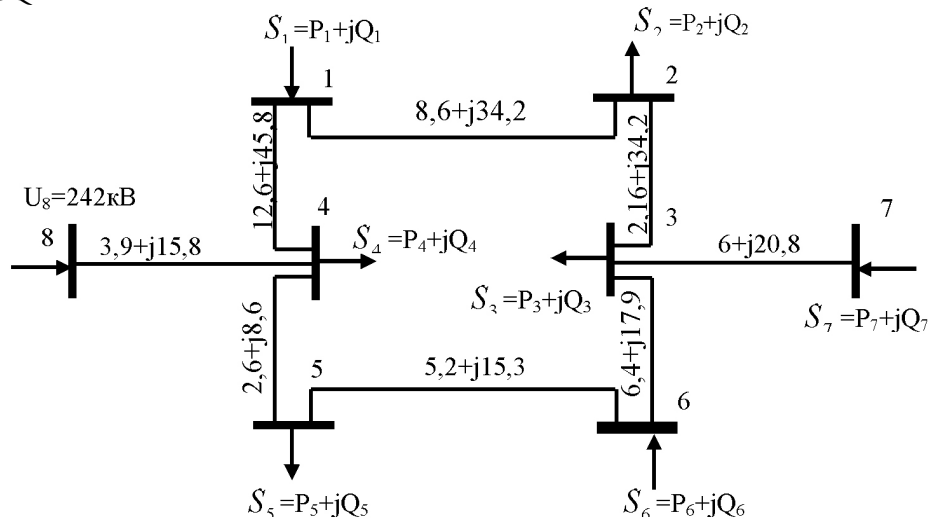


Figure 1. The circuit of the power system

$$B_1 = 90 + 0,1P_1 + 0,0007P_1^2,$$

$$B_6 = 70 + 0,11P_6 + 0,0004P_6^2,$$

$$B_7 = 80 + 0,15P_7 + 0,0005P_7^2,$$

$$B_8 = 60 + 0,12P_8 + 0,00055P_8^2.$$

The circuit of power system is presented in Fig. 1. TPPs are located in points (nodes) of 1, 6, 7 and 8. The TPP in node 8 is a balancing plant.

Load nodes 2, 4, 5, and 6 have adjustable electric consumers. Load schedules of consumers with four characteristic time intervals are given in Table 1. The limiting capacities of TPPs, loads of consumers and the amount of electricity received by consumers during the planning period are presented in Table 2.

Table 1. Load schedules of consumers

| Number of interval of time | $P_2$ , MW | $P_3$ , MW | $P_4$ , MW | $P_5$ , MW | Total load $P_H$ , MW |
|----------------------------|------------|------------|------------|------------|-----------------------|
| 1.                         | 230        | 400        | 130        | 340        | 1100                  |
| 2.                         | 280        | 470        | 150        | 400        | 1300                  |
| 3.                         | 350        | 580        | 260        | 490        | 1680                  |
| 4.                         | 300        | 500        | 180        | 420        | 1400                  |

Active power factors for power plants are 0.85, and for consumers are 0.9.

Table 2. Limiting capacities of TPPs, loads of consumers (in MW) and the amount of electricity received by consumers in the nodes (in MWh)

| Parameters     | Number of nodes with TPP |     |     |     | Number of nodes with regulated consumers |      |     |      |       |
|----------------|--------------------------|-----|-----|-----|--|------|-----|------|-------|
|                | 1                        | 6   | 7   | 8   | 2  | 3    | 4   | 5    | Total |
| $P^{min}$ , MW | 200                      | 200 | 200 | 200 | 230                                      | 400  | 130 | 340  | 1100  |
| $P^{max}$ , MW | 600                      | 600 | 600 | 600 | 350                                      | 580  | 260 | 490  | 1680  |
| $E$ , MWh      |                          |     |     |     | 1160                                     | 1950 | 720 | 1650 | 5480  |

To assess the effect of taking into account the network factor, as well as comparing the results of optimization, in Table 3 the results of optimal planning of power system's mode with the optimal control of load of electric consumers without taking into account the network factor are presented (the derivative of losses on the capacities of TPPs and loads of consumers are zero).

For optimal planning of power system mode with load control of electric consumers and the network factor consideration, calculations of the steady-state modes of the electric network at the load nodes are presented in Table 3 were performed and the derivatives of losses based on the solution of the system of linear algebraic equations obtained from condition (12) were determined. As a

result, the corresponding derivatives of losses and the dependences of  $\sigma(P)$  for all the nodes corresponding to these loads are obtained. These dependencies are used to determine the derivatives of losses when calculating the components of the objective function's gradient according to (11) and (11a) during the iterative optimization process.

Table 3. Results of the optimal planning of power system mode without taking into account the network factor

| $t$   | Loads of power consumers |               |               |               | Power losses $\pi$ , MW | Loads of power plants |               |               |               | $B$ , t. c.f./h. |
|---|--------------------------|---------------|---------------|---------------|-------------------------|-----------------------|---------------|---------------|---------------|------------------|
|   | $P_{2'}$ , MW            | $P_{3'}$ , MW | $P_{4'}$ , MW | $P_{5'}$ , MW |                         | $P_{1'}$ , MW         | $P_{6'}$ , MW | $P_{7'}$ , MW | $P_{8'}$ , MW |                  |
| 1.  | 269.95                   | 479.75        | 159.77        | 399.95        | 58.41                   | 321.41                | 267.24        | 455.09        | 324.10        | 706.14           |
| 2.  | 295.12                   | 485.10        | 164.68        | 430.81        | 68.84                   | 339.94                | 281.20        | 479.73        | 343.68        | 743.26           |
| 3.  | 300.00                   | 500.00        | 210.00        | 400.00        | 80.33                   | 350.52                | 289.70        | 494.51        | 355.59        | 766.13           |
| 4.  | 294.92                   | 485.14        | 185.55        | 419.24        | 68.93                   | 341.93                | 283.03        | 482.68        | 346.14        | 747.83           |
| Total expense of conditional fuel for period of planning: 2963,36 t. c.f. |                          |               |               |               |                         |                       |               |               |               |                  |

Table 4 shows the results of the optimal power system mode planning with optimal load control of electric

consumers taking into account power factor by the algorithm described above.

Table 4. Results of the power system mode optimal planning with optimal load control of electric consumers taking into account power factor

| $t$   | Loads of power consumers |               |               |               | Power losses $\pi$ , MW | Loads of power plants |               |               |               | $B$ , t. c.f./h. |
|---|--------------------------|---------------|---------------|---------------|-------------------------|-----------------------|---------------|---------------|---------------|------------------|
|   | $P_{2'}$ , MW            | $P_{3'}$ , MW | $P_{4'}$ , MW | $P_{5'}$ , MW |                         | $P_{1'}$ , MW         | $P_{6'}$ , MW | $P_{7'}$ , MW | $P_{8'}$ , MW |                  |
| 1.  | 269.35                   | 479.75        | 159.44        | 399.36        | 58.55                   | 322.91                | 457.93        | 285.26        | 300.36        | 708.67           |
| 2.  | 308.38                   | 484.63        | 165.00        | 428.84        | 55.74                   | 333.16                | 467.14        | 328.40        | 313.90        | 744.73           |
| 3.  | 300.66                   | 500.00        | 215.31        | 401.98        | 66.10                   | 341.16                | 485.71        | 337.07        | 320.11        | 765.53           |
| 4.  | 281.61                   | 485.62        | 180.24        | 419.85        | 56.61                   | 337.84                | 471.26        | 297.16        | 317.64        | 736.69           |
| Total expense of conditional fuel for period of planning: 2955,61 t. c.f. |                          |               |               |               |                         |                       |               |               |               |                  |

Comparing the results obtained as a result of optimal planning of power system mode with control of load of consumers without taking into account (Table 3) and

taking into account the network factor (Table 4), we see that the network factor is significantly cost-effective. In the example under consideration, the total consumption

of conventional fuel in the power system from taking into account the network factor is reduced by 7.75 tons of conditional fuel, which is 0.26% of the total fuel consumption in the initial mode.

#### IV. Conclusions

1. A mathematical model of the problem of optimal planning of short-term mode of power system with optimal control of load of electric consumers and network factor consideration is proposed.

2. The conditions of optimality for coverage of schedule of loads of power system with optimal control of load of regulated electric consumers taking into account the network factor are obtained.

3. The algorithm of taking into account of network factor at optimal planning of short-term modes of power system with control of loads of electric consumers is proposed. The algorithm allows solving the problem with high accuracy and reliability. Using the obtained dependences of  $\sigma(P)$  in calculation process creates the possibility for taking into account the network factor without iteratively.

4. It has been established that taking into account the network factor in the optimal planning of short-term modes of power system with control of loads of electric consumers give a significant economic effect.

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## **INCREASE IN DURABILITY AND PLASTICITY OF THE CEMENT STONE IN ANNULAR SPACE OF WELLS**

**Abstract:** In work some ways increase in durability of a cement stone in annular space of wells are recommended. As a result of the conducted researches a number of chemical and inert additives, to cement mortar, allowing regulating in the wide range of density, durability and size of expansion of grouting solution is offered. The majority of additives are production wastes of the enterprises of the Republic of Uzbekistan. Availability and low cost of additive allows reducing the price of the cost of wells in difficult geological conditions.

**Keywords:** durability, tightness, grouting solution, well, pressure, layer, cement stone, annular space.

The analysis of trade and literary data demonstrates the main reason for annular shows of formation fluids low-quality cementation of behind-the-casing space. At all stages of construction of the well, since cementation of behind-the-casing space in a cement stone channels and cracks are formed that reduces the resilience of the upsetting columns to action of the external and internal loadings leading to accidents, demanding significant additional costs of rescue and recovery operations. Grouting solution and a stone in the well in connection with small thickness, commensurable with an extent of not uniformity, it is impossible to characterize by average values of indicators of properties as he perceives not average value of sheeted influences, and all scale of casual properties of layers on cementation interval length. Therefore, on length of a column sites in which “deterioration” in property of solution and a stone will meet “extreme” sheeted influences are possible. Thus, for ensuring long work of a cement stone for upsetting a column and a high output of the well creation of cement grouting material of high crack resistance and plasticity is necessary [1; 2].

When hardening and in the period of an intensive set of durability the cement stone on the basis of the Portland cement decreases in volume. Any rigid obstacle to this process causes in a cement stone, the big stretching voltage about 1–3 MPa. As a result of the cement stone filling behind-the-casing space of the well there are cracks. Besides, shrinkage leads to formation of gaps on the surface of contact of a cement stone, pipes and walls of the well.

The gap between casing pipe and a cement ring can also appear due to residual deformations of a cement stone at changes of temperature and pressure in use [3; 4].

Use of the extending and nonshrinking cements exclusively favorably influences quality dissociation of layers of oil and gas wells in various geological specifications. The expanding cement improves coupling of a cement ring with an upsetting column and dense breeds in open sites of a trunk and with both columns in intercolumned space. This unique does to feature of the expanding cements them by exclusively valuable insulating material for the explorative wells, especially multisheeted deposits and powerful gas-bearing layers consisting of the layer with various collection properties divided by dense crossing points [5].

For the solution of an objective in laboratory of fastening of wells of the Tashkent state technical university by the author pilot studies on selection of composition of grouting solution of high durability and the moderate expanding effect are conducted when curing. For cementation of wells which have the reservoir pressure equal to hydrostatic pressure water columns by the author studied a possibility of use as additive to cement mortars of marble powder and other fillers.

Marble powder has density of 2200–2250 kg/m<sup>3</sup>. The grouting cement used on a large scale in Uzbekistan for cementation of wells has density of 3150 kg/cm<sup>3</sup>. At a ratio of marble powder and cement 1:3 we receive a water cement factor 0.5 and spreadability of 20–22 cm, density of



solution makes 1740–1760 kg/m<sup>3</sup>. Durability of a cement stone on a bend  $\sigma_{\text{bend}} = 0.30$  MPa. The received parameters of grouting composition meet conditions of cementation of wells, however density is big for wells with the reservoir pressures corresponding to the hydrostatic pressure of a water column. By researches it is established that and available nonshrinking knitting usual grouting cements with

additive to 15% of ground sand, 1–5% of clay, up to 20% of marble powder and also a phosphite in side-altars of 7–13% concern the simplest. The last in dumps of the enterprises of Uzbekistan is in quantity more than 100 million t., and these dumps continuously increase.

Results of the physicomechanical tests mixed grouting compositions are presented in (tab. 1).

Table 1. – The main characteristics of grouting composition hardening at 293K, V/C = 0,6

| Structure of grouting composition in% |             |               |      |           | Durability at a MPa bend |            | Shrinkage (-) expansion (+),% |
|---------------------------------------|-------------|---------------|------|-----------|--------------------------|------------|-------------------------------|
| Portland cement                       | Ground sand | Marble powder | clay | Phosphite | In 2 days.               | In 7 days. |                               |
| 100                                   | –           | –             | –    | –         | 0.19                     | 0.33       | –1.5                          |
| 80                                    | 5           | 6             | 2    | 7         | 0.24                     | 0.38       | +2.2                          |
| 60                                    | 8           | 13            | 3    | 10        | 0.37                     | 0.43       | +3.1                          |
| 50                                    | 16          | 20            | 4    | 10        | 0.30                     | 0.48       | +2.8                          |

According to these tab. 1 the grouting composition where the structure contains 60% of the Portland cement has the best technological indicators. High content of a cement stone (80–100%) and low quantity (it is lower than 50%) the grouting Portland cement much more reduces durability and the extending effect of the specified stone. Presence at structure of grouting composition of a phosphite (up to 10%) and marble powder in side-altars of 13–20% of the volume of cement provides the sufficient durability of a cement stone and indicators of his expansion.

Other most perspective direction for the solution of average problem is us age of powdery plastic, for example polyethylene of average density of 0.932–0.940 kg/m<sup>3</sup> of the WC brand – V736A released by the Shurtan gas-chemical complex in Uzbekistan. Considering availability, rather low price the author experiments in various combinations of the Portland cement to plastic were conducted. Results of researches are presented in (tab. 2).

Table 2.

| P/n | The name of components as a part of grouting composition | Key indicators of grouting composition |      |      |      |
|-----|--|--|------|------|------|
|     |  | 100                                    | 95   | 90   | 85   |
| 1.  | Portland cement  | 100                                    | 95   | 90   | 85   |
| 2.  | Powdery plastic of the WC brand – V736A                  | –                                      | 5    | 10   | 15   |
| 3.  | Water cement relation (w/c)                              | 0.5                                    | 0.6  | 0.6  | 0.6  |
| 4.  | Density, kg/m <sup>3</sup>                               | 1850                                   | 1730 | 1520 | 1340 |
| 5.  | Spreadability on a cone of AZNII, cm                     | 23                                     | 24   | 25   | 25   |
| 6.  | Durability on a bend (in 2 days), MPa                    | 0.21                                   | 0.25 | 0.22 | 0.21 |
| 7.  | Shrinkage (-), expansion (+)                             | –1                                     | +2   | +2.4 | +2.5 |

Following from these (tab. 2) that the most acceptable composition of this composite mix for cementation of oil and gas wells with the normal and lowered reservoir pressure is mix of 90% of the Portland cement with plastic of 10%, at w/c = 0.6 density of solution have 1520 kg/m<sup>3</sup> which cement stone has durability on a bend of 0.22 MPa in two days of curing and has sufficient effect of expansion. For cementation of gas wells where reservoir pressures are 10–15% more than, a water column the author has studied polymeric

mixes with additives of mineral fillers, for example the marble powder (MP), the KFZh synthetic pitch (carboamideformaldehyde liquid) and hardener – adduct of a polietilenimin, also sulfate copper (APSC) without presence of the Portland cement at solution. On the basis of KFZh, APSC and MT by the author are received grouting solution with a density of 1400 kg/m<sup>3</sup> at the high durability on a bend of 0.34 MPa with curing in two days and the extending effect up to 25%. Results of pilot studies are given in (tab. 3).

Table 3.

| Contents mass of% |    |                                     |      | Experience temperature, °C | Pressure of experience, MPa | Durability on a bend in 2 days, MPa | Expansion, % |
|-------------------|----|-------------------------------------|------|----------------------------|-----------------------------|-------------------------------------|--------------|
| KFZh              | MP | Solution density, kg/m <sup>3</sup> | APSC |                            |                             |                                     |              |
| 50                | –  | 1240                                | 0,5  | 75                         | 30                          | 0.27                                | 15           |
| 50                | –  | 1260                                | 1,0  | 75                         | 30                          | 0.30                                | 17           |
| 50                | 15 | 1300                                | 2,0  | 75                         | 30                          | 0.32                                | 20           |
| 50                | 20 | 1460                                | 2,0  | 75                         | 30                          | 0.32                                | 23           |
| 50                | 25 | 1400                                | 2,5  | 75                         | 30                          | 0.34                                | 25           |

For the purpose of receiving a complex of developments of the cement stone allowing to use him in various geological specifications, the author has investigated color metallurgical production of the so-called elimination of aluminum slags (EAS), fraction of 0.15 millimeters which in a large number have accumulated at the plant of joint stock company « Uzvtortsvetmeta ». EAS represents powder of aluminum of gray color with a den-

sity of 2260 kg/m<sup>3</sup>. EAS easily mixes up with cement. It consists of oxides of aluminum, SiO<sub>2</sub> silicon iron, etc. EAS is investigated regarding his use as additive to a Portland cement for the purpose of increase in tightness of a cement ring of an operational column and prevention of annular gas-manifestations at expected cement hardening (ECH) and formations of intercolumned pressure in (tab. 4) are given results of pilot studies below.

Table 4. – Results of researches of the elimination of aluminum slag (EAS) with a Portland cement in the presence of 5% of a phosphite

| № P/n | Composition of grouting solution                                  | Technological parameters grouting solution |      |      |      |      |
|-------|---|--|------|------|------|------|
|       |   | 100  | 95   | 90   | 85   | 80   |
| 1     | Portland cement of masses, %                                      | 100  | 95   | 90   | 85   | 80   |
| 2     | EAS additive, masses, %   | –  | 5    | 10   | 15   | 20   |
| 3     | Water-cement relation   | 0.5  | 0.6  | 0.7  | 0.7  | 0.7  |
| 4     | Density of solution, kg/m <sup>3</sup>                            | 1840                                       | 1760 | 1680 | 1600 | 1560 |
| 5     | Spreadability on a cone of AZNII, cm                              | 26   | 25   | 24   | 24   | 24   |
| 6     | Durability on a bend through the 2nd days of curing, MPa          | 0,24                                       | 0,21 | 0,15 | 0,10 | 0,07 |
| 7     | Shrinkage (–) or expansions (+), %                                | –1   | +3   | +4   | +5   | +5   |
| 8     | Setting terms: the beginning, hour – min.<br>the end, hour – min. | 1–50                                       | 1–45 | 1–30 | 1–10 | 1–10 |
|       |   | 2–35                                       | 2–35 | 2–10 | 1–40 | 1–35 |

Following from tab. 4 that EAS additive to a Portland cement on weight of 5–10% in more stoutly meets requirements imposed to grouting solution stone has acceptable spreadability, admissible durability of a stone on a bend of 0,24–0,21 MPa in two days of curing and also the effect expansion of 3–4% possesses that will favorably influence coupling of cement with a column and breed. However at increase the maintenance of EAS up to 15% and higher than durability of a stone on a bend becomes insignificant 0.07 MPa and extent of expansion – weak.

It composition of solution can be used as fast-grabbing mix (FGM) at isolation a zone of leaving of boring solutions and grouting composition.

On the basis of the made experiments it is possible to draw the following conclusions:

1. The most acceptable structure for the solution of an objective is the grouting composition on the basis of carboamideformaldehyde liquid with APSC hardener, the rest marble powder and water which at  $T=75\text{ }^{\circ}\text{C}$  and  $P=30\text{ MPa}$  gives expansion to 25% at the density of solution of 1400 kg/m<sup>3</sup>.

Such very essential expansion of grouting composition certainly enhances adhesion of solution – a stone with the limiting surfaces a stone – a pipe and a stone – rock and also interferes with formation of a crack, channels filled with drilling mud fluid, formed in a stone in a ring, impenetrable and strong weight.

The crack resistance of a grouting stone is provided due to plasticity of grouting mix as a part of which there is no Portland cement.

2. The grouting composition on the basis of the Portland cement and powdery plastic is acceptable for cementation of wells where there are absorbing zones and where the effect expansion is of secondary importance.

3. The grouting composition on the basis of the blank Portland cement has solution shrinkage – a stone therefore she won't influence strengthening of contact with the limiting surfaces.

4. The perspective direction in this problem is search of complexons of cement mortars, the t.e of chemical compounds which considerable degree increase the expanding effect of solution – a stone without decrease in their durability.

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## KINEMATIC ANALYSIS OF THE CRANK-BEAM MECHANISM WITH COMPOUND HINGES WITH FIXED CHANGES IN THE LENGTH OF THE LINKS

**Abstract:** The article presents a new scheme and principle of operation of the crank and rocker mechanism with composite kinematic pairs with elastic elements. Taking into account the fixed deformations of the elastic elements, the analytical kinematics of the mechanism are obtained, the numerical solution of the problem determines the laws of motion of the rocker mechanism, the main parameters are substantiated.

**Keywords:** mechanism, crank, connecting rod, rocker, kinematic pair, elastic element, excess coupling, fixed deformation, length, displacement speed.

In the classical theory of machines and mechanisms, graphical, graph-analytical and analytical methods for the kinematic analysis of plane lever mechanisms [1; 2]. At the same time, the links are considered rigid and the deformations of the elastic elements in the mechanisms are not taken into account. To obtain more complex laws of motion of the output links of the mechanisms necessary for technological machines, we developed a crank-rocker plane mechanism with compound hinges and elastic elements [3].

The essence of the recommended crank and rocker mechanism is that the kinematic pairs (hinges) are made integral, including an axle, fitted on it with an elastic (rubber) bushing on which the bushing is rigidly connected to the link (crank, connecting rod or rocker). Elastic bushings allow to amortize and smooth shock interactions in the hinges in the extreme positions of the links, and also due to the deformation of the elastic bushings, the lengths of the links change, which allows them to correct the laws of their motion within the necessary limits. For this purpose, the thickness of the elastic (rubber) bushings of composite balls are chosen according to the ratio of the lengths of the links. The thickness of the elastic

sleeve in the joint hinge (kinematic pair) is chosen equal to the ratio of the length of the next link to the length of the previous link multiplied by 1.0 mm. The greater the difference in length between adjacent links, the greater the reaction force and shock interactions between them, so that the value of the thickness of the elastic sleeve will also be large. This allows the necessary amortization of loads and correction in the law of motion of links.

The construction is explained by a drawing, where in (Fig. 1), a is a 1-general diagram of the crank-rocker mechanism. The crank and rocker mechanism consists of a column 1, a crank 2, a connecting rod 3 and a rocker 4. The joints between the links 2 and 3, 3 and 4, 4 and 1 are made integral, which includes an axis 5, an elastic bush 6, the sleeve 7 rigidly connected to the links 1, 2, 3, 4 of the mechanism. In this case, the thicknesses of the elastic bushings 6 are chosen:

$$\Delta_1 = \frac{l_2}{l_1} \cdot 1,0 \text{ mm}; \Delta_2 = \frac{l_3}{l_2} \cdot 1,0 \text{ mm}; \Delta_3 = \frac{l_4}{l_3} \cdot 1,0 \text{ mm}$$

where,  $l_1, l_2, l_3, l_4$  – respectively, the lengths of the links 1, 2, 3, 4.

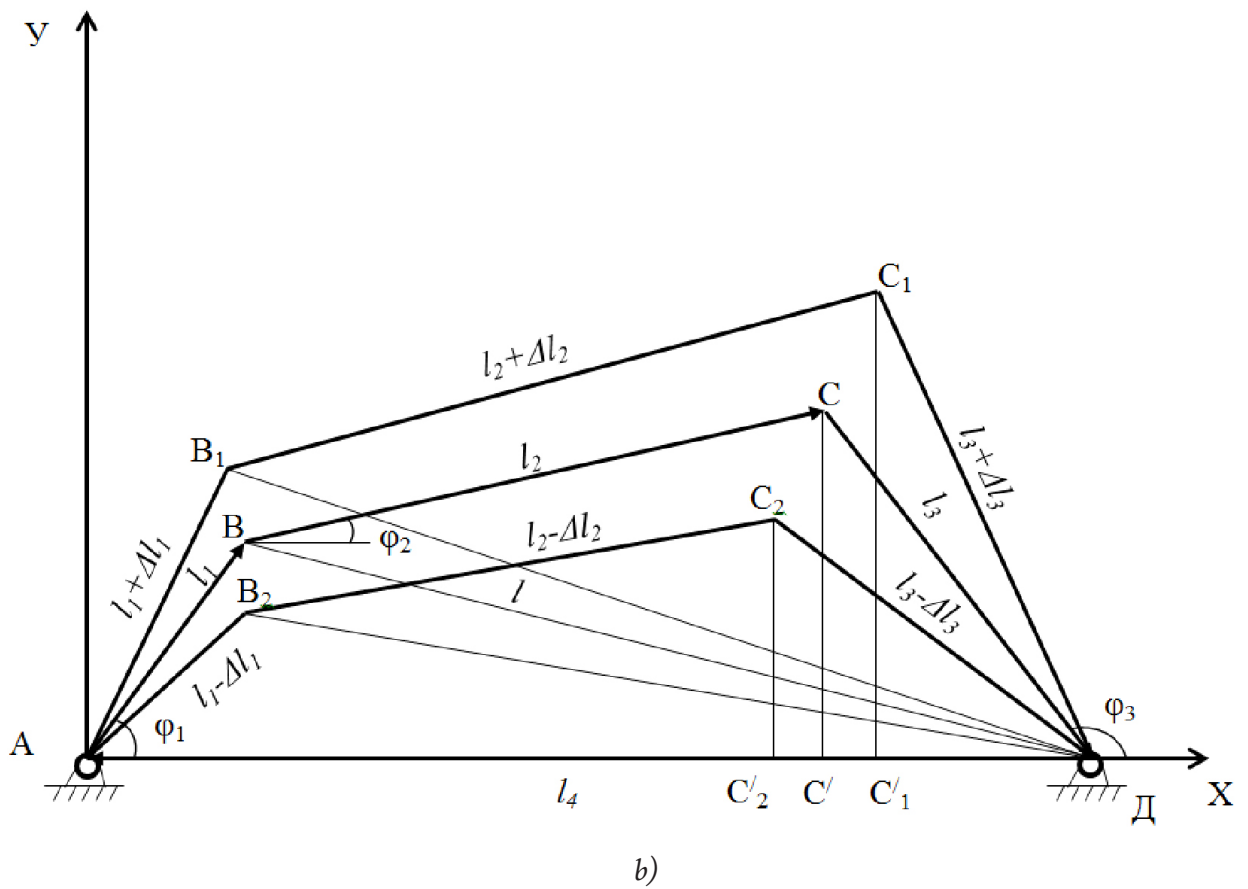
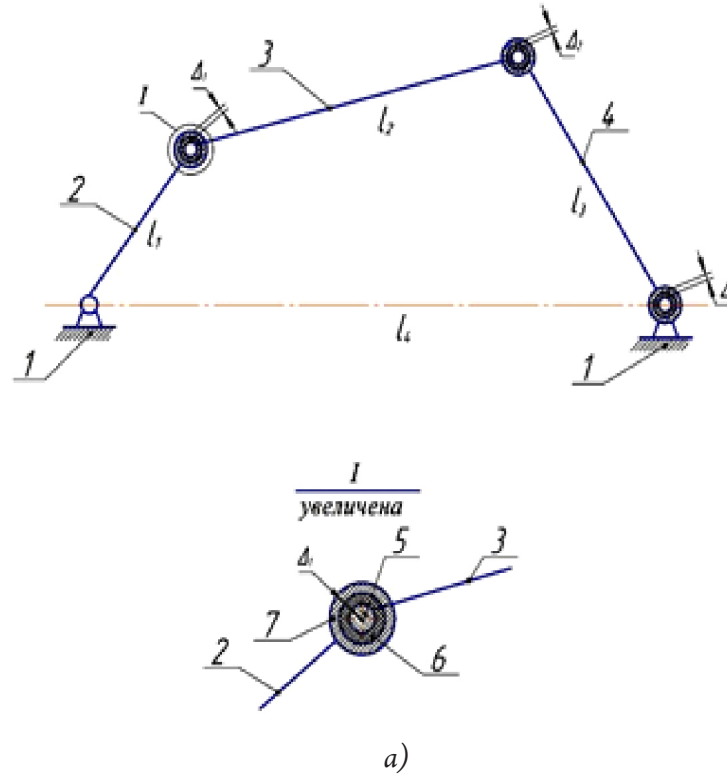


Figure 1. a – crank and rocker mechanism with compound hinges and elastic elements;  
 b – calculation scheme of the crank-rocker mechanism with elastic elements



The crank-rocker mechanism works as follows. Crank 2 receives rotational motion from the drive motor (not shown in the figure). Accordingly, the movement from the crank 2 is transferred to the connecting rod 3, then to the rocker arm 4. Movement of the mechanism occurs in the plane. At the extreme positions of the crank 2, connecting rod 3 and rocker 4, impact phenomena occur in the kinematic pairs between the links 2, 3, 4 and 1. At impacts, the elastic sleeve 6 absorbs the impact, the reaction force decreases. In addition, due to the deformation of the elastic sleeve 6, the lengths  $l_1, l_2, l_3, l_4$ . This leads to a change in the trajectory of the points 2, 3, 4. Therefore, choosing the thickness (rigidity) of the elastic sleeve 6, it is possible to regulate its deformations, thus the necessary laws (trajectory) of the movement of links 2, 3, 4 of the mechanism.

The thickness of the elastic sleeve 6 in the composite joints (kinematic pairs) is chosen equal to the ratio of the length of the next link to the length of the previous link and multiplied by 1,0 mm. The greater the difference in length between adjacent links, the greater the reaction force and impact interaction in the kinematic pair. Therefore, the thickness of the deformation of the elastic sleeve 6 will also be large.

In this case, in fact, the elastic sleeves 6 reduce or eliminate the amount of excess bonds in the kinematic pairs.

For the recommended mechanism

$$q = 1 - 6n - 5P_5 - K = 1 - 6 \cdot 3 + 5 \cdot 4 - 3 = 0$$

Hence, in the recommended crank-beam mechanism there are no excessive connections. This leads to an increase in the resource of work.

The mechanism allows necessary changes (corrections) of the movement of links (points of links) within certain limits necessary for the intensification of technological processes in the machine.

For the considered crank and rocker mechanism, taking into account the deformations of the elastic elements between the crank and the connecting rod, and also between the connecting rod and the rocker, we will compute the design scheme, which is shown in (Fig. 1b). In this case, the deformations of elastic bushes in kinematic pairs are taken into account in the form of fixed values, maximum and minimum. Then the length of the crank, connecting rod and rocker will be increased or decreased due to these values of fixed deformations of the elastic sleeves of the kinematic pairs. To study the kinematics

of the proposed mechanism, taking into account the fixed deformations of the elastic elements in the hinges B and C, we use the classical technique of vector contours [4; 5]. From the calculation scheme in (Fig. 2). It can be seen that the closed contour of the ABCD can be divided into two separate closed triangular contours  $\Delta ABD$  and  $\Delta DBC$ . Taking into account the equilibrium system, the sum of the vectors of closed contours will be zero. In this case we have [3]:

$$\bar{l}_1 + \bar{l}_2 + \bar{l}_3 = 0; \quad \bar{l}_1 + \bar{l}_2 + \bar{l}_3 = 0 \quad (1)$$

where,  $l_1, l_2, l_3, l_4$  – variables modulo vectors.

When designing the vector equations (1), and also taking into account the elongations of the links due to the fixed minimum and maximum deformations of the elastic elements of the kinematic pairs of the crank and beam mechanism on the x and y coordinate axes, we have:

$$\begin{aligned} & (l_1 + \Delta l_1) \cos(\phi_1 + \Delta \phi_1) + \\ & + (l + \Delta l) \cos(\phi_e - \Delta \phi_e) - l_4 \cos \phi_4 = 0; \\ & l_1 \cos \phi_1 + l \cos \phi_e - l_4 \cos \phi_4 = 0; \\ & (l_1 - \Delta l_1) \cos(\phi_1 - \Delta \phi_1) + \\ & + (l - \Delta l) \cos(\phi_e + \Delta \phi_e) - l_4 \cos \phi_4 = 0; \quad (2) \\ & (l_1 + \Delta l_1) \sin(\phi_1 + \Delta \phi_1) - \\ & - (l - \Delta l) \sin(\phi_e - \Delta \phi_e) - l_4 \sin \phi_4 = 0; \\ & l_1 \sin \phi_1 + l \sin \phi_e - l_4 \sin \phi_4 = 0; \\ & (l_1 - \Delta l_1) \sin(\phi_1 - \Delta \phi_1) - \\ & - (l - \Delta l) \sin(\phi_e + \Delta \phi_e) - l_4 \sin \phi_4 = 0. \end{aligned}$$

According to the design scheme (see Figure 1), the fixed values of the elongations of the crank, connecting rod and rocker arm due to deformations of the elastic elements of the kinematic pairs are taken into account by the following expressions

$$\begin{aligned} l_{1\max} &= l_1 + \Delta l_1; \quad l_{1\min} = l_1 - \Delta l_1; \\ l_{2\max} &= l_2 + \Delta l_2; \quad l_{2\min} = l_2 - \Delta l_2; \\ l_{3\max} &= l_3 + \Delta l_3; \quad l_{3\min} = l_3 - \Delta l_3; \\ l_{\max} &= l + \Delta l; \quad l_{\min} = l - \Delta l \end{aligned}$$

where,  $\Delta l_1, \Delta l_2, \Delta l_3, \Delta l$  – fixed values of changes in quantities  $l_1, l_2, l_3, l$ .

In this case, the maximum and minimum deviations of the angles  $\phi_2$  and  $\phi_3$  are determined from the following expressions

$$\begin{aligned}
 \phi_{2\max} &= \arccos \frac{(l_1 + \Delta l_1)^2 + (l_2 + \Delta l_2)^2 - (l_3 + \Delta l_3)^2 + l_4^2 + 2(l_1 + \Delta l_1)l_4 \cos \phi_1}{2(l_2 + \Delta l_2)\sqrt{(l_1 + \Delta l_1)^2 + l_4^2} - 2(l_1 + \Delta l_1)l_4 \cos \phi_1} + \\
 &\quad + \operatorname{arctg} \frac{(l_1 + \Delta l_1) \sin \phi_1}{(l_1 + \Delta l_1) \cos \phi_1 - l_4} \\
 \phi_{2\min} &= \arccos \frac{(l_1 - \Delta l_1)^2 + (l_2 - \Delta l_2)^2 + l_4^2 - (l_3 - \Delta l_3)^2 - 2(l_1 - \Delta l_1)l_4 \cos \phi_1}{2(l_2 - \Delta l_2)\sqrt{(l_1 - \Delta l_1)^2 + l_4^2} - 2(l_1 - \Delta l_1)l_4 \cos \phi_1} + \\
 &\quad + \operatorname{arctg} \frac{(l_1 - \Delta l_1) \sin \phi_1}{(l_1 - \Delta l_1) \cos \phi_1 - l_4} \\
 \phi_{3\min} &= \arccos \frac{(l_2 - \Delta l_2)^2 - (l_1 - \Delta l_1)^2 - (l_3 - \Delta l_3)^2 - l_4^2 + 2(l_1 - \Delta l_1)l_4 \cos \phi_1}{2(l_3 - \Delta l_3)\sqrt{(l_1 - \Delta l_1)^2 + l_4^2} - 2(l_1 - \Delta l_1)l_4 \cos \phi_1} + \\
 &\quad + \operatorname{arctg} \frac{(l_1 - \Delta l_1) \sin \phi_1}{(l_1 - \Delta l_1) \cos \phi_1 - l_4}
 \end{aligned} \tag{3}$$

In this case, the linear velocity of the hinge axis between the crank and the connecting rod changes within

$$V_{\max} = (l_1 + \Delta l_1)\omega_1; \quad V_{\min} = (l_1 - \Delta l_1)\omega_1 \tag{4}$$

The solution of the kinematics problem of the crank and beam mechanism with the elastic elements of the composite hinges was carried out with the following values of the parameters:  $\omega_1 = 350 \text{ s}^{-1}$ ;  $l = 32 \cdot 10^{-3} \text{ m}$ ;  $l_2 = 65 \cdot 10^{-3} \text{ m}$ ;  $l_3 = 36 \cdot 10^{-3} \text{ m}$ ;  $l_4 = 62 \cdot 10^{-3} \text{ m}$ ;  $\Delta l_1 = (1.8 \dots 2.1) \cdot 10^{-3} \text{ m}$ ;  $\Delta l_2 = (0.06 \dots 1.0) \cdot 10^{-3} \text{ m}$ ;  $\Delta l_3 = (1.7 \dots 2.0) \cdot 10^{-3} \text{ m}$ .

On the basis of the numerical solution of the kinematics problem of the mechanism under consideration, graphical dependences of the angular velocity of the connecting rod and rocker are plotted without considering the deformations of the elastic elements of the mechanism hinges, which are shown in (Fig. 2). Analysis of the graphs in (Fig. 2), a show that an increase in  $l_3$  from  $2.7 \cdot 10^{-3} \text{ m}$  to  $4.2 \cdot 10^{-3}$  causes the amplitude of the angular velocity of the rocker to increase from  $2.90 \cdot 10^2 \text{ s}^{-1}$  to  $5.05 \cdot 10^2 \text{ s}^{-1}$ . In this case, the amplitude of the oscillations of the angular displacement of the beam increases from 6.85 degrees to 11.8 degrees (see Fig. 2 b). It should be noted that, taking into account the fixed values of  $\Delta l_1$ ,  $\Delta l_2$  and  $\Delta l_3$ , the angular displacement and angular velocity of the connecting rod and rocker the mechanism under consideration. In (Fig. 3) shows the obtained regularities of the change with variation,  $\Delta l_1$ ,  $\Delta l_2$  and  $\Delta l_3$ . By processing the obtained regularities of the change, graphical dependences are constructed, which

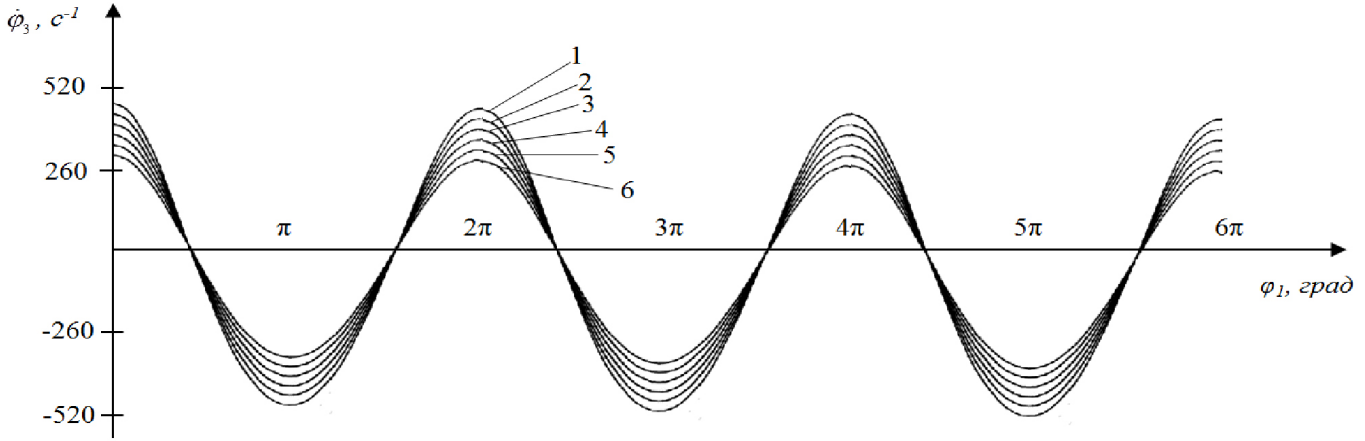
are presented in (Fig. 4). It is seen from them that with an increase in the length  $l_3$  of the beam of a flat four-link from  $2.7 \cdot 10^{-2} \text{ m}$  to  $4.2 \cdot 10^{-2} \text{ m}$ , the angular velocity of the rocker decreases from  $3.35 \cdot 10^{-2} \text{ s}^{-1}$  to  $0.75 \cdot 10^{-2} \text{ s}^{-1}$  for  $l_2 = 6.0 \cdot 10^{-2} \text{ m}$  (see Figure 4a). With the length of the connecting rod  $l_2 = 7.0 \cdot 10^{-2} \text{ m}$ , the angular frequency of the oscillation of the rocker decreases from  $5.0 \cdot 10^{-2} \text{ s}^{-1}$  to  $2.95 \cdot 10^{-2} \text{ s}^{-1}$ . Analysis of the graphs in Fig. 4 shows that to increase the angular velocity of the rocker arm, it is advisable to increase the length of both the connecting rod and the rocker itself.

Increasing the difference in the lengths of the crank and rocker leads to an increase in the swing angle of the angular oscillations of the connecting rod with its plane-parallel motion. Therefore, to ensure the smallest angular oscillations, it is advisable to decrease the value of  $l_3 - l_1$ , and at a value of  $l_3 - l_1 = 0$ , the connecting rod moves parallel to the horizontal,  $\phi_2 = 0$ .

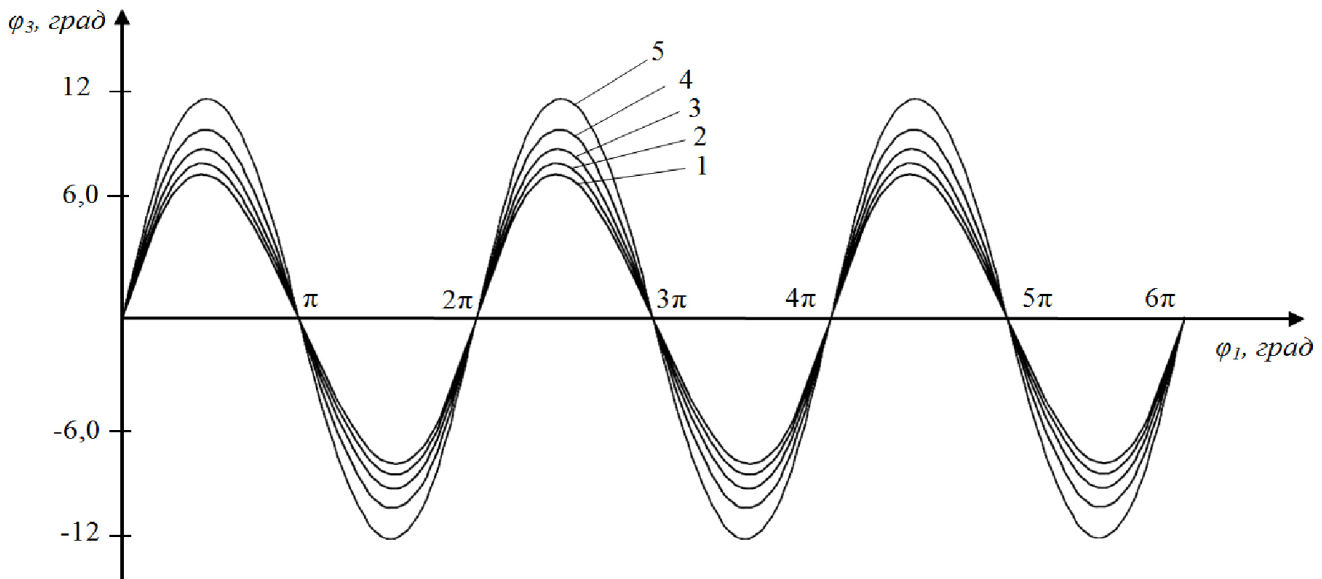
Important are the studies with a variation of the fixed values of the deformations of the elastic elements of the kinematic pairs of the mechanism. The changes in  $\Delta l_1$ ,  $\Delta l_2$  and  $\Delta l_3$  are mutually related and proportional to the respective lengths of the links of the mechanism. Fixed strains according to the above allow you to select the necessary rubber bushings for the corresponding hinges of the mechanism. Analysis of the studies shows that, in the presence of deformations,  $\Delta l_1$ ,  $\Delta l_2$  and  $\Delta l_3$  lead to some high-frequency oscillations. At the same time, an increase in the values of  $\Delta l_1$ ,  $\Delta l_2$ ,  $\Delta l_3$  leads to an increase in the amplitude of high-fre-

quency angular oscillations of the rocker mechanism. The increase in  $\Delta l_1$  and  $\Delta l_3$  leads to an increase in low-frequency oscillations of the beam. This is explained by the fact that an increase in  $\Delta l_3$  actually results in an increase in the length of the beam by  $\Delta l_3$ . At the same

time, the range of oscillations decreases. The increase in  $\Delta l_2$  influences insignificantly on the range of oscillations. It should be noted that the greater the difference between  $\Delta l_1$  and  $\Delta l_3$ , the greater the amplitude of high-frequency oscillations of the rocker arm.



a) where, 1 – at  $l_3 = 4.2 \cdot 10^{-2}$  m; 2 – at  $l_3 = 3.9 \cdot 10^{-2}$  m; 3 – at  $l_3 = 3.6 \cdot 10^{-2}$  m;  
4 – at  $l_3 = 3.3 \cdot 10^{-2}$  m; 5 – at  $l_3 = 3.0 \cdot 10^{-2}$  m; 6 – at  $l_3 = 2.7 \cdot 10^{-2}$  m



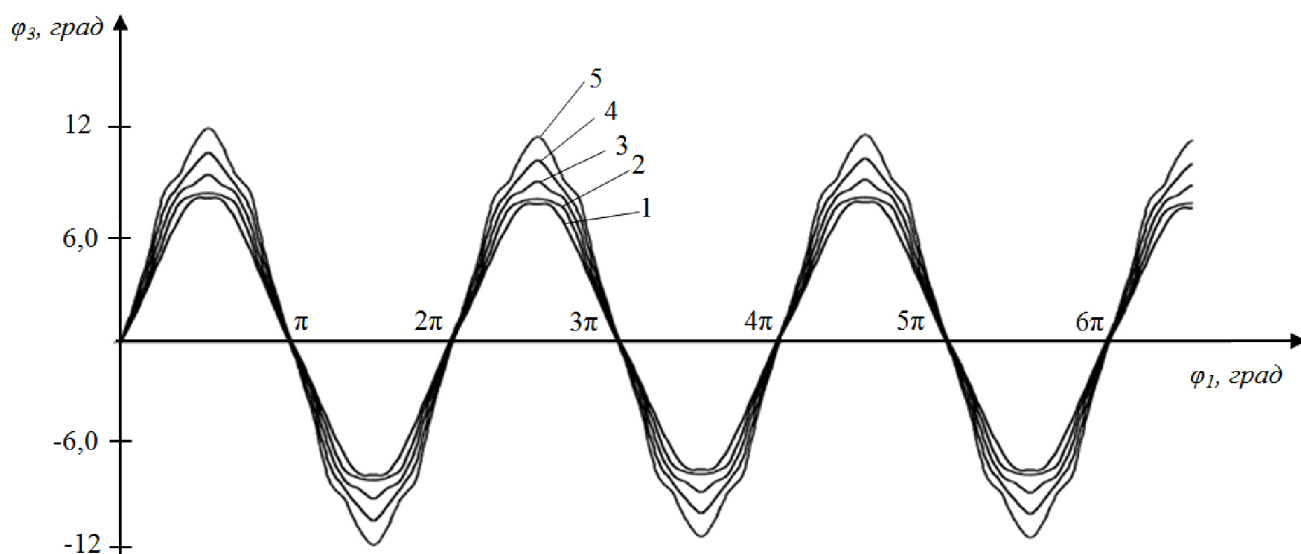
b) where, 1 – at  $l_3 = 42 \cdot 10^{-3}$  m; 2 – at  $l_3 = 39 \cdot 10^{-3}$  m; 3 – at  $l_3 = 36 \cdot 10^{-3}$  m; 4 – at  $l_3 = 33 \cdot 10^{-3}$  m; 5 – at  $l_3 = 30 \cdot 10^{-3}$  m

Figure 2. a – graphical dependences of the angular velocity variation of the rocker mechanism of the crank angular motion function for various  $l_3$  and at  $\Delta l_1 = 0$ ;  $\Delta l_2 = 0$ ;  $\Delta l_3 = 0$ ;

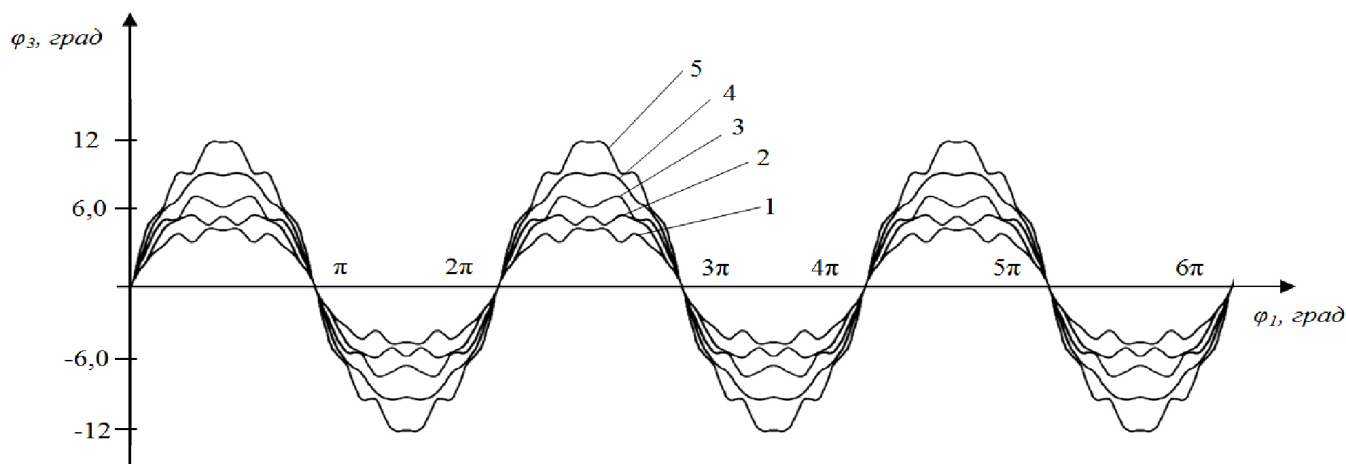
b – graphical dependences of the change in the angular displacement of the rocker arm from the change in the angular displacement of the crank for different  $l_3$  and at  $\Delta l_1 = 0$ ;  $\Delta l_2 = 0$ ;  $\Delta l_3 = 0$

To ensure the necessary amplitudes of high-frequency oscillations of the connecting rod due to fixed deformations of the elastic elements of the hinges, it is advisable to change the values of  $\Delta l_1$  and  $\Delta l_3$  rather than  $\Delta l_2$ .

Similar regularities were obtained by studying the variation of  $\Delta l_1$ ,  $\Delta l_2$ ,  $\Delta l_3$ . In order to increase the amplitude of the high-frequency oscillations of the beam, it is also advisable to increase the difference  $\Delta l_1 - \Delta l_3$ .



a) where, 1 – at  $\Delta l_3 = 2.5 \cdot 10^{-3}$  m; 2 – at  $\Delta l_3 = 2.0 \cdot 10^{-3}$  m; 3 – at  $\Delta l_3 = 1.5 \cdot 10^{-3}$  m; 4 – at  $\Delta l_3 = 1,0 \cdot 10^{-3}$  m; 5 – at  $\Delta l_3 = 0.75 \cdot 10^{-3}$  m



b) where, 1 – at  $\Delta l_3 = 4.0 \cdot 10^{-3}$  m; 2 – at  $\Delta l_3 = 3.5 \cdot 10^{-3}$  m; 3 – at  $\Delta l_3 = 3.0 \cdot 10^{-3}$  m; 4 – at  $\Delta l_3 = 2,0 \cdot 10^{-3}$  m; 5 – at  $\Delta l_3 = 1.0 \cdot 10^{-3}$  m

Figure 3. Graphical dependences of the change in the angular movements of the rocker arm mechanism on the variation of the angular movement of the crank with the variation of  $\Delta l_2$  (a) and  $\Delta l_3$  (b)

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## **ANALYSIS OF THE UNEVEN GEAR RATIO CHAIN TRANSMISSION WITH ELASTIC ROLLER SLEEVE**

**Abstract:** The article describes the scheme and operation of the recommended design of the chain transmission with elastic roller sleeve. Provides an analytical method for the determination of the coefficient of uneven gear ratio chain transmission with flexible roller chain including an elastic rubber sleeve, substantiates the values of the recommended parameters.

**Keywords:** Chain drive, compound roller, an elastic sleeve, the unevenness, gear ratio, sprocket, link, teeth, and deformation of rubber.

### **Introduction**

In the existing design of the chain transmission contains driving and driven sprocket, and a flexible element—a chain transmitting motion from the drive sprocket to the driven one [1; 2]. The disadvantage of this chain transmission is in operation, the reduction angle of wrap of the chain sprockets, a significant slack in the driven (idle) branch of circuit that conducts to decrease in efficiency, and in some cases tearing or snagging of the chain with the sprockets. Additionally, when transmitting heavy loads at high speed modes of movement there appears noise due to the shock interaction of the teeth with the surfaces of the rollers of the chain, increases friction, and thus wear and tear, as rollers of the chain and the teeth of the sprockets.

**The development of construction.** We recommended a new design of chain transmission (see Fig.1) [3; 4].

In the process, this chain transmits rotational motion from the sprocket 1 to the driven sprocket 2 via the chain 3. Further movement of the sprocket 2 is transmitted to the base 6 to the output shaft 7 via an elastic annular bushing 5. the change in angular displacement of the driven sprocket 2, arising because of the gaps be-

tween the chain 3 and the sprocket teeth 2, and also due to changes in friction and wear and gearing etc. to some extent aligned (damped) elastic annular bushing 5. Where in rotation of the base 6 to the output shaft 7 sprocket 2 becomes more uniform and smoother. In the interaction of the teeth of the sprockets 1 and 2 with the roller 12 due to the deformation of the rubber sleeve 15 significantly reduced the wear sleeve 13 and the teeth of the sprockets 1 and 2. It also reduces the friction between the bushing 11 and the roller 10. This leads to increased durability and reliable operation of the chain transmission. In the process, by performing the outer surface 16 of the rubber bushing 15 when interacting with the teeth of the sprockets 1 and 2 is the required deformation of the sleeve 15, particularly at its edges is provided by a kind of centering the pressure of the roller 12 from the teeth of the sprockets 1 and 2. This leads to uniform distribution of load over the entire length of the roller 12, which allows increasing the reliability, thereby increasing the resource chain 3 assists.

The analysis of the operation of the chain transmission shows that the gear ratio is changed continuously. Meanwhile, the average value of the ratio will be constant [5]:



$$U_{12} = \frac{\omega_1}{\omega_2} = \frac{Z_2}{Z_1}$$

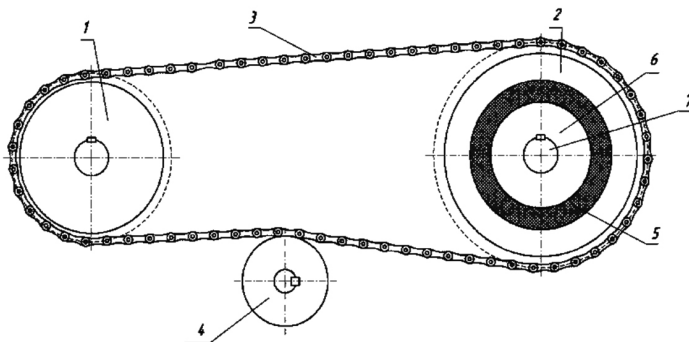


Figure 1. Diagram of the chain transmission

**Definition of uneven gear ratios.** In technological machines an important thing is the determination of the uneven gear ratio chain transmission with flexible roller chain due to deformation of the elastic sleeve. This provides the ability to control the unevenness of the angular velocity of driven sprocket directly connected with the working body of the machine.

In (Fig. 2) presents the scheme of the chain of transmission at different positions of the chain and sprockets with account of deformation of the elastic bushing roller chain.

If we consider that the length of the leading branches of the multiples of a whole number of links in a chain, the distance between the axes of the sprockets will be:

$$A = \frac{kt}{\cos \alpha} \quad (2)$$

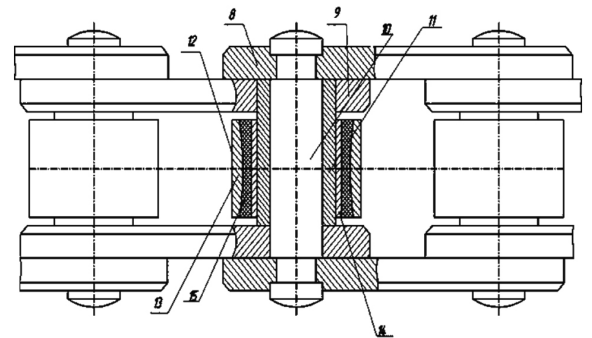
Where  $k$  is the number of whole links in the leading branch of the chain;  $t$  is the step between the teeth of the sprockets.

According to this we have:

$$\alpha = \arctg \frac{1}{2k} \left( \frac{1}{\sin \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)} - \frac{1}{\sin \left( \frac{\pi}{Z_1} + \Delta\varphi_1 \right)} \right) \quad (3)$$

Where  $\Delta\varphi_1$ ,  $\Delta\varphi_2$  are the offset angles of the axes of the rollers of the chain due to deformation of the elastic rubber bushings in engagement with the teeth of the driving and driven sprockets. In this case, the angular speed of the driven sprocket at first gear (the chain shown in solid line) taking into consideration [5]:

where  $\omega_1$ ,  $\omega_2$  is the angular velocity of driving and driven sprockets  $Z_1$ ,  $Z_2$  the number of teeth of the driving and driven sprockets.



$$\omega_{21} = \frac{V_2}{R_2 \cos \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)} = \frac{\omega_1 R_1 \cos \left( \frac{\pi}{Z_1} + \Delta\varphi_1 \right)}{R_2 \cos \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)} \quad (4)$$

Then we have:

$$\omega_{21} = \omega_1 \frac{\operatorname{tg} \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)}{\operatorname{tg} \left( \frac{\pi}{Z_1} + \Delta\varphi_1 \right)} \quad (5)$$

For this position the chain in engagement with the sprockets the gear ratio will be:

$$U_{21} = \frac{\omega_1}{\omega_2} = \frac{\operatorname{tg} \left( \frac{\pi}{Z_1} + \Delta\varphi_1 \right)}{\operatorname{tg} \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)} \quad (6)$$

In this case, the angular speed of the driven sprocket after rotating it to the corner (chain and sprockets shown in (Fig. 2) a by dash-dotted line):

$$\omega_{22} = \omega_1 \frac{R_1}{R_2} = \omega_1 \frac{\sin \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)}{\sin \left( \frac{\pi}{Z_1} + \Delta\varphi_1 \right)} \quad (7)$$

The gear ratio of chain transfer in this moment would be:

$$U_{12}^1 = \frac{\omega_1}{\omega_{22}} = \frac{\sin \left( \frac{\pi}{Z_1} + \Delta\varphi_1 \right)}{\sin \left( \frac{\pi}{Z_2} + \Delta\varphi_2 \right)} \quad (8)$$

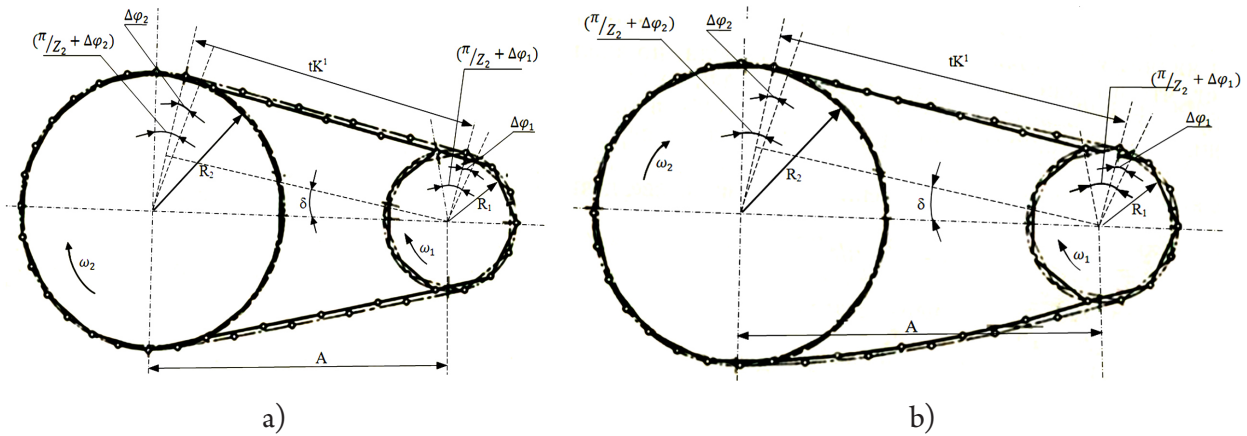


Figure 2. Scheme chain transmissions with elastic elements of the roller chain; where – a) is the length of the leading branches equal to the length of the integer member number of the links; – b) is the length of the leading branches equal to the length of the whole number of links plus the half link

Comparison of expression ratios (6) and (8) are different and depend mainly on the number of teeth of the sprockets. In this case the angular speed of the driven sprocket also varies.

Important is to define actual values of transfer numbers with a glance of the deformation of the elastic rubber bushings roller chain transmission. In (Fig. 2 b) the transfer length of the drive chain is determined from the expression.

The angular speed of the driven sprocket in this moment is:

$$\omega_{23} = \omega_1 \frac{R_1}{R_2} \cos\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right) = \omega_1 \frac{\sin\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)}{\operatorname{tg}\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right)} \quad (10)$$

Taking into account (10) the gear ratio will be:

$$U_{13} = \frac{\omega_1}{\omega_2} = \frac{\operatorname{tg}\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right)}{\sin\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)} \quad (11)$$

In the second point of the gearing (chain and sprockets shown in (Fig. 2 b), by the dash-dotted line) the angular velocity of driven sprocket is determined from the following expression:

$$\omega_{24} = \frac{V_2}{R_2 \cos\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)} = \omega_1 \frac{\operatorname{tg}\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right)}{\sin\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)} \quad (12)$$

At the time of engagement of the chain with sprockets the gear ratio will be:

$$U_{13}^1 = \frac{\operatorname{tg}\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right)}{\sin\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)} \quad (13)$$

In our case, we have:

$$U_{13} > U_{13}^1, \omega_{24} > \omega_{23}; U_{12}^1 > U_{13}^1 \quad (14)$$

Then the coefficient of unevenness ratio of the chain transmission will be:

$$\delta_u = \frac{2(U_{13} - U_{13}^1)}{U_{13} + U_{13}^1} \quad (15)$$

Substituting (11) and (13) to (15) we obtain:

$$\delta_u = \frac{\sin\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right) - \sin 2\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right) \cos\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)}{\sin\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right) + \sin 2\left(\frac{\pi}{Z_1} + \Delta\varphi_1\right) \cos\left(\frac{\pi}{Z_2} + \Delta\varphi_2\right)} \quad (16)$$

**The solution of the task and analysis of the results.**

Analysis (16) shows that the coefficient of unevenness of gear ratios recommended chain depend on the number of sprocket teeth and magnitudes of deformation of the elastic bushings of the chain at engagement with the sprocket. In (Figure 3 a) presented the patterns of change of the coefficient of uneven gear ratio chain transmission from variations in the number of teeth of the sprockets.

With the increase of the average value of the transmission ratio  $Z_2/Z_1$  coefficient is increased  $\delta_u$  with non-linear patterns.

When the value of the deformation  $\Delta\varphi_1$  and  $\Delta\varphi_2$  is equal to 0.15% from the step value of the transmission and  $Z_2/Z_1$  changed from 1.4 to 3.2 coefficient of unevenness in-

creases from  $1.1 \cdot 10^{-2}$  to  $9.2 \cdot 10^{-2}$ , and at an angular deformation of the elastic rubber bushings to 0,225% from the value of the step coefficient  $\delta_u$  increases to  $12,31 \cdot 10^{-2}$ .

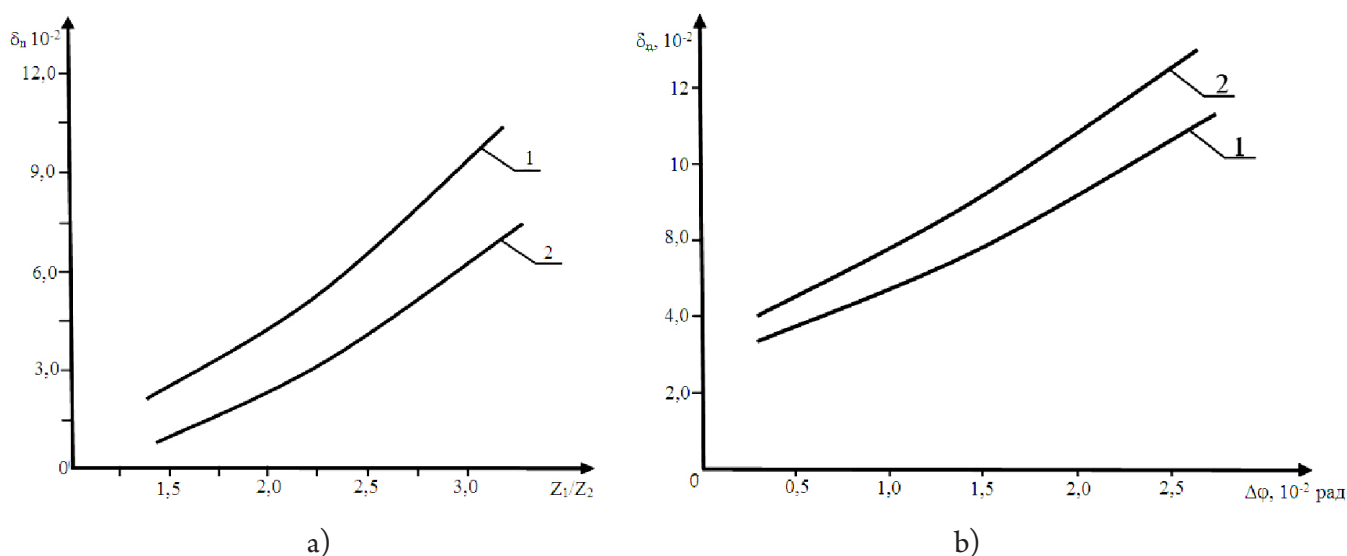


Figure 3 Graphic dependences of change of coefficient of uneven gear ratio chain transmission from changes in the number of teeth of the sprockets (a) and values of angular deformation of the elastic rubber bushings of roller chain in the process of gearing with the sprocket; Where 1 at  $\Delta\varphi_1$  and  $\Delta\varphi_2$  equals to 0,15t, 2 at  $\Delta\varphi_1$  and  $\Delta\varphi_2$  equals to 0.225t and t is step value of the transmission; Where 1–1 –  $\delta_u$  equals to  $f(\Delta\varphi_1)$ ; 2 –  $\delta_u$  equals to  $f(\Delta\varphi_2)$

It should be noted that the increase of the uneven rotation of the driven sprocket is deemed necessary for the intensification of technological processes in machines (particularly in cotton cleaners and machines for soil treatment). But, a significant increase of  $\delta_u$  could lead to a breach of the gearing in the transmission.

Therefore, the recommended values of  $\delta_u$  for ginning machines are  $(3.4...6.5) \cdot 10^{-2}$ . In (Fig. 3 b) shows a graphical dependence of change of coefficient of uneven gear ratio chain transmission from changes in angular strain of the elastic bushings of the chain rollers with meshing teeth of sprocket. The increase of  $\Delta\varphi_1$  and  $\Delta\varphi_2$  strain leads to increase of  $\delta_u$  by non-linear patterns. The difference between  $\Delta\varphi_1$  and  $\Delta\varphi_2$  influence to change  $\delta_u$  is insignificant.

When changing  $\Delta\varphi_1$  from 0,5  $0.5 \cdot 10^{-2}$  rad to  $2.6 \cdot 10^{-2}$  rad  $\delta_u$  increases from  $3.25 \cdot 10^{-2}$  to  $9.8 \cdot 10^{-2}$ , and with the increase of  $\Delta\varphi_2$  in the specified limits, the coefficient  $\delta_u$  of uneven gear ratio chain transmission is increased to  $11.92 \cdot 10^{-2}$ . The difference  $\delta_u$  for changes  $\Delta\varphi_1$  and  $\Delta\varphi_2$  comes to  $0.89 \cdot 10^{-2}$ .

### Conclusion

Practically in the transmission chain with an elastic rubber sleeve roller chain in many cases,  $\Delta\varphi_1 = \Delta\varphi_2$ . Therefore, the recommended values of  $\delta_u (3.4...6.5) \cdot 10^{-2}$   $\Delta\varphi_1$  and  $\Delta\varphi_2$  should be taken in the range of  $(0.6...1.4) \cdot 10^{-2}$  number. These values of deformation of the elastic bushings provided by rubber stamps 7B-4 MBC.

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## **TECHNOLOGY OF OBTAINING SILICATE MATERIALS AND PRODUCTS BASED ON MINERAL RAW MATERIALS AND PRODUCTION WASTE**

**Abstract:** Development of technology for obtaining autoclave-silicate materials and products based on mineral raw materials and production wastes in the Republic of Karakalpakstan is considered in the paper.

**Keywords:** raw mix, ceramic bricks, use of local raw materials, lime-slag, lime-cement, lime-belite.

At the present stage of economic and social development of the Republic of Uzbekistan, the issue of the complex use of local raw materials, the development of environmentally friendly, energy – and resource-saving highly-effective technologies for the production of building materials is of great importance.

Rapidly growing rates of industrial and housing construction require the growth of production of building materials and products, including autoclave-silicate materials, the need for which has increased in recent years. The increase in transportation costs dictates the need to organize the production of building materials (including silicate materials) locally, where there is a demand for them and the availability of relevant raw materials.

Recently, a special attention is paid to the development of research in the field of chemical technology and membrane technology, as well as the creation of new structural materials, the integrated use of natural resources, which excludes harmful effects on the environment.

The production and use of Portland cement, alumina and other types of binders is based on the fact that the raw mix is fired at high temperature in order to obtain silicates, aluminates and calcium ferrite. The process of firing is very energy-intensive and the organization of cement production requires very high costs [1].

The building materials industry of the Republic uses only ceramic bricks as wall materials; they are produced by high-temperature firing and clays are used as raw material. Clay minerals are the main and vital components of the soil, necessary for the existence of the flora.

The development of production of these materials requires the expansion of the raw material base through the use of local raw resources. In the production of silicate autoclave materials, various binders such as lime, limestone-belite, limestone-slag, lime-cement, etc., are used as a binder.

Technology for obtaining autoclave-silicate materials and products based on mineral raw materials and production wastes is developing in the Republic of Karakalpakstan.

### **Objectives of the study:**

– Physical-chemical substantiation and development of highly effective technology for obtaining autoclave silicate materials with increased physical and mechanical properties of special purpose on the basis of local raw materials;

– Analysis of the current state of the matter in the field of structure formation and hydration of binder materials under hydrothermal conditions of setting.

The introduction of autoclave silicate materials on the basis of limestone-belite binders will bring huge



economic benefits, as currently the building materials are mainly produced from relatively expensive and not easily accessible Portland cement. The cost of silicate products will be 30–40% lower than the cost of products made of cement concrete.

Accordingly, the development of environmentally friendly, resource-saving, highly efficient technologies for the production of building materials based on barkhan (crescentic dunes) sands and waste products of the Republic is very relevant.

Improvement of the production of lime-and-sand brick is based on the achievements of domestic scientists who conduct research to identify the nature and laws of physical and chemical processes to improve technology and quality of lime-and-sand bricks. This makes it possible to create a theoretical basis for further improvement of the technology of autoclave materials [2].

Study of physical-chemical and physical-mechanical properties of carbonate minerals in the Ustyurt deposit shows that the rock consists mainly of calcareous and marly minerals based on calcium carbonate  $\text{CaCO}_3$ .

The chemical-mineralogical composition of the Ustyurt carbonate-argillaceous rocks of the explored deposits is a mixture of calcium and magnesium carbonates, silica and alumina compounds (in the form of clay particles), some calcium sulfate in the form of gypsum, a small amount of soluble salts of sulfuric and hydrochloric acids.

Physical and chemical characteristics of the carbonate-clay rocks of the Ustyurt plateau testify to the

possibility of their use for the production of various binders for building materials: air lime, construction lime, limestone-belite binder, water lime and Roman cement.

The kinetics of hydration structure formation was judged by the change in plastic strength ( $P_m$ ) of the system measured on a Geppler consistometer.

The study of HS processes hydration structure formation in concentrated limestone-belite binders pastes makes it possible to reveal the role of the nature of the hydrated phase in the kinetics of strength formation and its creation in originated spatial structure.

The nature of kinetic changes in plastic strength of the system at  $B/T = 0.90$  differs from the nature of change in strength of the system at  $B/T = 1.0$  and  $B/T = 1.2$ ; plastic strength first increases, then, after three days of exposure of the system, falls sharply, followed by a second sharp increase after 14 days. At other  $B/T$  ratios, a sharp increase in the strength of the system after 14 days has also been observed.

From the data presented, it can be seen that the water demand of the limestone-belite binders, obtained on the basis of studied marls is greater than that of Portland cement or gypsum. This is due to the fact that free calcium oxide  $\text{CaO}$  (58.24 and 50,30%) is present in large amounts in the composition of the IPM limestone-belite binders, together with belite ( $\beta - \text{C}_2\text{S}$ ), which, when hydrated with a high water requirement, passes into calcium oxide hydrate.

Table 1. – Results of physical researches of limestone-belite binders pastes

| №  | limestone-belite binder on the basis of marls deposit | Normal density, % | Time of setting, min. |     | Specific surface, $\text{cm}^2/\text{g}$ |
|----|---|-------------------|-----------------------|-----|--|
|    |   |                   | beginning             | end |  |
| 1. | Porlytau  | 90                | 48                    | 131 | 3200                                     |
| 2. | Porlytau  | 90                | 46                    | 144 | 3500                                     |

Table 1 shows the dependence of mechanical strength of the limestone-belite binders samples on the time of setting. As can be seen from the table, both in

conditions of moisture-air and thermal-moist setting, the mechanical strength of the specimens increases with time; its greatest value takes place after 28 days.

Table 2. – Results of the study of mechanical strength under compression of samples of limestone-belite binders in conditions of moisture-air and thermal-moist setting

| №  | ИББ on the basis of marls, deposit | $B/T$ | Compressive strength, MPa |        |         |                       |        |         |
|----|------------------------------------|-------|---------------------------|--------|---------|-----------------------|--------|---------|
|    |                                    |       | moisture-air setting      |        |         | thermal-moist setting |        |         |
|    |                                    |       | 3 days                    | 7 days | 28 days | 3 days                | 7 days | 28 days |
| 1. | Porlytau                           | 0.90  | 0.98                      | 2.83   | 7.35    | 4.05                  | 6.40   | 14.26   |
| 2. | Porlytau                           | 0.90  | 1.86                      | 4.77   | 9.41    | 4.30                  | 7.81   | 14.53   |

Thus, the processes of hydration structure formation in the variances of the limestone-belite binders obtained on the basis of the marls of the Akburly and Porlytau deposits are characterized not only by the formation of different types of structures in the system – coagulation and crystallization ones, with the transition of the first one in-

to the second, but also by different stages of formation of the crystallization structure. On the basis of studies of physical-chemical and physical-mechanical properties of the limestone-belite binders, it can be concluded that they present an effective binding material for obtaining high-strength products of autoclave setting.

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## **TECHNOLOGIES FOR OBTAINING HIGH-STRENGTH GYPSUM FROM GYPSUM-CONTAINING WASTE OF SULFUR PRODUCTION – FLOTATION TAILINGS**

**Abstract:** Development of technology for obtaining gypsum binder from gypsum-containing wastes of sulfur production–flotation tailings is considered in the paper, it requires the investigation of the effectiveness of various methods for obtaining gypsum binders and searching for optimal technological parameters.

**Keywords:** mono-mineral binder, gypsum-containing waste, phosphor-gypsum, flotation tailings, organic and inorganic compounds, chemical composition, granulometric composition, thermal treatment, container.

Vast experience is gained in the production and use of gypsum mono-mineral binder, one of the most studied building materials. Moreover, in recent years, the production and use of gypsum and especially gypsum products in highly developed countries are continuously increasing.

At present the most important raw materials for the production of gypsum products are gypsum-containing wastes from chemical industry and, above all, waste from phosphorus fertilizers (phosphor-gypsum) production. In terms of waste utilization and ecology, the study solves an actual problem.

The need of Uzbekistan's industry for gypsum raw materials can also be met through industrial by-products. This will reduce the extraction of natural gypsum stone, as well as reduce the cost of the construction and operation of slag accumulators of gypsum-containing wastes. The use of by-products containing calcium sulfate in industry has not only economic but also environmental implications. Significant funds are spent to the disposal of waste, sometimes they reach 8–10% of the cost of the main products.

A small proportion of used gypsum-containing waste from their total quantity is due to the peculiarities of physical-chemical composition and properties that do not allow to apply traditional methods for processing natural gypsum raw materials. Flotation tailings con-

tain a small amount of semi-aqueous calcium sulphate, which is formed with the technology of obtaining sulfur from natural sulfuric stone.

The basis for the production of gypsum binders is the process of thermal dissociation of calcium sulfate dihydrate. Losing a part of crystallization water, the dihydrate gypsum passes into a semi-aquatic gypsum, which under normal conditions is chemically active with respect to water; that makes it possible to use this product as a binder.

The use of gypsum-containing wastes in the production of binders is dictated by economic and environmental objectives.

Except calcium sulphate, the main substance of gypsum-containing waste, they can contain impurities that significantly alter the technical properties of the binders obtained. Impurities may contain both organic and inorganic compounds, namely, compounds of silicon, fluorine, aluminum and iron, alkaline and rare earth elements, radioactive compounds, as well as certain amounts of free acids.

Mechanical impurities of organic substances, as well as the presence of easily soluble salts of sodium and magnesium, leads to the staining of gypsum, contribute to the formation of efflorescences on the surface of products, impair the setting process. Physical-chemical impurities are the most difficult removed. It is sufficient to

rinse the raw material to remove mechanical impurities, but in order to eliminate physical-chemical impurities, a recrystallization process must be carried out along with washing. Free acids, present as impurities in gypsum-containing waste, contribute to the lengthening of the setting time, deterioration of binder adhesion and the strength of products, and cause corrosion of the equipment. In order to get rid of impurities, active washing and neutralization are necessary [5].

However, the results of more recent studies [1, 4] indicate that in the plants, designed to process natural gypsum stone, it is impossible, without the introduction of additional technological operations, to obtain from gypsum-containing waste a binder that meets the required standards.

Flotation tailings are a powdery substance of grayish-white color with a specific surface of 900–1000 cm<sup>2</sup>/g, which are formed as a result of separation of sulfur inclusions from ore. According to the technology, sulfur ore from the quarry is ground, mixed with water; sulfur inclusions due to the difference in the density of materials are on the surface of crushed ore (pulp), which is collected by special devices and directed for the processing. Pulp with gypsum-containing waste with a significant amount of water is diverted to special collectors-sedimentation tanks, where it is dried under atmospheric influence.

The average bulk density of waste in a loose state is 950 kg/m<sup>3</sup>, in a compacted state – 1100 kg/m<sup>3</sup>.

Flotation tailings consist mainly of dihydrate gypsum, the total content of which varies between 80–90% by weight. In addition, they contain sulfur, silica, alumina and other substances from the original rock.

Flotation tailings also contain a small amount of semi-aqueous calcium sulphate formed when sulfur is produced from natural sulfuric stone as a by-product of the technology adopted at the plant.

It is known that each type of gypsum binder has a certain structure of the crystal lattice. Studies show that according to granulometric composition, the ordinary building gypsum consists, as a rule, of fine and porous grains of detrital nature, which determine the high water intake of gypsum during mixing and the low strength of the products obtained from it. All this is due to the free removal of hydrated water from the gypsum.

Despite a significant number of studies devoted to the technology of obtaining high-strength gypsum bind-

ers, the researchers do not have a single opinion on the technological parameters, the methods of preparing raw materials for hydrothermal treatment, and on comparative effectiveness of using various methods for obtaining high-strength gypsum.

In the production of gypsum binders from gypsum-containing waste, the technology can undergo certain changes related to the material composition of the raw material, i. e. its morphology.

In general, the process of obtaining high-strength gypsum from gypsum stone includes the following technological methods: crushing of gypsum stone, autoclave treatment of crushed gypsum stone, drying the obtained calcium sulfate hemihydrate and grinding the finished product.

Gypsum-containing raw material -flotation tailings of sulfur production differ from known gypsum-containing wastes by the composition of impurities, the state of calcium dihydrate and other features.

In this regard, the actual problem is the development of technology for obtaining high-strength gypsum from gypsum-containing waste of sulfur production — flotation tailings; this development requires investigation of the effectiveness of various methods for obtaining gypsum binders and searching for optimum technological parameters.

Due to the powdery state of flotation tailings, it is necessary to determine the possibility of its thermal treatment in an autoclave in its natural state

One meter high container is filled with a slightly moistened initial product. After autoclaving, samples of obtained binder from different points along the height and width of the container are taken. The experimental data are presented in Table 1.4.

As can be seen from the table, the deeper (down to 40–50 cm) samples are taken, are lower the strength parameters. Studies have shown that autoclaved treatment at an optimum vapor pressure of 0.2 MPa, a steaming time of 20 hours and a drying time of 20–22 hours, the formation of the necessary number of centers of recrystallization of the dihydrate into the hemihydrate in the entire volume of the material occurs only to a depth of 20 cm.

We have constructed a special stack with trays 20 cm high (on the basis of above mentioned experiments), into which slightly moistened flotation tailings in a loose state were poured. The thermal treatment of the product was carried out according to the optimum mode.

Table 1. – Influence of the height of the waste layer on the properties of gypsum binder at thermal treatment

| Height of raw material layer in autoclave container, cm | Strength MPa under |         | Time of setting, min |              | Water – gypsum ratio |
|---|--------------------|---------|----------------------|--------------|----------------------|
|   | compression        | bending | beginning            | end          |                      |
| 10  | 8.3                | 3.6     | 12                   | 2103         | 0.37                 |
| 20  | 8.6                | 3.8     | 12                   | 20           | 0.37                 |
| 40  | 2.9                | 1.6     | 25                   | 70           | 0.55                 |
| 50  | 2.7                | 1       | 37                   | 120          | 0.55                 |
| 60  | 2.7                | 1       | 40                   | <i>unset</i> | 0.55                 |

Despite the high values of strength of gypsum binder obtained with this technology, it should be noted that certain production processes, in particular, unloading and labor-consumption, increase the net cost of the binder.

In this regard, the finely ground flotation tailings should be coarsened into granules or briquettes and heat treated.

As noted earlier, the waste of sulfur production -flotation tailings, as gypsum-containing by-products of sulfur production, is a pulp with a significant amount of water (up to 45%), and in a dried state (in case of dehydration in natural conditions)- a powdery greyish-white substance. It is impossible to obtain wastes with a certain moisture-content. This makes difficult to use wastes

of sulfur production without additional procedures for their conditioning.

A number of methods for conditioning (granulating) gypsum-containing wastes are known from the literature [2; 3]; these methods are developed mainly for phosphor-gypsum. They have several drawbacks, which make them inapplicable for the conditioning of waste products of sulfur production-flotation tailings, since they demand either the introduction of additives as binders that are not used primarily in production; that significantly complicates the conditioning process, or making it uneconomical, complex and multistage.

All this necessitates the development of more economical and simple methods for conditioning raw materials.

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## CONTROL PARAMETERS OF COTTON-RAW AND ITS PRODUCTS IN AGRO-INDUSTRIAL COMPLEX

**Abstract:** In the article methods and ways, development and improvement of system of technical control as one of the most important elements of quality management of cotton-raw and its products in agro-industrial complex are considered. Electro physical characteristics of cotton-raw and its products are analysed. By results of experimental data the dielectric method for control of parameters of cotton-raw and its products in agro-industrial complex is recommended.

**Keywords:** humidity of cotton-raw, heatphysical method, chemical method, distillation method, mechanical method, capacitor method, metrological characteristics of hydrometers, metrological support, testing scheme, checking of Moisture Meter.

Development and improvement of system of technical control as one of the most important elements of quality management of cotton-raw and its his products in agro-industrial complex, for what:

- carries out systematic work on the analysis of system effectiveness of technical control at acceptance, completing, storage of cotton-raw and its processing, elimination the reasons of production of poor quality;

- will organize, and carry out standards on cotton-raw and cotton production and controls their observance;

- participates in tests of the new, modernized samples of processing equipment, technological processes, laboratory measuring instruments, techniques of assessment of qualitative characteristics of cotton-raw and production from it;

- provides laboratories with new, more perfect devices for control of parameters (for example, humidity, temperature, density) qualities of raw materials and production and also standards and standard samples of cotton-raw and its production.

Materials of agro-industrial complex, including cotton-raw and its products of processing have complex structure and usually almost all types of production include organic and mineral weed impurity. Physical properties a component of these materials ( $F_{ki}$ ) significantly differ and depend from a number of factors, including on their humidity ( $W_{ki}$ ) also microstructures ( $S_{ki}$ ), degree of

a maturity ( $Z_{ki}$ ), storage conditions and processing ( $X_{ki}$ ), temperature ( $T_{ki}$ ).

$$F_{ki} = f(W_{ki}, T_{ki}, S_{ki}, Z_{ki}, X_{ki}) \quad (1)$$

It is obvious that physical properties of material ( $F_M$ ) depend on property his component ( $F_{ki}$ ), their quantitative ratio ( $M_{ij}$ ), a relative positioning ( $R_{ij}$ ), quantity ( $N$ ), and volume ( $R$ ) of air inclusions between them.

$$F_m = Q(F_{ki}, M_{ij}, R_{ij}, N, P) \quad (2)$$

The humidity of material ( $W$ ) is defined as the relation of all mass of water in controlled volume to the dry mass of this volume ( $M$ ).

$$W = \frac{M_B}{M} = \frac{\sum_1^n W_{ki} \cdot M_{ki}}{\sum_1^n M_{ki}} \quad (3)$$

where  $M_{ki}$  – weight i-components;

$n$  – quantity material component.

Cotton-raw as humidity object of measurement, all above-mentioned features are inherent. Cotton-raw on the structure belongs to the category of fibrous badly loose bodies. Elastic forces, fibrous weight interfere with his self-consolidation therefore at free states a part of cotton-raw is filled with air.

In the (figure 1) it is visible that in different zones of control key parameters cotton raw and production of his processing ( $T$  – temperature,  $W$  – humidity,  $Z$  – density) absolutely differ from each other. Nevertheless

dependences of dielectric parameters on humidity for these materials have an identical appearance and are close among themselves.

In (fig. 1). the model of non-uniform material is shown.

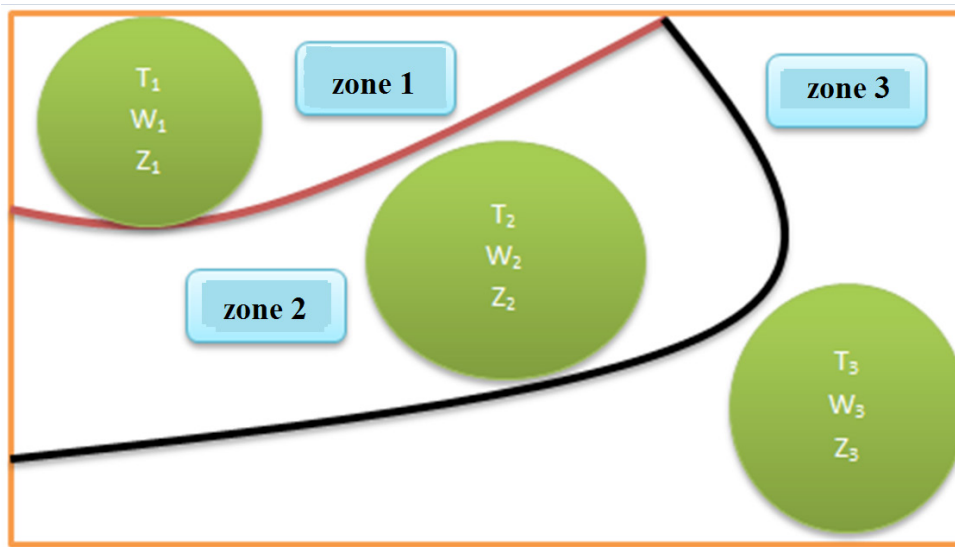


Figure 1. Model of non-uniform material

For control of humidity (W) in any physical parameter, it is necessary information on values:

$$W = f(T, S, Z, X, M, R, N, P)$$

where: T – cotton-raw temperature; S – of feature of macro and micro structure; Z – cotton-raw density; X – cotton grades; M, N, P – other influencing factors on result of measurement.

Experimental researches show that the main lack of almost all known cotton hydrometers – dependence of indications on a grade, density, temperature, the area of growth of cultures, etc. what causes need of receiving real functions of transformation of hydrometers (workers the grading characteristics). If not to consider it, in

results of measurement of humidity considerable errors can creep.

Any product, including cotton raw and products of his processing can't be considered as ideal dielectric and therefore the electric energy brought to the condenser converter filled with a product is spent not only for a condenser recharge, but also dissipates in the form of thermal losses in dielectric. Thus, not the true, but the valid, seeming condenser capacity significantly depending on losses is practically measured.

If to consider a controlled product as the dielectric filling the converter, then the equivalent scheme of the converter can be presented in the form of the electric chain shown in (fig. 2).

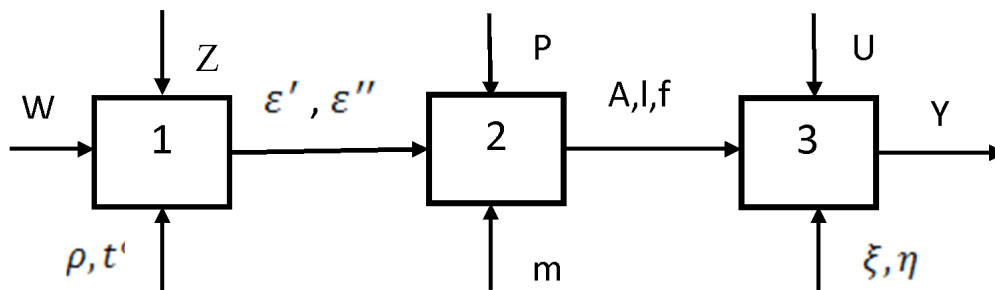


Figure 2. The generalized mathematical model of measurement

Static characteristics of primary probe converter of humidity and temperature of fibrous materials are provided

on the (figure 3). Apparently, have fiber the best linear characteristics, than other types of cotton products.

The modern express hydrometer has a number of advantages, the main ones of which are: a possibility of their use for control of humidity of a wide class of materials which physical and chemical indicators doesn't change in time of the electrophysical parameters; using rather simple, inexpensive, easy-to-work and highly reli-

able electronic equipment in work; a possibility of receiving the errors meeting requirements of the existing normative documents to devices for control of humidity; lack of need of application of any means of biological protection at their operation as such systems don't make harmful effects on service personnel.

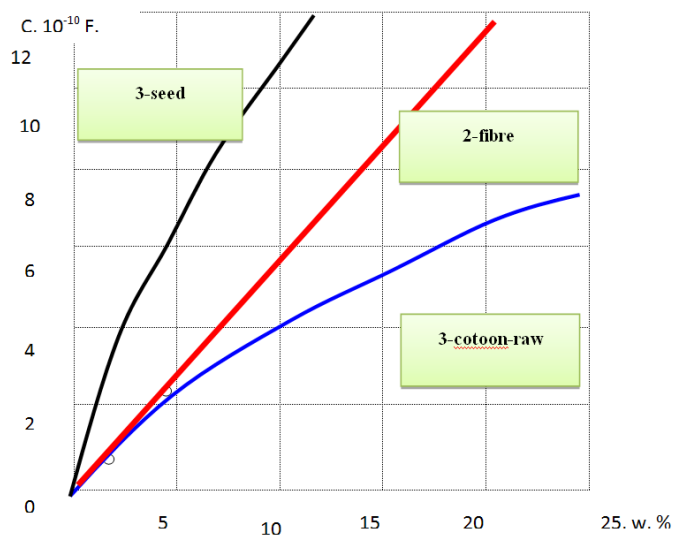


Figure 3. Characteristics of the converter of humidity seeds – (1), fiber – (2) and cotton-raw – (3)

Introduction of the probe device for control parameters of cotton-raw and its products in agro-industrial complex to reduce time for control raises efficiency and

efficiency of technological process. Also improved technical and metrological characteristics of the device increases mobility at measurements.

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## MODELS OF SERVICE CALLS IN THE RAILWAY NETWORKS

**Abstract:** Currently, the rail network communication share on the network operational technological communication (OTC) and overall technological communication (OvTC). They operate separately. In each of these networks are set switching stations serving only their subscribers.

**Keywords:** network operational technological communication, overall technological communication, network, model, dispatch communication.

### 1. Call service networks in OTC and OvTC

Call service networks and resources in networks OTC and OvTC fundamentally different. In the network OTC basic subscribers are dispatcher and subordinates them to performers who are united in the following dispatch communication. Dispatch circle is an isolated subnet OTC, which closes all calls. For each dispatcher circle offers a shared network resource: analog network – a group voice frequency channel, digitally – a group the main digital channel E0 (64 kbit/s). Calls coming in, served without losses and without expectations. The only time indicator of the digital service system is the time to establish the connection. This time in the digital network depends on the number of switching stations involved in the connection, signaling traffic load control devices. In the digital network to dispatch communication, affecting the safety of trains, this time should not exceed 2 seconds [1, 6–9].

In OvTC network subnet is not allocated, and the subscribers serviced primarily through a system with a loss of call. The exception is the call centers used to organize manual intercity stations (MIS) with semi-automatic and connections for passengers (booking and reservation of tickets, help desk). In these centers, calls from the subscribers served by the system with the expectation. Resource OvTC network is only available for

the transmission of user information in a single communication session. In this case, the individual channels are formed between subscriber user devices.

When you create digital networks with circuit, switching OTC attempts were partial federated systems OTC and OvTC. For example, switching stations were set up with distributed switching field, part of which was allocated for the OTC, and the other – for OvTC. Normative documents on the creation of digital systems allow for OTC systems the union of OTC and OvTC level connection management systems. These control systems presented a requirement for logical separation of call control functions in networks OTC and OvTC.

When switching to packet switching technology there are new preconditions for unification systems OTC and OvTC. Effective packet network transmission of information from different subnets on the same channels. In such a network, the principle of the separation of call control and switching processes, as well as the allocated function to provide additional services, for example conferencing. Therefore, in the packet network call control functions in the OTC and OvTC systems can be combined in a shared server, which controls the process of connections, user access to network services, distribution of network resources.

**2. Model service call in the united network**

It is possible to examine the following model of service call to the the united network, taking into account the features of systems and OTC and OvTC:

MODEL 1 – with a combined stream of information of all subscribers dispatch communication network OTC and all users of ObTS network;

MODEL 2 – with the union of the flow of information subscribers dispatch communication network OTC, except subscribers train dispatcher communication (TDC) and all the users ObTS network; TDC subscribers are provided with a dedicated resource network constantly. Consider the model 1.

MODEL 1 – shared resources for all subscribers OTC and OvTC. The subscribers are divided into three classes, depending on the priority of the call service. In the first class with the highest priority, include subscribers TDC circles. This class of subscribers serviced with an absolute priority, and thus no losses and standby. The second class is formed by subscribers of other dispatching circles: energy-dispatch communication (EDC), the service dispatch communication (SDC), linear-directional communication (LDC), wagons and administrative communication (VAC) and other. Here also may include subscribers of different dispatchers movement control, for example, DLU – dispatcher of loading and unloading, DTLC – dispatcher to manage transportation of liquid cargo and others. Calls from these subscribers are served with a relative priority when employment network resources calls are in the queue. The third class includes subscribers ObTS and they served no priorities for system calls loss. Calls may be lost for two reasons: due to the employment of all network resources and thus interrupt the connection. The latter occurs when a call from a first-class, and the absence of a free resource network [2, 80–85].

In figure 1 showing scheme of the model. The model calls three groups of sources, with the number of calls the group of sources corresponds to the number of subscribers of class. From the first and second sources of independent groups received primitive call flows, from the third – a simple call flow. Network resources are characterized by permissible number of concurrent connections –  $V$ . For call the second group of sources provides queuing, which are not limited by length. In queue calls are when the number of concurrent connections reaches the value  $V$ . Calls in the third group are lost with a probability  $P_p$  – due to reaching the limit established connections with probability  $P_1$  – in the case of interruption of the connection to subscribers of the first class. The intensity of the call receipts for the first ( $\lambda_1$ ) and second ( $\lambda_2$ ) source groups are defined by the formulas:

$$\lambda_1 = (N1 - i)a1; \lambda_2 = (N2 - i)a2$$

$N1$  and  $N2$  – the number of circles for the dispatch of the first and second classes of subscribers;  $a1$  and  $a2$  – the intensity of the receipts of calls in one round for the dispatch of the first and second classes of subscribers, respectively;  $i$  – the number of dispatch circles which are in a call condition.

The flow from the third group of sources – the simplest and is characterized by the intensity of calls  $\lambda_3$ . The intervals between calls are distributed exponentially. In this group, the number of sources is not limited. All call arrives intensities per unit of time adopted an hour. The duration of calls to subscribers of all classes is subject to an exponential law.

In the process of modeling the task of determining the value of  $V$  for specified load parameters must be addressed and indicators of quality of service calls.

The simulation was performed for two variants of the original data, given in table 1.

Table 1. Initial data

| Variants | Sources group 1 |            |                 | Sources group 2 |            |                 | Sources group 3 |                       |
|----------|-----------------|------------|-----------------|-----------------|------------|-----------------|-----------------|-----------------------|
|          | $N1$            | $\tau1, c$ | $a1$ call./hour | $N2$            | $\tau2, c$ | $a2$ call./hour | $\tau3, c$      | $\lambda3$ call./hour |
| 1.       | 10              | 26         | 47              | 20              | 40         | 12              | 90              | 800                   |
| 2.       |                 |            |                 |                 |            |                 |                 | 1200                  |

In the model, the following quality service call rates can be obtained by:

– for the second class of subscribers: chance expectations  $P_{ex}$ ; the average waiting time for all calls  $\gamma$  and expectant caller  $\gamma_{ex}$ ;

– for subscribers of third class: of probability  $P_p, P_1$  and the probability of the common challenges of losses  $P_c$ .  $\tau1, \tau2, \tau3$  – the average duration of calls to the appropriate sources of group. The following values have been taken  $V$ : in the first variant – from 24 to 40, the second variant – from 28 to 52.



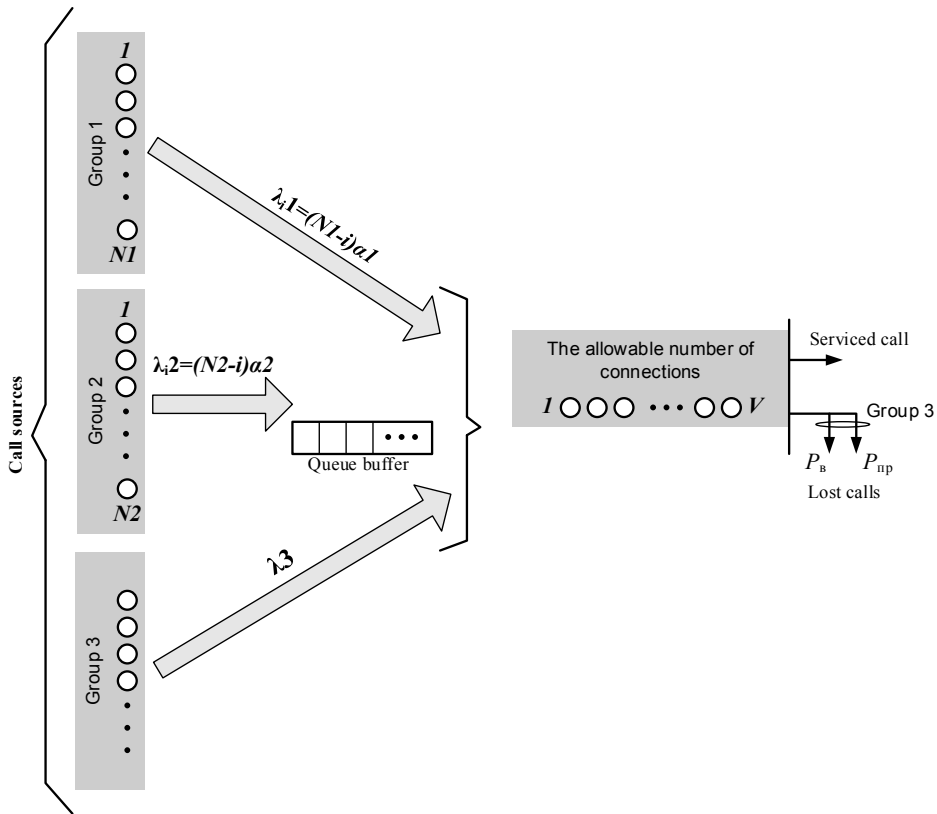


Figure 1.

The simulation results are presented in graphs

The dependence of the probability of expectation  $P_{ex}$  from  $V$

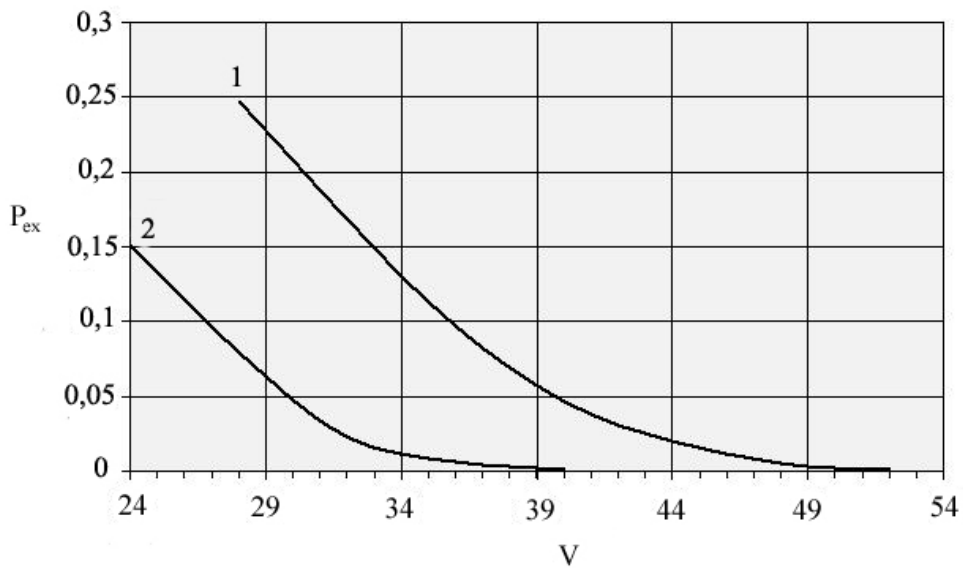


Figure 2. 1 – variant 2; 2 – variant 1

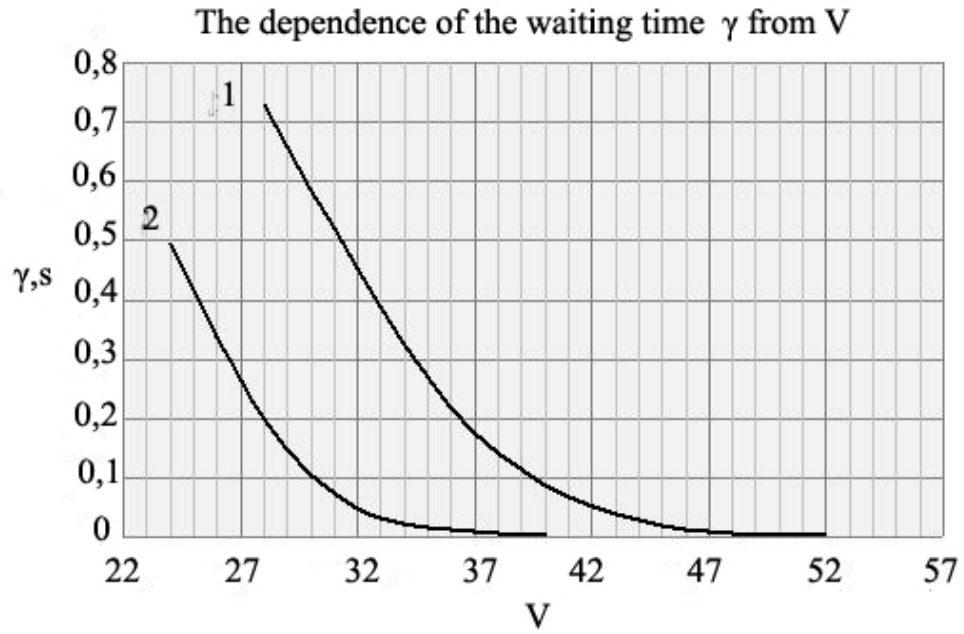


Figure. 3. 1 – variant 2; 2 – variant 1

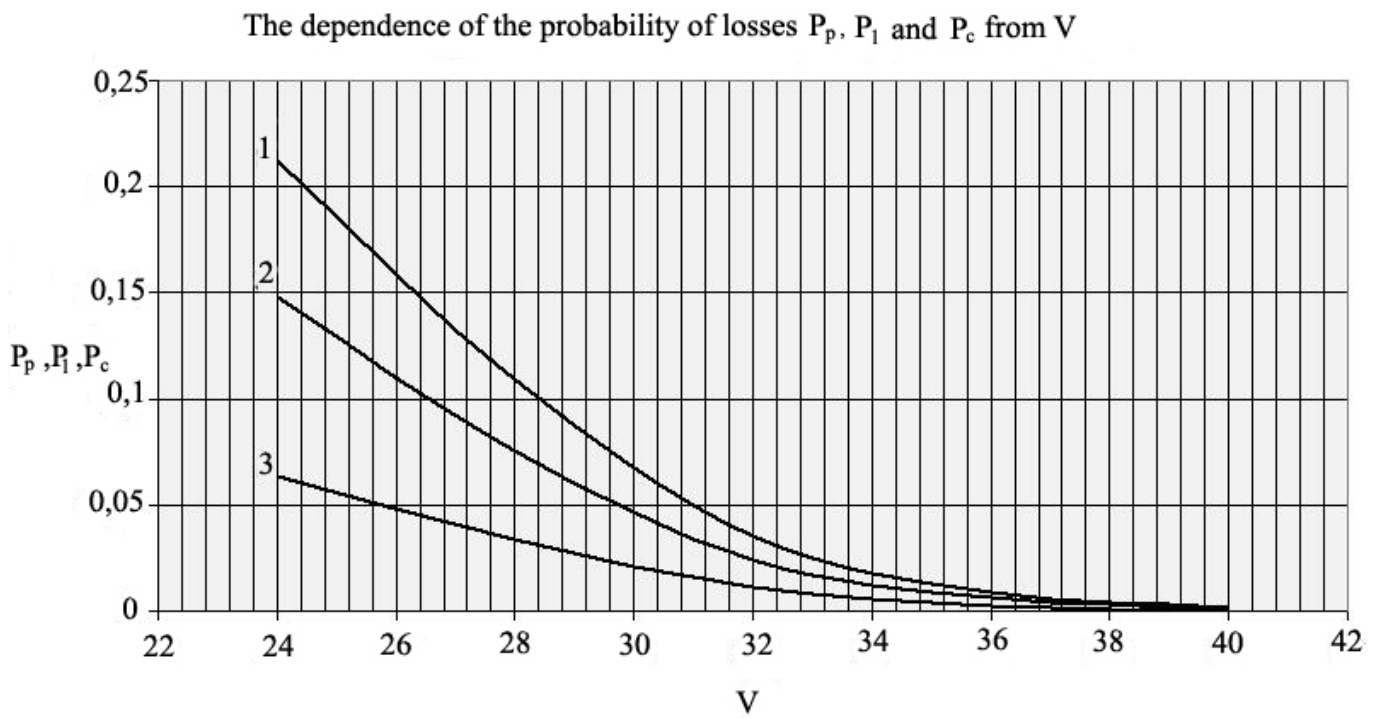
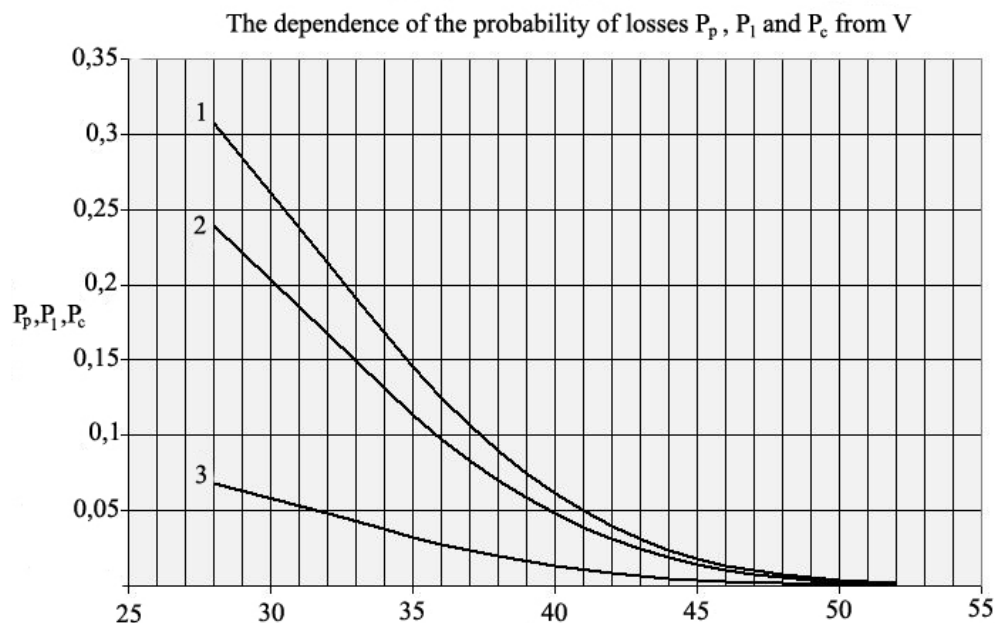


Figure 4. Variant 1: 1 –  $P_c$ ; 2 –  $P_p$ ; 3 –  $P_l$

Figure 5. Variant 2: 1 –  $P_c$ ; 2 –  $P_p$ ; 3 –  $P_1$ 

### Conclusion

To evaluate the results obtained in the simulation is necessary to set parameters of quality of service calls. Compare the model under the current system, in which the service calls from each group of sources occurs separately. In this case, for each group of sources in the network are allocated their own resources, with the first and second groups of sources the number of concurrent con-

nections equals the number of sources. Then, in each version 1 and 2 for the first and second groups of sources need to 30 simultaneous connections. In the third group for the service, subscribers need the following number of simultaneous connections: Variant 1–31, variant 2–42. Table 2 shows the values of the total number of concurrent connections  $V$  for the model and the system with a separate call service.

Table 2.

| System of service of calls | $V$       |           |
|----------------------------|-----------|-----------|
|                            | Variant 1 | Variant 2 |
| The reviewed model         | 39        | 51        |
| A separate call service    | 61        | 72        |

The table shows that in case of association of groups of sources need to network resources by 35% (Variant 1) and 32% (Variant 2) less. Taking into account that for the subscribers of the second class wait-

ing is rare and short time, and for subscribers of third class – Interrupt are very rare, it can be concluded about the appropriateness of the model in practice.

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## **CORPORATE AND TECHNOLOGICAL NETWORK FOR REMOTE MONITORING SYSTEMS**

**Abstract:** At present time, it is very important to build corporate networks that meet all modern requirements. Proposals on the construction of a modern complex of network technologies based on the example of the power industry are considered, which will help optimally develop the necessary network for the monitoring of hazardous facilities, using various communication lines.

**Keywords:** Corporate network, technological network, monitoring systems, convergent networks, information, CCNS technologies, high-frequency technologies, information protection.

### **Introduction**

The corporate network is territorially distributed, that is, uniting offices, subdivisions and other structures that are at a considerable distance from each other. The principles behind the corporate network are quite different from those used to create a local network [1]. This limitation is fundamental, and when planning a corporate network, all measures should be taken to minimize the amount of data transferred. In the rest, the corporate network should not impose restrictions on which applications and how they process the information transferred on it.

A characteristic feature of such a network is that it operates equipment of various manufacturers and generations, as well as heterogeneous software, which is not initially oriented to the joint processing of data.

In the conditions of commercialization of relations between many government agencies and users, such aspects of building networks as first of all: their functional fullness, safety and reliability of functioning, real-time monitoring of the state [2].

### **Formulation of the problem**

At all stages of extraction, processing, storage and transportation of explosive gases, gas leakage warning systems, explosive gas concentration monitoring systems and protection systems are used. The subdivisions and head offices of energy companies that use such monitor-

ing systems consider it necessary to have access to the information of such systems, and on their own corporate network to remotely watch the status of monitoring systems in the interesting local areas.

Features of the requirements for building corporate networks of such enterprises are in danger of the objects themselves, the geographical locations of monitoring objects, the infrastructure of factory buildings, remoteness of controlled areas and other indicators [3]. The occupational safety specialists must continuously watch the status of the sensor readings at any point in the production process in order to avoid the occurrence of emergencies at the plants and main lines.

In the article we will consider some types of networks through which, depending on conditions and requirements, it is possible to create an optimal network, engaging in the extraction, processing and transportation of natural gas.

### **Results and discussion**

The main condition in the task is to rationally build optimal data transmission networks that meet the criteria of price and quality, which will take into account all the requirements of the customer.

Each network system is unique and has its own peculiarities: geographic, system and others. Network building can include various systems: cable, fiber, radio frequency and others.

### General structure of the network being developed

The technological basis for building a network for the monitoring system for dangerous gases in industrial facilities is a sensor network that combines sensor modules of combustible and explosive gases and an executive device in the form of a central information gathering unit [4]. The monitoring network is built on the radio channel in the unlicensed frequency range with the star topology [5].

To combine the collection of information from several such radio monitoring systems, it is necessary to build networks of the most convenient technologies and optimal structure [3]. At the same time, all information, with several separate systems, should be collected on the server and archived for further processing.

To connect remote users to the corporate network, the simplest and most affordable option is to use telephony. Where possible, ISDN networks can be used. In most cases, global data networks are used to connect network nodes. Even where it is possible to install dedicated lines (for example, within a city), the use of packet switching technologies allows reducing the number of necessary communication channels and, importantly, ensuring compatibility of the system with existing global networks.

To transfer data within a corporate network, it is also worthwhile to use virtual channels of packet switching networks. The main advantages of this approach are universality, flexibility, security.

### Collection of information

The organization of a reliable and efficient data archiving system is one of the most important tasks to ensure the safety of information in the network. In small networks, where one or two servers are installed, the most common method is to install the backup system directly into the free server slots. In large corporate networks, it is most preferable to organize a allotted specialized archive server. Storage of archival information of special value must be organized in a special guarded room. Specialists recommend storing duplicate archives of the most valuable data in another building, in case of a fire or a natural disaster [6].

Access to the information of such servers will have specialists who can remotely monitor the state of their objects on the corporate network. And also, in case of occurrence of an extra situation, will be instantly notified for taking appropriate measures in a particular place.

### Converged networks

Until recently, energy companies' networks, as a rule, were built on three independent functional criteria: the transmission of speech and telemechanics signals, protection and automation, office applications, using appropriate equipment.

In recent years, the combination of voice, telemechanics, monitoring and protection functions is quite actively used. In high-frequency technology, the principle of frequency division multiplexing is used for this purpose, in the cable channels – TDM multiplexing [6].

For office applications, including for automatic control system of energy resources, remote monitoring of potentially dangerous objects and diagnostics, transmission of post-emergency information, mail and the Internet, cable or radio channels, own or rented, with IP technology are usually used. A separate application consists of radio, satellite or trunking networks for mobile teams. Technological and engineer achievements of the recent time have led to the creation of equipment that combines the technological and office components of the corporate network of power engineers, which allows us to talk about a new philosophy of applied communication networks – Converged Corporate Network Solutions (CCNS).

### Advantages of CCNS technology

- Reduction of financial and functional dependence on third parties;
- Increase the return on own assets;
- Ability to quickly change the configuration;
- Ability to secure network resources for critical applications;
- Unified management and monitoring environment;
- Full control of the stability and reliability of the network;
- Safety of technological and commercial data;
- Secure remote connection, including via the Internet;
- Secure provision of network resources to third parties.

Wherein the main emphasis is not on simply replacing old equipment with new ones, but on changing the principles of designing technological networks and combining heterogeneous network traffic. The main thing is not the usual performance of functional requirements for the channels, and the equipment of their generators, but



the economic efficiency of the network being created, its adaptability to new tasks.

### **High-frequency technologies**

In the existing high-frequency technologies, network channels are invested huge investments, which sooner or later must be returned, and consequently, issues related to high-frequency communication for a long time will be quite relevant. It follows that with fiber-optic lines or channel lengths of less than 5–7 km, cable channels using the simplest multiplexers are more profitable. For long fiber-optic lines or channels and a lack of financing, high-frequency channels should be used [2].

With longer fiber optic lines or channels, the more powerful the multiplexer will be installed, the higher the system's efficiency will be, and the return on investment will be faster. Especially if it is possible to rent out part of the system's capacity.

### **Thereby:**

- With fiber-optic lines or channel lengths of less than 5–7 km, with existing cable infrastructure (fiber optic lines or radio channels), channels with broadband high-frequency systems are more profitable;

- If the length of fiber-optic lines or channel is less than 5–7 km, in the absence of cable infrastructure, it is necessary to consider the applicability of radio channels of the point-to-multipoint type;

- With optical fiber or channel lengths of less than 5–7 km, in the absence of a cable infrastructure and problems with electromagnetic compatibility, optical or copper channels using simplest multiplexers are more advantageous.

Above we do not speak of specialized channels intended, for example, only for data transmission of automated remote monitoring systems (other channels, GSM or satellite, can be effective here), but about the converged channels that solve most of the tasks in the corporate networks of power engineers.

Up to now, high-frequency communication channels are the most in demand both in terms of capital costs and in terms of the large lengths of fiber-optic lines. They also have an advantage over optical lines from the point of view of constructing systems that take into account the requirements for the time parameters of the transmitted command signals. As well as physical limitations on the propagation time of signals in an optical fiber, high-frequency channels can have a large extent.

### **Protection of corporate network information**

The problem of protecting information from unauthorized access has escalated with the widespread use of local and, in particular, global computer networks. It should be noted that very often the damage is not caused by “malicious intent”, but because of elementary errors of users who accidentally spoil or delete vital data. In this regard, in addition to access control, the necessary element of information security in computer networks is the delineation of the powers of users [7].

It can be detailed the classification of ways to ensure the security of computer networks. Because of this, it is worth considering how to protect computer networks from unauthorized access – the use of certain security services. Such services indicate directions for neutralizing possible security threats. Here are the main security services: 1. Authentication; 2. Ensuring integrity; 3. Classification of data; 4. Access control; 5. Protection from failures.

It should be noted that the number of security connections should be equal to the number of security services installed. That is, if for a given virtual connection at the same time requires authentication, confidentiality and reliability of the data, then three separate security connections are established.

A set of information security services that provide user requirements form a security profile.

### **Conclusion**

It should be concluded that the correctly chosen method of building a corporate network should help to understand the variety of options for building networks and the large number of nuances that arise at all stages of creating and upgrading the enterprise network.

It is important to note that when building networks that have a heterogeneous and complex structure, it is necessary to use those types of devices that are most suitable for price and functional requirements. For example, in the complex infrastructure of a larger city, it is more appropriate to use a radio channel, and within a large building, it would be more appropriate to use fiber lines.

Providing computer security in corporate networks should be given special significance. A hierarchically correctly constructed data access system, modern equipment, a staff of skilled workers responsible for computer security is the guarantor of the safety of state and com-

mercial information. The more attention will be paid to the problems of computer security, the more will be the confidence that information of special importance will not be lost if there is a slight malfunction in the operation of the equipment or with unauthorized access.

I would also like to emphasize that no hardware, software or any other means or organizational work of various kinds can guarantee the absolute reliability and security of data, but at the same time reducing the risk of loss to a minimum is possible only with a conscious, integrated approach to computer security.

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## EQUATIONS OF MOTION AND THE FORMATION OF A DIFFERENCE SCHEME FOR CALCULATING THE CONICAL PART OF SHELL STRUCTURES

**Abstract:** Based on the variation principle of the Hamilton-Ostrogradsky principles, mathematical models are deformed and finite-difference schemes for calculating the conical part of shell structures are formulated.

**Keywords:** conical shell, design scheme, equations of motion, equilibria, stresses, deformation, sweep method.

As is known, composite thin-walled shell structures are widely used in modern technology and have a significant specificity of structural forms, manufacturing technology, operating conditions and material properties. Simulation of deformation processes, the development of numerical methods and the creation of software tools for calculating composite shell structures (tank type) consisting of cylindrical, spherical or conical shell elements under static and dynamic loads have acquired particular urgency [1–4]. In this connection, the paper considers the equations of motion (equilibrium) and the formation of a finite-difference scheme for calculating the conical part of shell structures. In this case, the Hamilton-Ostrogradsky variational principle and the Bubnov-Galerkin's method are used [3].

Consider a truncated conical shell of thickness  $h$  and length  $l = S_1 - S_0$  along the generator. The position of the shell point will be determined in the conic coordinates

$(\alpha, \beta, \gamma)$ . Concerning the middle surface and the length along the generatrix, we have the following relations.

$$-\frac{h}{2} \leq \gamma \leq \frac{h}{2}, 0 \leq \beta \leq \beta_1, S_0 \leq S \leq S_1. (S_0 \neq 0)$$

The coefficients of the first quadratic form are equal to  $A = 1; B = S \cdot \sin \alpha$ , and the radii of curvature of the middle surface  $R_1 = \infty, R_2 = ctg \theta / S$ . For this problem, the Lamé coefficients have the form:

$$H_1 = 1; H_2 = S \sin \theta + \gamma \cos \theta; H_3 = 1 \quad (1)$$

Denote the displacements by  $U_1 = U_\alpha, U_2 = U_\beta, U_3 = U_s$ . Using Kirchhoff-Love, according to which the deformation of the shell occurs without deformation of shear  $l_{12}$  and  $l_{13}$  in the plane of normal sections and without deformation of elongation  $l_{11}$  over the thickness of the shell:

$$l_{12} = l_{13} = l_{11} = 0. \quad (2)$$

For  $U_1, U_2, U_3$  we have:

$$U_1 = W(\alpha, \beta), U_2 = \left(1 + \frac{\gamma}{s} \operatorname{ctg} \theta\right) V \frac{\gamma}{s \cdot \sin \theta} \frac{\partial W}{\partial \beta}, U_3 = U - \gamma \frac{\partial W}{\partial s} \quad (3)$$

According to formula (3), we represent deformations in the following form:

$$\begin{aligned} l_{33} &= \frac{\partial U}{\partial \alpha} - \gamma \frac{\partial^2 W}{\partial \alpha^2}; l_{22} = \frac{1}{\alpha \sin \theta + \gamma \cos \theta} \left(1 + \frac{\gamma}{\alpha} \operatorname{ctg} \theta\right) \frac{\partial V}{\partial \beta} - \frac{\gamma}{\alpha \sin \theta} \frac{\partial^2 W}{\partial \beta^2} + W \cos \theta + \left(U - \gamma \frac{\partial W}{\partial \alpha}\right) \sin \theta; \\ l_{23} &= \frac{1}{\alpha \sin \theta + \gamma \cos \theta} \frac{\partial U}{\partial \beta} + \left(1 + \frac{\gamma}{\alpha} \operatorname{ctg} \theta\right) \frac{\partial V}{\partial \alpha} - \gamma \left(\frac{1}{\alpha \sin \theta} + \frac{1}{\alpha \sin \theta + \gamma \cos \theta}\right) \frac{\partial^2 W}{\partial \alpha \partial \beta} + \\ &\quad + \frac{\gamma}{\alpha} \left(\frac{1}{\alpha \sin \theta} + \frac{1}{\alpha \sin \theta + \gamma \cos \alpha}\right) \frac{\partial W}{\partial \beta} - \frac{1}{\alpha} \left(1 + \frac{\gamma}{\alpha} \operatorname{ctg} \theta\right) V \end{aligned} \quad (4)$$

The stress components are determined by the formulas:

$$\sigma_{\alpha\alpha} = (\lambda + 2G)l_{\alpha\alpha} + \lambda l_{\beta\beta}; \sigma_{\beta\beta} = \lambda l_{\alpha\alpha} + (\lambda + 2G)l_{\beta\beta}, \sigma_{\alpha\beta} = Gl_{\alpha\beta} \quad (5)$$

Now, on the basis of the Hamilton-Ostrogradski's principle, we make the variational equation [1]:

$$\int_t (\delta T - \delta \Pi + \delta A) dt = 0 \quad (6)$$

In determining the variation of the kinetic, potential energy, and the work of external forces, the following relationships are used [3; 4]:

$$\begin{aligned} \int_t \delta T &= \iiint_t \rho \left( \frac{\partial U_1}{\partial t} \delta \frac{\partial U_1}{\partial t} + \frac{\partial U_2}{\partial t} \delta \frac{\partial U_2}{\partial t} + \frac{\partial U_3}{\partial t} \delta \frac{\partial U_3}{\partial t} \right) (\alpha \sin \theta + \gamma \cos \theta) d\alpha d\beta d\gamma dt \quad (7) \\ \int_t \delta \Pi &= \iiint_t (\sigma_{22} \delta l_{22} + \sigma_{33} \delta l_{33} + \sigma_{23} \delta l_{23}) dv dt \\ \int_t \delta A &= \iiint_t [X_1 \delta U_1 + X_2 \delta U_2 + X_3 \delta U_3] (\alpha \cdot \sin \theta + \gamma \cdot \cos \theta) d\alpha d\beta d\gamma dt + \\ &\quad + \iiint_t \left\{ \left[ \phi_1^+ \delta U_1 \left( +\frac{h}{2} \right) + \phi_2^+ \delta U_2 \left( +\frac{h}{2} \right) + \phi_3^+ \delta U_3 \left( +\frac{h}{3} \right) \right] \left( \alpha \sin \theta + \frac{h}{2} \cos \theta \right) + \right. \\ &\quad \left. + \left[ \phi_1^- \delta U_1 \left( -\frac{h}{2} \right) + \phi_2^- \delta U_2 \left( -\frac{h}{2} \right) + \phi_3^- \delta U_3 \left( -\frac{h}{2} \right) \right] \left( \alpha \sin \theta - \frac{h}{2} \cos \theta \right) \right\} d\alpha d\beta dt + \\ &\quad + \iiint_t [P_1 \delta U_1 + P_2 \delta U_2 + P_3 \delta U_3]_{\beta} d\alpha d\gamma dt + \iiint_t [q_1 \delta U_1 + q_2 \delta U_2 + q_3 \delta U_3]_{\alpha} (\alpha \sin \theta + \gamma \cos \theta) d\beta d\gamma dt \end{aligned} \quad (8)$$

Following [3], we form the variational equation taking into account (4) – (5) and (7) – (8), then we apply the Bubnov-Galerkin procedure with respect to the coordinate:

$$U = \sum_n U_n(x, t) \sin \frac{n\pi\beta}{\beta_1}; V = \sum_n V_n(x, t) \cos \frac{n\pi\beta}{\beta_1}; W = \sum_n W_n(x, t) \sin \frac{n\pi\beta}{\beta_1} \quad (9)$$

As a result, we obtain the following system of differential equations of motion of the conical shell with the corresponding boundary and initial conditions:

$$\begin{aligned} -a_1^{(1)} \frac{\partial^2 U_n}{\partial t^2} + a_2^{(1)} \frac{\partial^3 W_n}{\partial x \partial t^2} - a_3^{(1)} \frac{\partial^3 W_n}{\partial x^3} + a_4^{(1)} \frac{\partial^2 U_n}{\partial x^2} + a_5^{(1)} \frac{\partial U_n}{\partial x} - a_6^{(1)} \frac{\partial V_n}{\partial x} + a_7^{(1)} \frac{\partial W_n}{\partial x} - \\ - a_8^{(1)} U_n + a_9^{(1)} V_n - a_{10}^{(1)} W_n + X_n = 0; \\ -a_1^{(2)} \frac{\partial^2 V_n}{\partial t^2} + a_2^{(2)} \frac{\partial^2 W_n}{\partial t^2} + a_3^{(2)} \frac{\partial^2 V_n}{\partial x^2} - a_4^{(2)} \frac{\partial^2 W_n}{\partial x^2} + a_5^{(2)} \frac{\partial U_n}{\partial x} + a_6^{(2)} \frac{\partial V_n}{\partial x} + a_7^{(2)} \frac{\partial W_n}{\partial x} + \\ + a_8^{(2)} U_n - a_9^{(2)} V_n + a_{10}^{(2)} W_n + Y_n = 0; \\ -a_1^{(3)} \frac{\partial^2 W_n}{\partial t^2} + a_2^{(3)} \frac{\partial^2 V_n}{\partial t^2} - a_3^{(3)} \frac{\partial^3 U_n}{\partial x \partial t^2} + a_4^{(3)} \frac{\partial^4 W_n}{\partial x^2 \partial t^2} - a_5^{(3)} \frac{\partial^4 W_n}{\partial x^4} + a_6^{(3)} \frac{\partial^3 U_n}{\partial x^3} - a_7^{(3)} \frac{\partial^3 W_n}{\partial x^3} - \end{aligned} \quad (10)$$

$$-a_8^{(3)} \frac{\partial^2 V_n}{\partial x^2} + a_9^{(3)} \frac{\partial^2 W_n}{\partial x^2} - a_{10}^{(3)} \frac{\partial U_n}{\partial x} + a_{11}^{(3)} \frac{\partial V_n}{\partial x} - a_{12}^{(3)} \frac{\partial W_n}{\partial x} - a_{13}^{(3)} U_n + a_{14}^{(3)} V_n - a_{15}^{(3)} W_n + Z_n = 0$$

Border conditions:

$$\begin{aligned} & \left[ b_1^{(1)} \frac{\partial^2 W_n}{\partial x^2} - b_2^{(1)} \frac{\partial U_n}{\partial x} - b_3^{(1)} U_n + b_4^{(1)} V_n - b_5^{(1)} W_n + T_{1n}^* \right] \delta U_n \Big|_x = 0; \\ & \left[ -b_1^{(2)} \frac{\partial V_n}{\partial x} + b_2^{(2)} \frac{\partial W_n}{\partial x} - b_3^{(2)} U_n + b_4^{(2)} V_n - b_5^{(2)} W_n + S_{1n}^* \right] \delta V_n \Big|_x = 0; \\ & \left[ -b_1^{(3)} \frac{\partial^2 U_n}{\partial t^2} + b_2^{(3)} \frac{\partial^2 W_n}{\partial x \partial t^2} + b_3^{(3)} \frac{\partial^3 W_n}{\partial x^3} - b_4^{(3)} \frac{\partial^2 U_n}{\partial x^2} + b_5^{(3)} \frac{\partial^2 W_n}{\partial x^2} + b_6^{(3)} \frac{\partial V_n}{\partial x} + a_7^{(3)} \frac{\partial W_n}{\partial x} - \right. \\ & \quad \left. - b_8^{(3)} U_n - b_9^{(3)} V_n - b_{10}^{(3)} W_n + R_{1n}^* \right] \delta W_n \Big|_x = 0; \\ & \left[ -b_1^{(4)} \frac{\partial^2 W_n}{\partial x^2} + b_2^{(4)} \frac{\partial U_n}{\partial x} - b_3^{(4)} \frac{\partial W_n}{\partial x} - b_4^{(4)} V_n + b_5^{(4)} W_n - M_{1n}^* \right] \delta \frac{\partial W_n}{\partial x} \Big|_x = 0. \end{aligned} \quad (11)$$

Initial conditions:

$$\begin{aligned} & \left[ -c_1^{(1)} \frac{\partial W_n}{\partial t} - c_2^{(1)} \frac{\partial V_n}{\partial t} - c_3^{(1)} \frac{\partial^3 W_n}{\partial x^2 \partial t} + c_4^{(1)} \frac{\partial^2 U_n}{\partial x \partial t} \right] \delta W_n \Big|_t = 0; \\ & \left[ c_1^{(2)} \frac{\partial U_n}{\partial t} - c_2^{(2)} \frac{\partial^2 W_n}{\partial x \partial t} \right] \delta U_n \Big|_t = 0; \quad \left[ c_1^{(3)} \frac{\partial V_n}{\partial t} - c_2^{(3)} \frac{\partial W_n}{\partial t} \right] \delta V_n \Big|_t = 0. \end{aligned} \quad (12)$$

To form a difference scheme, first the system of differential equations (10) is represented in vector form.

We introduce the following vectors

$$U_n = (W_n U_n V_n)^T; \quad F_n = (Z_n X_n Y_n)^T \quad (13)$$

According to (13), the equation of motion of the conical shells (10) takes the form:

$$\begin{aligned} & A_1 \ddot{U}_n + A_2 \dot{U}_n + A_3 \ddot{U}_n + A_4 U_n^{IV} + A_5 \dot{U}_n^{III} + \\ & + A_6 \dot{U}_n + A_7 U_n + A_8 U_n + F_n = 0 \end{aligned} \quad (14)$$

The initial conditions will also be represented in vector form:

$$\left[ B_1 \dot{U}_n + B_2 \dot{U}_n + B_3 \dot{U}_n \right] \delta U_n \Big|_t = 0 \quad (15)$$

Here the matrices  $u$  are of the third order, respectively, with the elements  $a_i(x, n)$  and  $b_i(x, n)$ .

We rewrite the boundary conditions (11) in the form:

$$\begin{aligned} & Z_m \delta U_n \Big|_x = 0; \quad Z_{2n} \delta V_n \Big|_x = 0; \\ & \left( Z_{3n} - b_1^{(3)} \dot{U}_n + b_2^{(3)} \dot{W}_n \right) \delta W_n \Big|_x = 0; \quad Z_{4n} \delta W_n \Big|_x = 0. \end{aligned} \quad (16)$$

Equation (15) is written without taking into account inertial terms:

$$A_4 U_n^{IV} + A_5 U_n^{III} + A_6 \ddot{U}_n + A_2 U_n + A_8 U_n + F_n = 0 \quad (17)$$

Now we use central difference schemes approximating the derivatives with second-order accuracy [5]. As a

result of approximation we have the following systems of algebraic equations:

$$\begin{aligned} & A_n U_{n,i-2} + B_n U_{n,i-1} + C_n U_{n,i} + D_n U_{n,i+1} + \\ & + E_n U_{n,i+2} + F_{n,i} = 0 \end{aligned} \quad (18)$$

where  $A_n = A_4 N^4 - A_5 \frac{N^3}{2}$ ;  $B_n = -4A_4 N^4 + A_5 N^3 +$

$$+ A_6 N^2 - A_7 \frac{N}{2}; \quad C_n = 6A_4 N^4 - 2A_6 N^2 + A_8;$$

$$D_n = -4A_4 N^4 - A_5 N^3 + A_6 N^2 + A_7 \frac{N}{2};$$

$$E_n = A_4 N^4 + A_5 \frac{N^3}{2}; \quad (19)$$

We consider the difference boundary conditions. We assume that the conical shell is clamped when  $x = 0$  and  $x = 1$ . It follows from the conditions:

$$W_{n,0} = 0, U_{n,0} = 0, V_{n,0} = 0, W_{n,N} = 0, U_{n,N} = 0, V_{n,N} = 0$$

$$W_{n,-1} = W_{n,1}, W_{n,N+1} = W_{n,N-1}; \quad (20)$$

These relations can be written in vector form:

$$U_{n,0} = 0, A_{-1}^1 U_{n,-1} = A_{-1}^1 U_{n,1}, U_{n,N} = 0,$$

$$A_{N+1}^1 U_{n,N+1} = A_{N+1}^1 U_{n,N-1} \quad (21)$$

Substituting (21) into the system of difference equations (19), we obtain a system of linear algebraic equations in the form:





mal values. A similar picture is observed for the displacement ( $U$ ), and shearing forces ( $Q_1$ ).

**Conclusion.** Equations of motion and finite-difference schemes for solving boundary-value problems of

the conical part of shell structures with the use of the sweep method and also the diagrams of the calculated quantities are given.

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## **RESEARCH THE COMPLEX EFFECT OF NEW INGREDIENTS ON THE RUBBER PROPERTIES**

**Abstract:** The purpose of this work was the research of complex influence of the new ingredients obtained on the basis of oil slimes on properties of rubbers. The results of the researches have shown a possibility of using in compounding of rubber mixes for production of wearproof onboard tape as ingredients — organic (softener) and mineral (filler) of a part of oil slime, polymeric sulfur of LLP “PKOP” (the vulcanizing agent). The rubber compounds are obtained with using of organic and mineral parts of oil slime of LLP “PKOP” and the polymeric sulfur which synthesized from gas technical sulfur of LLP “PKOP” is competitive both on the physical and mechanical properties, and at cost that, in turn, utilization of oily waste and rational use of sulfur in production of rubber products and buses allows to solve problems.

**Keywords:** oil slimes, organic and mineral parts of oil slime, sulfur polymer, rubber mixture, rubber, mixing, vulcanization, vulcanizing agent.

The oil industry in terms of negative impact on the environment is one of the leading positions among the industries, the development of which contributes to the increase in volumes generated oily wastes that have a negative impact on the environment. In the Republic of Kazakhstan oil industry is growing rapidly. In this regard, certainly one of the priority tasks aimed at reducing the negative impact of waste on the environment and improving the resourcing of the economy, is the development and implementation of new perspective directions of disposal of large waste oil refining with the creation of innovative industries. Therefore, the search for rational use of sludge in various industries acquires a relevant importance for the economy of Kazakhstan. A wide range of compositions of oily waste requires the development of economically viable and environmentally efficient technologies contributing to the solution of the problem of comprehensive utilization of oil sludge. One of the possible ways of disposing of sludge is its use as ingredients in rubber compounds [1].

In connection with the foregoing, the objective of this work is to research the combined effect of new ingredients, obtained on the basis of oil sludge on properties of rubber compounds.

In the previous analysis [2] we have found that in the organic part of sludge LLP “PetroKazakhstan OilProducts” (LLP “PKOP”), there are no light fractions in composition and properties it is close to heavy oil residuals having a high content of gums and asphaltenes. The presence of large quantities of aromatics and unsaturated hydrocarbons in the organic part of sludge allowed us to use it as an emollient in the recipes of rubber compounds for the manufacture of rail pads. A study of the mineral part of sludge LLP “PKOP” has allowed us to make a conclusion about possibility of its use as filler in rubber compounds as it has high dispersity and well-developed specific surface. The analysis of granulometric composition of mechanical impurities, isolated from sludge of LLP “PKOP” has shown that is 87.9% of the mineral part

of sludge is small (less than 0.5 mm). The value of the specific surface of the sludge amounted to 31.2 m<sup>2</sup>/g.

The mineral admixtures of oil sludge contains salts of alkali metals, organometallic compounds, which are

part of the fuel mass of oil sludge and containing atoms of iron, magnesium, aluminum, copper, etc. Mechanical admixtures represent sand (quartz), clay (kaolinite), silt, corrosion products of metals (rust) [3].

Table 1. – Shows the chemical composition of mechanical impurities extracted from the oil sludge

| Quality indicators, %            | SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaSO <sub>4</sub> | CaO | MgO | Al <sub>2</sub> O <sub>3</sub> | The loss of ignition |
|----------------------------------|------------------|--------------------------------|-------------------|-----|-----|--------------------------------|----------------------|
| The values of quality indicators | 35,6             | 11,5                           | 5,3               | 3,3 | 2,6 | 1,2                            | 40,5                 |

X-ray diffraction analysis of sludge LLP “PKOP” on the device XDGP-3 (X-ray diffractometer general purpose) showed that the main components of the mineral part of sludge are quartz, calcite.

X-ray diffraction analysis of sludge LLP “PKOP” on the device XDGP-3 (X-ray diffractometer general purpose) showed that the main components of the mineral

part of sludge are quartz, calcite. In the sample (figure 1) diffraction peaks with the values of the interplanar distances  $d/n=4,24-4,08-3,24-2,45-2,28-1,81-1,53\text{Å}$  are crystalline arrays of  $\beta$ -cvar ( $\beta\text{SiO}_2$ ) is the main phase. In small quantities by the values of the interplanar distances  $d/n=3,02-2,52-2,28-2,08\text{Å}$  observed calcium carbonate [4].

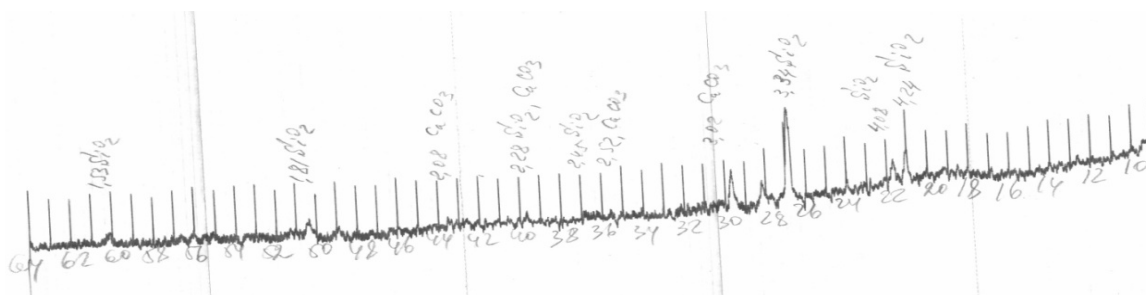


Figure 1. X-ray analysis of mineral component of sludge

It is known that fillers are introduced into the rubber mixture to improve the technological properties of increasing the physical-mechanical properties of rubbers, give them certain specific properties and reduce the cost of production. The choice of filler is determined primarily by the size of its particles and their size distribution (polydispersity) and shape of the particles and the nature of their packaging. The dispersibility of the filler largely affects the final properties of the composite material. The

interaction of rubber with filler particles, a crucial role in the amplification of the rubbers played by the size and shape of particles and the structure of the filler surface [5].

To detect activity of organic parts and mineral parts of sludge LLP “PKOP” in rubber compounds were examined in standard rubber mixture based rubbersynt heticcaoutchoucisoprene SCI-3 for the manufacture side tape. Recipe rubber compound for the manufacture of wear-resistant side tape are shown in table 2.

Table 2. – Recipe rubber compound for abrasion-resistant side tape

| The name of the ingredients                           | 100 masses parts of rubber |                    |      |      |      |      |
|---|----------------------------|--------------------|------|------|------|------|
|   | Standard                   | Research variation |      |      |      |      |
| 1   | 2                          | 3                  |      |      |      |      |
| SCI-3   | 40,0                       | 40,0               | 40,0 | 40,0 | 40,0 | 40,0 |
| Synthetic rubbers butadiene-methylstyrene SCMS-30 ARC | 60,0                       | 60,0               | 60,0 | 60,0 | 60,0 | 60,0 |
| Polymeric sulfur LLP «PKOP»                           | 4,0                        | 4,0                | 4,0  | 4,0  | 4,0  | 4,0  |
| Sulfenamide «M»                                       | 1,2                        | 1,2                | 1,2  | 1,2  | 1,2  | 1,2  |
| Technical stearic acid                                | 2,0                        | 2,0                | 2,0  | 2,0  | 2,0  | 2,0  |
| White Zinc  | 5,0                        | 5,0                | 5,0  | 5,0  | 5,0  | 5,0  |
| Santogard PVI   | 0,4                        | 0,4                | 0,4  | 0,4  | 0,4  | 0,4  |
| Pine wood colophony EM                                | 2,0                        | 2,0                | 2,0  | 2,0  | 2,0  | 2,0  |

| <i>I</i>                      | <i>2</i> | <i>3</i> |      |      |      |      |
|-------------------------------|----------|----------|------|------|------|------|
| Softener AREG                 | 4,0      | –        | –    | –    | –    | –    |
| Органическая часть нефтешлама | –        | 4,0      | 4,5  | 5,0  | 5,5  | 6,0  |
| Oil GO-6T                     | 4,0      | 4,0      | 4,0  | 4,0  | 4,0  | 4,0  |
| Wax protective WPP            | 2,0      | 2,0      | 2,0  | 2,0  | 2,0  | 2,0  |
| Acetonanil RD                 | 2,0      | 2,0      | 2,0  | 2,0  | 2,0  | 2,0  |
| Deafen (IPPD)                 | 2,0      | 2,0      | 2,0  | 2,0  | 2,0  | 2,0  |
| Technicalcarbon F 514         | 40,0     | 40,0     | 40,0 | 40,0 | 40,0 | 40,0 |
| Technicalcarbon F 234         | 40,0     | 35,0     | 30,0 | 25,0 | 20,0 | 15,0 |
| The mineral part of sludge    | –        | 5,0      | 7,0  | 10,0 | 15,0 | 20,0 |

In the studied prescriptions were replaced: softener AREG (asphaltene-resinous emollient granular) on the organic part of sludge, and partially technical carbon F 234 on the mineral part of sludge, the quantity of the mineral part of sludge ranged from 5 to 20 m.p at 100 mass parts of rubber. As the curing agent used polymeric sulfur LLP “PKOP”, synthesized from a gaseous technical sulphur LLP “PKOP” with the content of elemental sulfur is 90,4%, the stability of 85.6% (table 2).

The quality of sulphur curing agent of rubber compounds, to meet such requirements as a high degree of purity of the product (minimum content of harmful impurities — metals of variable valency) and high degree of dispersion [6]. The sulfur content in the gas technical sulfur LLP “PKOP” is 99,53%, indicating the high purity of the product.

Factors influencing the slow rate of diffusion of sulfur and accelerator in the elastomer, are — the increase in molar volume, polymerization of sulfur, the interaction of sulfur with other chemical compounds, adsorption on the surface of carbon black particles, replacement of the sulfur of sulfur-containing compounds, oligomers and polymers, as well as the binding of components of sulfur curing systems in solid solutions of intermolecular action, reduce or eliminate fading of sulfur on the surface of rubber compounds [7].

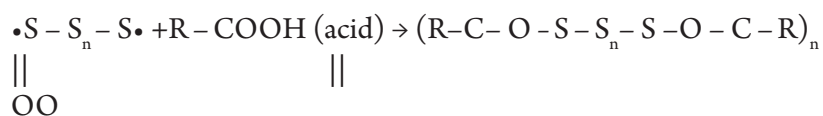
The polymer form is not soluble in the elastomers and has a low diffusion rate due to a sharp increase in molar volume. The molecular weight of polymeric sulfur, depending on the production method can vary from  $10 \cdot 10^4$  to  $30 \cdot 10^4$ . Polymeric sulfur at temperatures below

160 °C is a metastable modification and therefore it has a strong tendency to turn under normal conditions in the thermodynamically stable  $\alpha$ -rhombohedral modification that triggers the need for stabilization of polymeric sulfur. Therefore, at the present time the greatest attention is paid not so much to seek new methods of obtaining polymeric sulfur, as the most effective stabilizers [8].

For translation the gas technical sulfur LLP “PKOP” to the polymeric, as a modifier we have chosen a balance of fatty acids “, (bottoms residue of fatty acids) “BRFA”, which is a waste oil and fat industry, in the manufacture of cottonseed oil, which is obtained by the process of selective treatment by furfurylated alcohol gossypol. The modifier “BRFA” is a mixture of saturated and unsaturated hydrocarbon compounds. It is highly soluble in water, alcohol, poorly soluble in organic solvents. As the surfactant chosen was a modified polyacrylamide (MPAA) is a gel — like viscous mass of light-brown color [9].

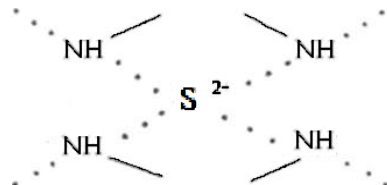
In the interaction of the molten sulfur with the modifier “BRFA” a dissolution modifier “BRFA” in the sulfur melt, and then chemical interaction with sulfur modifying agent. The process of chemical interaction of sulfur with a modifying additive proceeds in two stages. In the first stage, the transfer of sulfur in a reactive form as a result of decomposition at temperatures of 120–150 °C by the disclosure ring cyclooctanone  $S_8$ . In the second stage, the chemical interaction of sulfur with a modifying additive.

The proposed mechanism of formation a low molecular weight polymer chains of the modified sulfur has the form:





Further, surface-active substance modified polyacrylamide “MPAA” structures of polymeric sulfur. In our view, the structuring process has the following mechanism. Polymers series “MPAA” as well as other amine-derivatives to form ions with a number of complex compounds of sulfur having a structure of the following type [8]:



The main task in the rubber manufacturing is the creation from the rubber and various ingredients in a sustainable multicomponent system with maximum mechanical strength and elasticity, and is able to keep the properties over a long period as in a static state and dynamic loads.

Surfactant in rubber compounds is widely used for activation of fillers of rubber mixtures. Treatment of surfactants improves the dispersion of fillers in rubber and increases the intensity of their wetting the rubber, lowering the surface tension between the rubber and powdered ingredients [10]. Modified polyacrylamide “MPAA”, as a product of polyfunctional action, may be in the elastomer compositions of properties of the surfactants, plasticizer, antioxidant and modifier, and activate the curing process. “MPAA” raises increasing the level of interfacial interaction, increases efficiency particulate structures of technical carbon in the elastomeric compositions, this improves the dispersion in a mixture that promotes the formation of a more

responsible structure for the technical performance of rubbers.

It is known that “BRFA” rich in substituted polyphenols, fatty acids, triglycerides, hydrocarbons, azo-compounds and other compounds, is an effective modifier of complex action. The above listed compounds contained in the “BRFA”, in combination with phosphorus-containing modifier has a plasticizer effect in rubber compounds [11]. It is also known that fatty acids and their derivatives, when they are introduced in the rubber compound affect the vulcanization characteristics. It is a valuable assistant for the dissolution of zinc oxide, used as accelerator activators, and thus accelerates the curing process, allowing you to adjust the duration of scorching of rubber compounds [12].

The blend mode is usually determined by the following mandatory factors: order of introduction of ingredients and time of introduction of each ingredient or group of ingredients; mixing time of the mixture after the introduction of ingredients and order of mixing; mixing time; temperature of the rolls. Also, the blend mode is also the size of the gap, as this value has an impact on temperature and duration of mixing (table 3).

The manufacture of rubber mixtures was carried out on a laboratory drum (roll) HT (heating) 3200 1600/1600.

The temperature of the rolls 50 rolls front-60°C, backward 60–70°.

Rolls diameter 160 mm.

Length of rolls 320 mm.

The drive power is 4.6–7 kilowatt.

The optimum loading — 1 kg minimum.

Table 3. – Characteristics of laboratory rolls

| Rubber compound         | Technical characteristics of rolls and keeping the mixing process |                             |  |
|-------------------------|---|-----------------------------|--|
|                         | Friction  | Mixing                      | The temperature of the mixture when removed from roll, °C. |
| Wear-resistant sidetape | 1:1,2   | 1 stage – 25<br>2 stage – 4 | 1 stage – 45<br>2 stage – 30                               |

The total duration of mixing in all cases was the same — 29 min. Difficulties during the process of mixing was observed. After the first stage of the rubber blend was twice passed through rollers, the mixture was cooled to room temperature, ripen rubber compounds was at least 2 hours, then proceeded to the second stage. The finished rubber mixture twice again passed through

rollers. Prior to testing, the raw rubber compound was kept for days at room temperature. When performing the mixing and milling of rubber compounds violations and deviations were observed. The rubber compounds were characterized by uniform distribution of ingredients in the rubber, which ensured the homogeneity of the rubber compound properties.

Plastoelastic properties of rubber compounds are very important technological parameters that significantly affect the processing of rubber compounds. From plastoelastic properties depend on such processing properties as the processing speed, the ability to keep

the given form, the smoothness of the surface, tendency to scorching [4,12]. Data analysis of table 4 shows that the indicators plastoelastic properties of raw rubber compounds meet the standards of control in the dosage of the mineral part of sludge – 10 m.p.

Table 4. – Plastoelastic properties of rubber compounds for abrasion-resistant side tape

| Indicators  | Rate of control | Master blend | 100 masses. parts rubber |      |      |      |      |
|---|-----------------|--------------|--------------------------|------|------|------|------|
|   |                 |              | 5,0                      | 7,0  | 10,0 | 15,0 | 20,0 |
| Plasticity, conventional units                    | 0,20±5          | 0,22         | 0,29                     | 0,28 | 0,20 | 0,21 | 0,19 |
| Viscosity according to Mooney, conventional units | 70±5            | 70           | 70                       | 69   | 72   | 68   | 72   |

For definition of parameters of technological processes in the production of rubber needs to be known indicators of curing ability rubber compounds, their tendency to premature vulcanization is the beginning of curing and velocity (for processing), for the process of curing, in addition to the above indicators, the optimum vulcanisation plateau, the area of reversion. The ability

of rubber mixtures to premature vulcanization gives vulcanization characteristics taken on a Monsanto rheometer [13].

Table 5 shows the estimates of the parameters of vulcanization characteristics of rubber mixtures for the manufacture of wear-resistant side tape.

Table 5. – Results of calculation of vulcanization characteristics of rubber compounds for abrasion-resistant side tape on the Monsanto rheometer, mode: 155Cx20 minutes

| Indicators   | Standard<br>6 m.p. Oil<br>FO-6T | The organic part of sludge<br>100 m.p in rubber |         |         |         |         |
|--|---------------------------------|---|---------|---------|---------|---------|
|  |                                 | 5,0   | 7,0     | 10,0    | 15,0    | 20,0    |
| Minimum torque, $M_{\min}$ , H•M                   | 8,0                             | 9,0   | 8,6     | 8,2     | 8,0     | 8,0     |
| Saving the viscous-flow state, min                 | 1'22//                          | 1'35//  | 1'25//  | 1'27//  | 1'22//  | 1'28//  |
| The beginning of vulcanization, $M_2$ , H•M        | 10,0                            | 11,0  | 10,6    | 10,2    | 10,0    | 10,0    |
| The start time of vulcanization, M min             | 2'05//                          | 2'10  | 2'10//  | 2'10//  | 2'05//  | 2'10    |
| Point in the optimum vulcanization $M_3$ , H•M     | 34,1                            | 34,2  | 34,16   | 34,12   | 34,1    | 35      |
| The time to reach the optimum vulcanization, min   | 18'00//                         | 18'10//   | 18'00// | 17'30// | 18'00// | 17'40// |
| The maximum torque $M_p$ , H•M                     | 37                              | 37  | 37      | 37      | 37      | 37      |
| The maximum degree of vulcanization $\tau_4$ , min | 19'15//                         | 19'20//   | 19'15// | 19'20// | 19'15// | 19'27// |

Data analysis of table 6 shows that the optimal ratio of components, leading to the reduction of the minimum viscosity and increasing the start time of vulcanization, has the best technological properties of rubber compounds that are observed when 10 mass parts of the mineral part of sludge for rubber mixtures, intended for the manufacture of wear-resistant side tape.

As mentioned above on technological and operational properties of rubber mixtures and vulcanizates is strongly influenced by the molecular weight (M), molecular weight distribution (MWD) of rubber, as well as the type and dosage used fillers. The distribution of curing agents in the rubber compound, and the nature of the processes of change-linkage in the presence of insoluble

components (mainly the fillers). Activity fillers when used with uncrystallizable rubbers is significantly higher than when applied with crystallizing rubbers. As a result, there is a need of analysis of the combined effect of filler and curing agent on the crystallization process [14].

The obtained results can be explained with the changes occurring in the rubber matrix in the presence of the filler. Between the filler and the elastomer arise when one of three types: physical adsorption and chemisorption, formed in the process of preparation of a rubber mixture and in the curing process. Chemisorption of when determine the amount associated with the filler rubber and carbon rubber gel samples [15].

Increasing content of sulphur chemically bound to the surface of the filler, the proportion of rubber that is associated with the filler. When sulfuric vulcanization in the presence of the filler there is a migration of sulfur and mainly of the sulfenamide to the solid surface and their adsorption and chemisorption on the surface of the filler. The amount of adsorbed substance is proportional to its content in the mixture and speed of migration. The difference in the rate of migration of sulfur and accelerator to the surface of the filler leads to an increase of sulfides break up ties in the matrix of the rubber remote from the surface of the filler [16].

Thus, in the presence of the mineral part of sludge take place several processes simultaneously: the migration of curing agents to a solid surface and decrease of their content in the rubber matrix remote from the solid surface (this should take into account the different speed of migration of each ingredient); the increase in the number of connected rubber. The intensity of

these processes mainly at the stage of vulcanization, will determine the type and dosage of curing agent used. The decrease in the content of curing agent in the rubber matrix increases the rate of crystallization. The increasing sulfides break up the relationships due to the greater speed of migration of the accelerator to hard surface dramatically slows down the process of crystallization and this effect is mainly at small dosages filler.

Research the physical and mechanical properties of rubbers, synthesized using organic and mineral parts of the sludge confirmed the feasibility of their use in the manufacture of rubber products. As mentioned above, the organic portion of the sludge has good compatibility with synthetic rubbers and is easily inserted in the rubber compound and improves the dispersion of powdered ingredients. Data analysis of table 6 shows that the best results are observed at a dose of 10 mass parts of the mineral part of sludge for rubber mixtures, intended for the manufacture of wear-resistant side tape.

Table 6. – Physical-mechanical properties of rubber compounds for abrasion-resistant side tape

| Name of indicators   | 100 masses parts of rubber |     |     |      |      |      |
|--|----------------------------|-----|-----|------|------|------|
|  | Standard                   | 5,0 | 7,0 | 10,0 | 15,0 | 20,0 |
| Conditional tensile strength, kg s/sm <sup>2</sup> not less than | 190                        | 185 | 187 | 192  | 190  | 185  |
| Conditional stress at elongation 300%, kg s/sm <sup>2</sup>      | 120                        | 110 | 115 | 122  | 122  | 118  |
| Elongation at break,%  | 410                        | 400 | 390 | 405  | 415  | 420  |
| Shore hardness A, conditional unit                               | 77                         | 78  | 79  | 80   | 79   | 77   |

In the diagram (figure 2) clearly shows that the General level of physical and mechanical properties of the investigated rubber close to the reference.

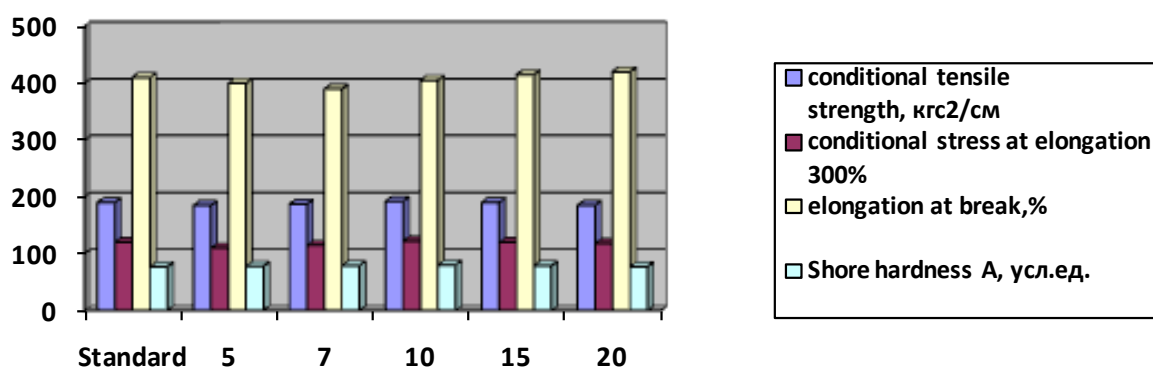


Figure 2. Diagram dependence on physical-mechanical properties of rubber compounds for abrasion-resistant side strips from the content of the mineral part of sludge LLP "PKOP".

Conducted enlarged-laboratory tests on the basis of LLP "EkoTire" with the results of the optimum technological parameters of obtaining rubber mixtures with organic and mineral parts of sludge, the technology

of obtaining the rubber mixtures for the manufacture of wear-resistant side tape.

Thus, the research results showed the possibility of use in the formulation of rubber compounds

for the manufacture of wear-resistant side tape as ingredients — organic (emollient) and mineral (filler) part of the sludge, polymeric sulfur (curing agent), LLP “PKOP”. The conducted research allows to claim that the rubber compound produced using organic and mineral parts of sludge LLP “PKOP” and polymeric sulfur, are

synthesized from the gas technical sulfur LLP “PKOP”, is competitive both in its physical and mechanical properties, and cost, which in turn, allows to solve problems of disposal of oily waste and the rational use of sulphur in the manufacture of rubber products and tires.

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## INVESTIGATION OF THE PROCESS OF RELEASE OF DIRT IMPURITIES IN THE ZONE OF INTERACTION OF IT WITH A NETLIKE SURFACE

**Abstract:** Interactions of the rubbish particle is considered in article with filament of the leaflet raw cotton and degree influence worker organ of the defoggers on leaflets raw cotton as well as process of the care speck of dust from composition stringy mass under dynamic interaction it with netlike surface. The analysis got numerical result shows that under small importance's factor springy relationship of the leaflet with surface prickly and nets exists the reduction its radial and relative angular velocities, as well as increase of time of the interaction of the leaflet with netlike surface.

**Keywords:** raw cotton, feather, cotton cleaner, model, netlike surface, spiked-drum, pin, blow.

**Introduction:** In the process of interaction of the mass of raw cotton with the working parts of the cleaning machine, separate scraps are formed, which contain various fractions of dirt impurities. In fact, scraps have an arbitrary shape, and in the area of the spear drum are subjected to a sequential impact with pins rotating at a constant angular velocity  $\omega$ , and the contact of the scab with the scrap can be shock, or, as a result of the deformability of the scrap, the impact is elastic. To simplify the formulation of the problem, we accept the mass of raw cotton that interacts with the spike in the form of a system of individual volleys that fill the space between two spikes. The origin of coordinates is set in the center of the spiked-drum, and the axis  $0x$  is directed to the left and the axis  $0y$  to the bottom (Fig. 1).

**Analyses.** We assume that the mass, in addition to the force of gravity, is acted upon by the frictional force on the netlike surface, and also by the elastic force on the side of the spike directed perpendicular to the axis of the radius of the spiked-drum. The number of spikes is considered equal  $N = 2n$  ( $n = 3, 4, 5..$ ). In this case, the value of the central angle between the two spikes will be equal  $\Delta\phi = 180 / n$ .

The central angle of the netlike arc is calculated by the formula in (degrees)  $\theta = 180(1 - 2 / n)$ .

The number of spikes interacting with the arc of the netlike, is assumed equal  $N_1 = n - 1$ , then the number of sectors in the cleaning drum containing raw cotton will be equal to  $E_1 = n - 2$  and still have  $\beta = \Delta\phi$ . The process is considered stationary and we introduce the polar coordinate system  $(r, \phi)$ . The action of the first spike on the mass occurs at a value of the polar angle  $\phi = \Delta\phi$ . The diagram of the movement of the mass of cotton in the space between the spikes is shown in Fig. 1a, which occurs periodically.

Let's study the movement of raw cotton material in the sections of the cleaning drum, where we assume the following assumptions:

1. The center mass of the raw cotton makes a one-dimensional parallel movement along the arc  $B_1B_n = R\Delta\phi$  in the sectors  $B_iA_iA_{i+1}B_{i+1}$  ( $i = 1..n - 1$ ) formed between the two spikes.

2. On the mass its force of weight, elastic force from the side of the spike and the frictional force between the netlike and the mass of raw cotton are acting.



3. The movement of the mass between the two spikes occurs when the spike hits the mass, with the angular velocity of the mass at the upper boundary of

the sectors being equal  $\omega_1$ , and in the lower section, as a result of the deformation of the mass, it differs from the speed of the spike.

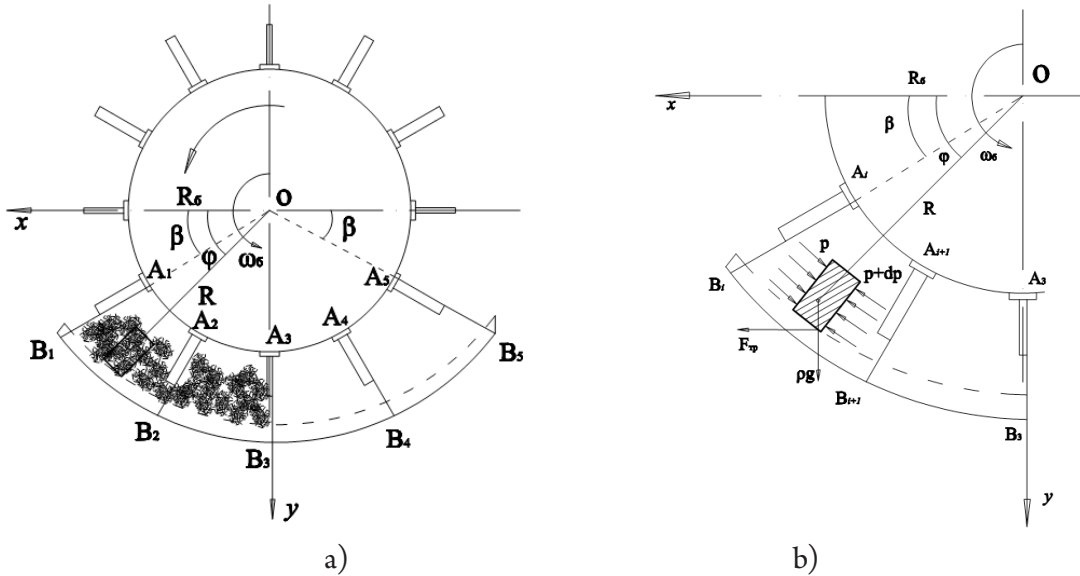


Figure 1. Scheme of interaction between the mass of raw cotton and the netlike surface

Under these assumptions form the equation of motion for the mass of raw cotton  $i$  – sector  $B_i A_i A_{i+1} B_{i+1}$  spiked-drum. Let us isolate the element from this mass  $ds$  (Fig. 1b) and compose the Euler equation for this element.

$$S p_i v_i dv_i = p_i S - (p_i + dp_i) S + p_i g S [\cos \varphi - f \sin \varphi] ds - k f L p_i ds - f_i p_i S \frac{v_i^2}{R} ds \quad (1)$$

Where  $v_i (m/s)$ ,  $\rho_i (kg/m^3)$ ,  $p_i (H/m^2)$  – in respectively the velocity, density and pressure in an arbitrary section of the sector,  $S = Lh$  – constant area of the cross-section throughout an arc interaction layer of raw cotton from the netlike surface,  $L (m)$  – the length of the drum,  $h (m)$  – the thickness of the layer of raw cotton,  $k$  – the coefficient of lateral pressure on the contact surface to weight spike, – the distance from the element to the drum center,  $f_i = f_0(1-s)$ ,  $f_0$  – the friction coefficient between the netlike material and the raw cotton,  $s_i = S_i/S_0$ ,  $S_i$  – the spike area in the presence of holes in  $i$  – sector,  $S_0 = \pi R_i L$  – the total area of the spike ( $R_c$  – radius arc spike).

Equation (1) is divided into a product  $S ds$ , and, taking into account  $ds = R d\phi$ , we obtain ( $i = 1..n-2$ )

$$\rho_i v_i \frac{dv_i}{d\phi} = -\frac{dp_i}{d\phi} + \rho_i g R [\cos \phi - f_i \sin \phi] - \frac{f_i k L}{S} p_i - f_i \rho_i v_i^2 \quad (2)$$

$i\Delta\phi < \phi < (i+1)\Delta\phi,$

Equations (2) contain unknowns  $v_i(\phi)$ ,  $\rho_i(\phi)$  and  $p_i(\phi)$ , which additionally satisfy the following conditions:

1. In each sector, the equation of state [1; 2]

$$\rho_i = \rho_0(1 + B p_i), \quad (i = 1..n-1). \quad (3)$$

Where  $\rho_0$  – is the initial density of raw cotton in the natural state in the feeder zone. If we take the productivity of feeding raw cotton into the purifier zone through  $Q_0$  and the feed rate of the raw material through the feeder  $v_0$ , then the density  $\rho_0$  – in the stationary feed mode can be determined from the formula  $\rho_0 = Q_0 / (v_0 S_n)$ , where  $S_n = L h_n$  – is the cross-sectional area of the feeder,  $L$  – the length of the drum,  $h_n$  – the width of the feeder.

2. The law of conservation of mass per unit time

$$\rho_i v_i S = const = Q_0, \quad (4)$$

Where  $\rho_0$  and  $p_0$  both the density of cotton and the pressure in the mass before it enters the cleaning zone,  $B$  – is the compliance factor, the reciprocal is the bulk expansion  $K = 1/B$  modulus of raw cotton,  $Q_0$  – the productivity of the cleaning machine. From (3) and (4), assuming  $B \ll 1$  we establish the relationship between velocity  $v_i$  and pressure  $p_i$

$$v_i = \frac{Q_0}{S \rho_0 (1 + B p_i)} \approx \frac{Q_0}{S \rho_0} (1 - B p_i) \quad (5)$$

Eliminating the density and velocity from (1) and (2) using dependences (3) and (4), we will compose the equation for determining the pressure in each section

$$\frac{dp_i}{d\phi} = p_i F_{1i}(\phi) + F_{2i}(\phi) \quad (6)$$

Where:  $F_{1i} = [BF_{0i}(\phi) + A_i] / (1 - \gamma)$ ,  
 $F_{2i} = [F_{0i}(\phi)(1 - Bp_0) - f_i B_0(1 + Bp_0)] / (1 - \gamma)$ ,  
 $F_{0i} = gR\rho_0[\cos\phi - f_i \sin\phi]$ ,  $A_i = f_i(\gamma - kLR/S)$ ,  
 $\gamma = BB_0$ ,  $B_0 = Q_0^2 / \rho_0 S^2$ ,

On the contact surface of the spike with the mass of raw cotton, the conditions ( $\omega_i$  ( $A^{-1}$ ) – angular velocity of the drum)

$$v_i = v_{i0} = v_l = R\omega_i \text{ at } \phi = \phi_i = i\Delta\phi \quad (i = 1..n-1)..$$

Using the dependences (5), we determine the pressure values on the contact surface of the mass with the pins

$$p_i = p_{i0} = p_l = \frac{Q_0 - \rho_0 S v_l}{B \rho_0 S v_l} = \left(1 - \frac{S v_b}{S_n v_0}\right) \frac{v}{B v_0},$$

with

$$\phi = \phi_i = i\Delta\phi \quad (7)$$

In this case, the condition  $\frac{S v_b}{S_n v_0} < 1$

The solution of equation (6) satisfying conditions (7) can be represented in the form

$$p_i = \exp[F_{1i}(\phi)] \left\{ p_l \exp[-F_{1i}(\phi)] + \int_{\phi_i}^{\phi} F_{2i}(t) \exp[-F_{1i}(t)] dt \right\} \quad (8)$$

Formula (8) establishes the law of distribution of pressure in the interaction zone of the mass of raw cotton with a netlike surface. The distribution of density and speed of raw cotton in this zone is determined by means of formulas (4) and (5).

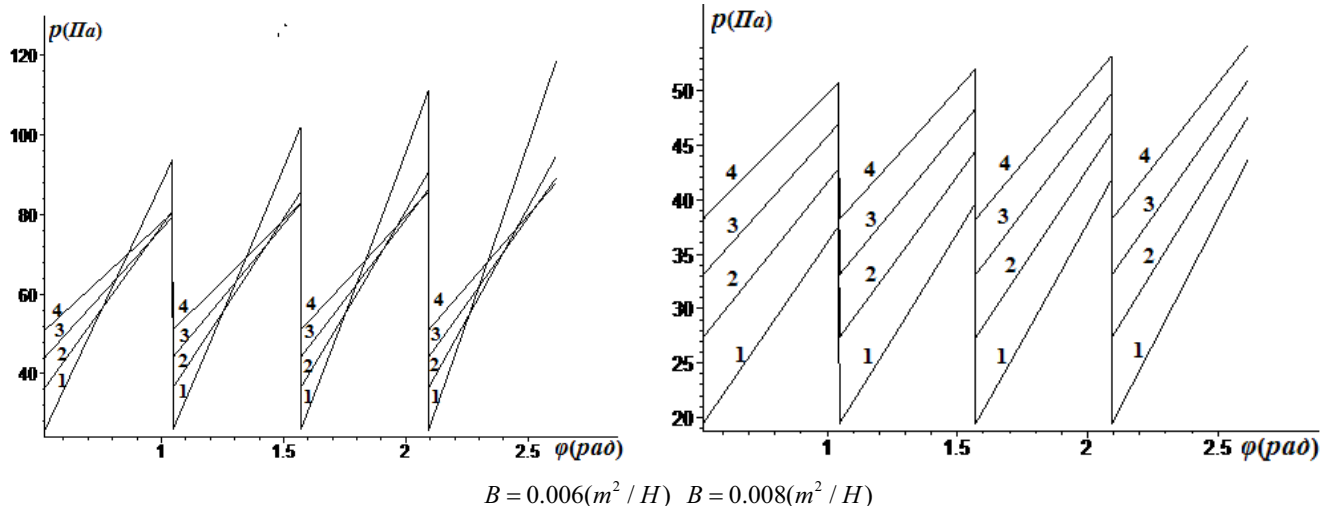


Figure 2. Krivye raw cotton pressure distribution along the arc of contact of its surface with a grid for different speed values:  $v_0$  ( $m/s$ ): 1 –  $v_0 = 1.165$ , 2 –  $v_0 = 1.259$ , 3 –  $v_0 = 1.338$ , 4 –  $v_0 = 1.417$

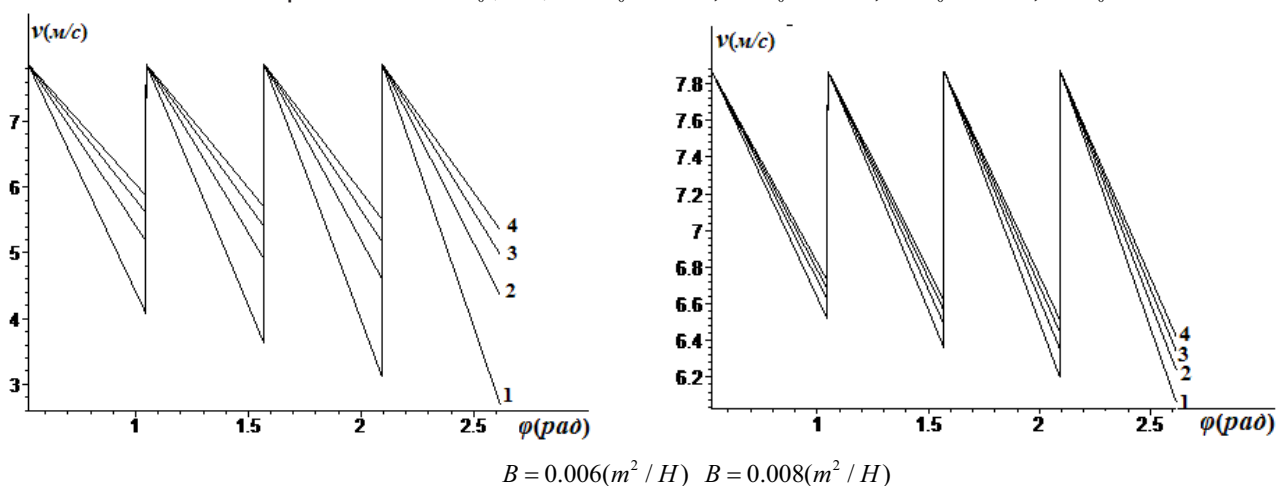


Figure 3. Krivye distribution of raw cotton particle velocity along the arc of contact of its surface with a grid for different speed values:  $v_0$  ( $m/s$ ): 1 –  $v_0 = 1.165$ , 2 –  $v_0 = 1.259$ , 3 –  $v_0 = 1.338$ , 4 –  $v_0 = 1.417$

Figures 2 and 3 show the pressure distribution curves (Figure 2) and velocity (Figure 3) on the arc contact mass of raw cotton by the action of spikes 12 ( $n=6$ ,  $\Delta\phi=30^\circ$ ) for various values of the feed rate of raw cotton into a purification zone. In the calculations made:  $Q_0=7000\text{kg/hour}$ ,  $L=1.9\text{m}$ ,  $R=0.164\text{m}$ ,  $h=0.05\text{m}$ ,  $h_n=0.4\text{m}$ ,  $B=0.008\text{m}^2/H$ ,  $\omega_i=48\text{A}^{-1}$ ,  $k=0.3$ ,  $f_0=0.3$ ,  $s_i=0.6$  ( $i=1..4$ ).

From the analysis of the curves it follows that the pressure and velocity of the raw cotton particles along the grid arc of each section are distributed according to a linear law. At the same time, the pressure and velocity during the transition from one section to the other end in a gap, where an increase in the pressure value and an insignificant change in velocity during the transition through the points of discontinuity are observed.

The proposed scheme for calculating mass motion can be used to determine the amount of released particles of dirt impurities when the mass of raw cotton is passed over the netlike surface over time  $t=T=\theta/\omega_i$ . For this we use the model of G. P. Sevostyanov [3], according to which the change in the mass of raw cotton is proportional to the relative change in the volume of cotton in the sections of the drum

$$\frac{dm_i}{m_i} = \lambda_i \frac{dV_i}{V_i}$$

Here  $\lambda_i$  – is the coefficient of proportionality of the  $i$  – section.

Taking into account equality  $\frac{dV}{V} = \rho d\left(\frac{1}{\rho}\right) = -\frac{d\rho}{\rho}$ , we obtain  $\frac{dm_i}{m_i} = -\lambda_i \frac{d\rho_i}{\rho_i}$

By supplying the expressions for the density by the formula (3), we obtain

$$\frac{dm_i}{m_i} = -\lambda_i B \frac{dp_i}{1+B(p_i-p_0)} \approx -\lambda_i B [1-B(p_i-p_0)] \frac{dp_i}{d\phi}$$

Having produced the integration, we find the expression for the relative decrease in the mass of the  $i$  – section

$$\frac{m_i}{m_0} = \exp[-\lambda_i B [p_i(\phi) - p_i(\phi_0)] \{1 + B p_0 - B [p_i(\phi) + p_i(\phi_0)] / 2\}]$$

The cleaning effect in each section of the drum is determined by the formula

$$\varepsilon = \frac{m_0 - m_i}{m_0}$$

The table shows the values  $\varepsilon_i = 1 - m_i / m_0$  for the sections of the drum for different values of the feed rate of cotton in the cleaning zone.

Table 1. – Distribution of cleaning effects  $\varepsilon_i = 1 - m_i / m_0$  for different values of the compliance factor  $B$  and drum speed

| $v_0(m/s)$      | $B = 0.006(m^2/H)$ |       |       |       | $B = 0.008(m^2/H)$ |       |       |       |
|-----------------|--------------------|-------|-------|-------|--------------------|-------|-------|-------|
|                 | 1.165              | 1.259 | 1.338 | 1.417 | 1.165              | 1.259 | 1.338 | 1.417 |
| $\varepsilon_1$ | 6.224              | 4.463 | 3.665 | 3.300 | 3.251              | 2.791 | 2.516 | 2.304 |
| $\varepsilon_2$ | 6.628              | 4.737 | 3.867 | 3.300 | 3.475              | 2.955 | 2.646 | 2.411 |
| $\varepsilon_3$ | 7.020              | 5.021 | 4.079 | 3.463 | 3.712              | 3.130 | 2.786 | 2.524 |
| $\varepsilon_4$ | 7.298              | 5.238 | 4.245 | 3.592 | 3.901              | 3.269 | 2.897 | 2.614 |

**Conclusions:** It is established that the parameters of the cotton mass (pressure, density and velocity of the particle) as a result of the impact of the spike have jumps at the starting point of the arc of the section

and then change linearly. The cleaning effect on the sections of the drum increases and it is established that this effect decreases with increasing speed of the feeding rolls.

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## ALGORITHM OF SOLUTION OF ONE TWO-CRITERIA STOCHASTIC ECOLOGY-ECONOMIC PROBLEMS OF AGRICULTURAL PRODUCTION

**Abstract:** in this article is considered the algorithm of solution of two-criteria stochastic problems of placing and specialization of agricultural production. There is mentioned the theorem of convergence.

**Keywords:** convolution method, method linearization, stochastic quasi gradient.

In the given work the algorithm of the decision of two criteria stochastic ecology-economic model of placing and the agricultural production specialization, considering deficiency of water resources is considered.

In work [1] it has been considered the qualitative analysis and marginal correlation of purpose function for an ecology-economic problem of placing and agricultural production specialization. Stochastic of two-criteria problem of placing and agricultural production specialization is led following stochastic problem by means of a convolution method:

$$F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)) = \alpha_1 E \bar{h}_1(\theta) - \alpha_2 E \bar{h}_2(\theta) \rightarrow \max \quad (1)$$

Under conditions:

$$\sum_{i \in I} a_{ij}(\theta) x_{ij} - \sum_{i \in I} y_{ij} \geq A_j h_j(\theta), \text{ a.l. } j \in J_1^i \quad (2)$$

$$\sum_{i \in I} z_{iv} \geq B_v h_v(\theta), \text{ a.l. } v \in J_2^i \quad (3)$$

$$\sum_{j \in J_1^i} \beta_{ij}(\theta) x_{ij} + \sum_{v \in J_2^i} \bar{\beta}_{iv} z_{iv} \leq Q_i h_i(\theta), \text{ a.l. } i \in I \quad (4)$$

(Water restrictions)

$$\sum_{j \in J_1^i} b_{ij}^k x_{ij} - \sum_{j \in J_1^i} q_{ij}^k y_{ij} + \sum_{v \in J_2^i} d_{iv}^k z_{iv} \leq T_i^k, \text{ } i \in I, k \in \overline{1, L} \quad (5)$$

(Resource restrictions)

$$h_1(\theta) \geq 0, h_2(\theta) \geq 0, x_{ij} \geq 0, y_{ij} \geq 0, z_{iv} \geq 0, i \in I, j \in J_1^i, v \in J_2^i, n \in N. \quad (6)$$

For the decision one two-criteria a stochastic problem (1) – (6), we will present it in the equivalent x-form.

The problem is resulted in a following form:

$$F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)) = \alpha_1 E \bar{h}_1(\theta) - \alpha_2 E \bar{h}_2(\theta) = E \min \left\{ \alpha_1 \left( \min_j \frac{\sum_{i \in I} a_{ij}(\theta) x_{ij} - \sum_{i \in I} y_{ij}}{A_j}, \min_v \frac{\sum_{i \in I} z_{iv}}{B_v} \right) + \alpha_2 \min_i \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta) x_{ij} + \sum_{v \in J_2^i} \bar{\beta}_{iv} z_{iv}}{Q_i} \right\} \rightarrow \max \quad (7)$$

$$\sum_{j \in J_1^i} b_{ij}^k x_{ij} - \sum_{j \in J_1^i} q_{ij}^k y_{ij} + \sum_{v \in J_2^i} d_{iv}^k z_{iv} \leq T_i^k, \text{ } i \in I, k \in \overline{1, L} \quad (8)$$

Here  $F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))$  – convex upwards function. The basic complexity of a problem (7) – (8) consists that it is practically impossible to receive obvious expression of function  $F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))$  and its derivatives because of a kind and presence of a random variable at purpose function. Therefore to solve decision the problem (7) – (8) it is applied direct methods of stochastic programming, in particular methods stochastic linearization [2] which is set by following recurrent parities:

$$\begin{aligned} x^{s+1} &= x^s + \rho_s (\bar{x}^s - x^s), \\ z^{s+1} &= z^s + \delta_s (\xi^s - z^s), \\ (z^s, \bar{x}^s) &= \max_{x \in X} (z^s, x^s), \end{aligned} \quad (9)$$

where  $X$  – convex set of points satisfying conditions (8),  $x^0, z^0$  – arbitrary points from this set. Here for stochastic quasi gradient criterion function and step-by-step multipliers following conditions are satisfied:

$$E(\xi^s / x^0, \dots, x^s) = \Delta F(x^s) \quad (10)$$

$$0 \leq \rho_s \leq 1, \sum_{s=0}^{\infty} \rho_s^2 < \infty, \sum_{s=0}^{\infty} \rho_s = \infty \quad (11)$$

$$0 \leq \delta_s \leq 1, \sum_{s=0}^{\infty} \delta_s^2 < \infty, \sum_{s=0}^{\infty} \delta_s = \infty \quad (12)$$

$$\rho_s / \delta_s \rightarrow 0 \text{ with } s \rightarrow \infty, \sum_{s=0}^{\infty} (\rho_s^2 + \delta_s^2) < \infty \quad (13)$$

Thus the choice of step-by-step multipliers is carried out as follows:

$$\rho_s = \frac{1}{(1+s)^\alpha}; \delta_s = \frac{1}{(1+s)^\beta}, \alpha > \beta, \frac{1}{2} < \alpha \leq 1, \frac{1}{2} < \beta \leq 1.$$

$\alpha, \beta, \rho_s, \delta_s$  – satisfy to correlation (11) – (13).

To use the methods of linearization, it is necessary to calculate the stochastic generalised gradient of function  $F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))$ .

It is known, that for function

$$F(x) = Ef(x, \theta) \quad (14)$$

where  $f(x, \theta)$  – convex upwards function on  $x$  and for every  $\theta$  then equality is carried out

$$\bar{\nabla} F(x) = E\bar{\nabla}_x f(x, \theta)$$

From here owing to determination of  $\xi^s$  – vector stochastic quasi gradient according to (10), for function (14) looks like [3]:

$$\xi^s = \bar{\nabla}_x f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s)) \quad (15)$$

Where  $\theta$  – is independent supervision over calculation of stochastic quasi gradient is enough to calculate generalised gradient under integrated function. Let's result the formula of calculation of the generalized gradient:

$$\bar{\nabla}_x \min_{i=1, n} f_i(x) = \bar{\nabla}_x f_{i(x)}(x) \quad (16)$$

Where  $f_{i(x)} = \min_{i=1, n} f_i(x)$ .

Let's designate  $\bar{\nabla}_{x,y,z} f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s))$  – generalised gradient of the function  $F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))$ .

In the formula (7) we will enter a designation:

$$g_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)) =$$

$$= \min_{ij} \left( \alpha_1 \frac{\sum_{i \in I} a_{ij}(\theta) x_{ij} - \sum_{i \in I} y_{ij}}{A_j} + \alpha_2 \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta) x_{ij} + \sum_{v \in J_2^i} \bar{\beta}_{iv} z_{iv}}{Q_i} \right)$$

$$g_2(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)) =$$

$$= \min_{iv} \left( \alpha_1 \frac{\sum_{i \in I} z_{iv}}{B_v} + \alpha_2 \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta) x_{ij} + \sum_{v \in J_2^i} \bar{\beta}_{iv} z_{iv}}{Q_i} \right)$$

Using well known formula (16) we will calculate the generalized gradient of the function  $F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))$

$$\begin{aligned} \bar{\nabla}_{x,y,z} \min_{i=1, n} f_i(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)) = \\ = \bar{\nabla}_{x,y,z} f(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))(x) \end{aligned} \quad (17)$$

$$\bar{\nabla}_{x,y,z} f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s)) =$$

$$= \left\{ \begin{aligned} & \bar{\nabla}_{x,y,z} g_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)), & g_1 \leq g_2 \\ & \bar{\nabla}_{x,y,z} g_2(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta)), & g_1 > g_2 \end{aligned} \right\} =$$

$$= \left\{ \begin{aligned} & \left( \alpha_1 \frac{\sum_{i \in I} a_{ij}(\theta)}{A_j} + \alpha_2 \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta)}{Q_i} \right. \\ & \left. - \frac{\alpha_1}{A_j} \right), & g_1 \leq g_2 \\ & \left( \alpha_2 \frac{\sum_{v \in J_2^i} \bar{\beta}_{iv}}{Q_i} \right. \\ & \left. \alpha_2 \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta)}{Q_i} \right) \\ & 0, & g_1 > g_2 \\ & \left( \alpha_1 \frac{1}{B_v} + \alpha_2 \frac{\sum_{v \in J_2^i} \bar{\beta}_{iv}}{Q_i} \right) \end{aligned} \right.$$

So stochastic quasi gradient of the functions  $F_1(x, y, z, \bar{h}_1(\theta), \bar{h}_2(\theta))$  has the following appearance:

$$\xi^s = \bar{\nabla}_{x,y,z} f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s)) =$$

$$= \left\{ \begin{aligned} & \left( \alpha_1 \frac{\sum_{i \in I} a_{ij}(\theta)}{A_j} + \alpha_2 \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta)}{Q_i} \right. \\ & \left. - \frac{\alpha_1}{A_j} \right), & g_1 \leq g_2 \\ & \left( \alpha_2 \frac{\sum_{v \in J_2^i} \bar{\beta}_{iv}}{Q_i} \right. \\ & \left. \alpha_2 \frac{\sum_{j \in J_1^i} \beta_{ij}(\theta)}{Q_i} \right) \\ & 0, & g_1 > g_2 \\ & \left( \alpha_1 \frac{1}{B_v} + \alpha_2 \frac{\sum_{v \in J_2^i} \bar{\beta}_{iv}}{Q_i} \right) \end{aligned} \right.$$



Using formulas (9) we use the method of stochastic linearization to problems (7) – (8).

The choice of stepper multipliers is carried out as follows:

$$\rho_s = \frac{1}{(1+s)^\alpha}; \delta_s = \frac{1}{(1+s)^\beta}, \text{ - where } \alpha \leq 1, \beta \leq 1.$$

$\rho_s$  and  $\delta_s$  – satisfy correlation (10) – (13).

$$\begin{aligned} z^{s+1} &= z^s + \delta_s (\bar{\nabla}_{x,y,z} f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s)) - z^s) = \\ &= z^s + \frac{1}{(1+s)^\beta} \bar{\nabla}_{x,y,z} f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s)) - \frac{1}{(1+s)^\beta} z^s = \\ &= z^s \left(1 - \frac{1}{(1+s)^\beta}\right) + \frac{1}{(1+s)^\beta} \bar{\nabla}_{x,y,z} f(x^s, y^s, z^s, \bar{h}_1(\theta^s), \bar{h}_2(\theta^s)) \end{aligned}$$

$$x^{s+1} = x^s + \rho_s (\bar{x}^s - x^s), (z^s, \bar{x}^s) = \max_{x \in X} (z^s, x^s) \quad (18)$$

For convergence of the method of linearization takes place:

**Theorem.** Let conditions (11) – (13) are satisfied and takes place  $\|\xi^s\| + \|\nabla F(x^s)\| \leq C$ . Then sequence  $F(x^s)$  – converges a. p. (almost probably) and each limiting point  $\{x^s\}$  belongs

$$X^* = \{x^* : \max_{x \in X} (\nabla_x F(x^*), x - x^*) = 0\}.$$

The theorem proof is spent similarly to the theorem of 9 chapters 5 of work [2].

As two-criteria problem is being solved, therefore  $\lambda_1, \lambda_2 = 1 - \lambda_1$  the method of grids is applied to a finding of value of parameters  $\lambda_1, \lambda_2 = 1 - \lambda_1$  [4].

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## **DEFORMATION OF COASTAL ESCARPMENT OF EARTH CHANNELS UNDER THE ACTION OF SURFACE WAVES**

**Abstract:** As it was mentioned earlier that laboratory experience of the author and dependencies of S. H. Abaliyans to advantage of the riverbed of the limiting balance is designed method of the calculation morphometrical features of dynamically firm riverbeds of the greater earth channels, working under the condition of wind waves. The general regularities of deformation of coast escarpment is described under the action of surface waves.

**Keywords:** wave flow, sediment transport by waves and currents, the intermittence of water streams, saturated sediments, ripples.

The questions about choice of the optimum transverse profile of earth channels, occupies the leading place when designing the hydro irrigation system. Urgency of this problem is confirmed with unusual interest of the researchers, which belongs the big amount of publication in this area [1–3]. The Difficulty of the decision of given problems on modern stage is connected with that circumstance that in purpose of increasing to efficiency of the work of the channel in row of the events happens to design these vitally important for agriculture hydro technical buildings for mode, which velocity of the current of water exceed not washing importance to laying under the bed of the earth channel's soil. Such statement of the problem brings to raise the row of the additional problems, in accordance with the account of transporting abilities of the flow in deformed channels and with the forecast of possible planned and high-altitude deformation of their riverbed. Besides, increasing of the requirements when designing greater channels conducts to need of taking into consideration of not stationary hydraulic factor (the waves which is made by the wind, ship and, long waves of the different origin and etc.), which can render the essential influence on erosion processes, running in riverbed, and conduct to change transporting abilities of riverbed flow. The last question has been described in domestic and foreign literature in insufficient degree and limited in most cases by analysis of the

contribution of the long gravitation waves (on type of the waves of the leash in riverbeds of the river) in running in channels of the riverbed forming processes. The study of deformation the riverbeds under the action of short (wind and ship) waves are dedicated only in separate publications, in which main attention is paid to shaping ashore forming of riverbed relief appearing as a result of destructions of the waves under their approach to ashore [4]. Therefore the question about the general regularity of deformation of coast escarpment of earth channels under the action of wind and ship waves remains open. In this work development of simplified schemes of the calculation of dynamically firm transverse profile of greater earth channels, working at the presence of existing wind and ship waves with the following of its checking for receptions of experimental material by author [7]. Herewith further we shall consider that the amount of transported alluviums in channel and missed consumption of water define the width, average of depth and longitude gradient of the riverbed, but the form of the cross-section of the channel conditions the distribution tangential appearing in channel under the action of different factor (the drain current, wind and ship waves and etc.). So the width, average depth and gradient of dynamical firm channels with the provision of the amount of entering alluviums are counted on the base of the physical approach [5], but the form of the

cross-section is counted with use of the method enticing power (the tangential tension). As source for calculation of the form of the firm transverse profile of the channel was chosen by S. H. Abaliyans that was accepted for condition statically firm riverbed:

$$\frac{h}{h_m} = \sqrt{1 - \frac{(dh/dy)^2}{tg^2\phi_0}} \quad (1)$$

Here  $h$ -local depth,  $h_m$  – a maximum depth in channel,  $Y$ - transverse coordinate,  $\nu$  – a corner of internal friction of given soil. Beside the following study [2] by author is given suggestions about possibility of the use (1) for description the parameters of the channel, transporting alluviums. For this S. H. Abaliyans suggested (1) to enter instead of corner of the natural escarpment ( $\phi_0$ ) of its reduced importance:

$$\phi_g = \frac{\phi_0}{1,65}, \quad (2)$$

Where  $\phi_g$  – corner of internal friction of the soil that is under the dynamic stability.

Hereinafter it Was used the confirmed laboratorial data by gravitation authors [7] suggested that under the action of surface гравитационных waves occurs the partial destruction of coast escarpment of channel that finds its expression in shaping more full profile of the bottom in this zone. For quantitative account of the process of weeding of coast escarpment under the action of wind and ship waves in the expression is entered new value of the corner of the natural escarpment, which can be recorded with provision for dimensionality in the manner of:

$$\sqrt{tg^2\phi_g - K \frac{U_m^2}{(\nu g)^{2/3}}} \quad (3)$$

Where  $\nu$  – factor molecular cinimatic viscosity;  $g$ - speed of the free fall;  $U_m$  – amplitude specific tensions, appearing on riverbed of the flow under wind waves, which is defined in accordance with dependency by author.

In expression (3) empirical factor remains the unknown.

In purpose of the quantitative acknowledgement of the proposed mechanism of the erosion of coast escarpment under the action of wind waves and for determination of the value of the empirical factor “K”, entering in

(3) was organized series of the experimental studies by the author [7].

The Following stage of the studies is the determinations of importance of the empirical factor «K» in expression (3). As a result of integrating (1), after un-complicated operation we have:

$$\frac{h}{h_m} = 1 - \left[ 1 - \frac{\sqrt{tg^2\phi_g - K \frac{U_m^2}{(\nu g)^{2/3}}}}{2h_{mb}} Y \right]^2 \quad (4)$$

Where  $h_{mb}$  – maximum depth of canal when wave to the direction of current.

Решая (4) относительно искомого коэффициента K получим:

$$K = \frac{(\nu g)^{2/3}}{U_{gm}} \left[ tg^2\phi_g - \frac{4h_{mb}^2}{y^2} \left( 1 - \sqrt{1 - \frac{h}{h_{mb}}} \right)^2 \right] \quad (5)$$

For the dynamical firm land canals when no waves we have:

$$\frac{h}{h_m} = 1 - \left( 1 - \frac{3h_{cp}}{B} \cdot \frac{Y}{h_m} \right)^2 \quad (6)$$

Where

$$h_m = \frac{Btg\phi_g}{4} \quad (7)$$

$h_{cp}$  and  $B$  average depth, and width of the channel with the absence of waves, which are defined on stated in [5] the methods in accordance with given by consumption of water and amount of inflow of water into the channel by pump.

Substituting (7) in (4) we get a transverse profile of the bottom of dynamically firm channel in the condition of wind waves:

$$\frac{h}{h_{mb}} = 1 - \left[ 1 - \frac{\sqrt{\left( \frac{6h_{cp}}{B} \right)^2 - \frac{0,27U_m^2}{(\nu g)^{2/3}}}}{2h_{mb}} y \right]^2 \quad (8)$$

Using the dependencies  $K$  has allowed on given transverse profile of the bottom the results were gotten in the course of laboratory studies to define importance of the sought factor, at which changed within  $k = 0,5 \dots 0,1$  (the

average importance  $k = 0,27$ ). For determination of the width of the channel in condition of the imposition of the waves on current ( $B_b$ ) was used suggestion, which majority of the events is confirmed given called on laboratory studies: imposition wave drain current, bring about increase the width of the riverbed, does not обуславливает

observable change an area of its cross-section. This suggestion is founded on receptions in the course of experiment fact that erosion of the channel when cut off part is accompanied approximately equal accumulation of intensities of alluvium in interfacing zone of the coast escarpment from the central part of channel.

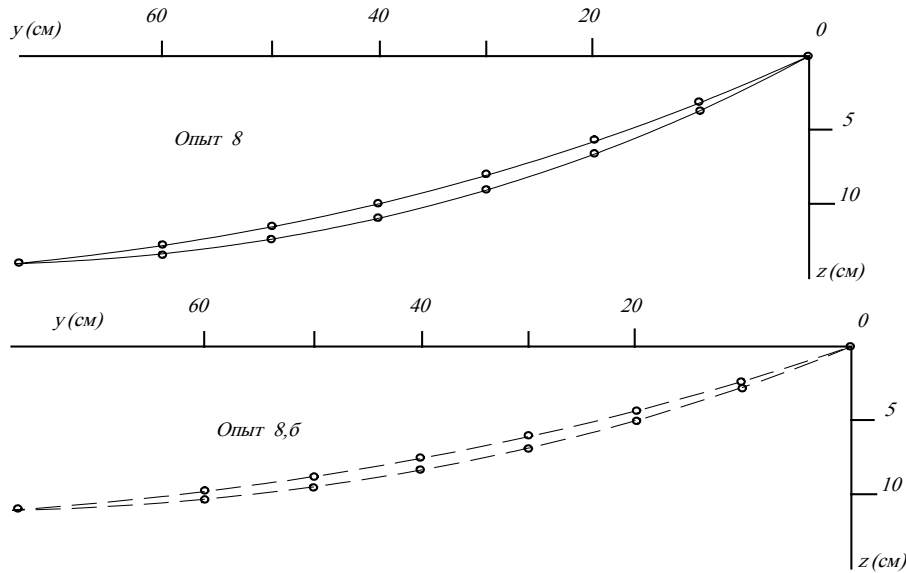


Figure 1. The Collation accounting (1) and measured (2) of the transverse profiles of the experimental channel as of laboratory experience, A – drain mode, B – imposition of the surface waves on drain current

Using the dependencies  $K$  has allowed on given transverse profile of the bottom the results were gotten in the course of laboratory studies to define importance of the sought factor, at which changed within  $k = 0,5, 0,1$  (the average importance  $k = 0,27$ ). For determination of the width of the channel in condition of the imposition of the waves on current ( $B_b$ ) was used suggestion, which majority of the events is confirmed given called on laboratory studies: imposition wave drain current, bring about increase the width of the riverbed, does not обуславливает observable change an area of its cross-section. This suggestion is founded on receptions in the course of experiment fact that erosion of the channel when cut off part is accompanied approximately equal accumulation of intensities of alluvium in interfacing zone of the coast escarpment from the central part of channel.

Use of this suggestion was recorded in the manner of:

$$\int_0^{B/2} hdy = const, \quad tg\phi_g B^2 = tg\phi_b B_b^2$$

It was allowed to get the expressions for calculation of the width ( $B_b$ ) and maximum of the channel under the condition of wind waves in the manner of:

$$B_b = B \sqrt{\frac{tg\phi_g}{tg\phi_b}} = B \sqrt{\frac{\frac{6h_{cp}}{B}}{\sqrt{\left(\frac{6h_{cp}}{B}\right)^2 - \frac{0,27U_m^2}{(vg)^{2/3}}}}} \quad (9)$$

Collation computable on fig.1 is brought on recommended methods and measured in laboratory condition, the profiles of the cross-section of dynamically firm channel with the presence of surface, gravitation waves, which shows enough good correspondence to results of calculation with actual data. Thereby, the work in this work has allowed to offer the algorithm calculation of the morph metric features of the large earth channels, working in the condition wind waves, of study increased hydraulic limits to applicability used in approach on the base of the account of the influence of surface gravitation waves on running in riverbed channel of erosion accumulating processes.

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## Section 7. Transport

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### RESEARCH OF PROCESS OF GUMMING OF GASOLINE ON SURFACES OF ELEMENTS OF A FUEL SUPPLY SYSTEM OF ENGINES

**Abstract:** The article examined pollution gasoline supply system elements of engines denial. Classified chemical structure of pollutants. Identify the types of failures caused by when applying contaminated fuel. Designed laboratory facility for testing of injectors and fuel pumps on measuring reliability. Conclusions leading to failure of supply system elements of engines in service in road and climatic conditions, hot and dusty regions.

**Keywords:** gasoline, engine, reliability, power system, dusty region, a hot climate, an injector, a fuel pump.

#### 1. Introduction

The results of performance tests have shown [1; 2], that the basic quantity of refusals of elements of a power supply system, occur owing to impurity of fuel, and in the general list of the refusals caused by gumming because of use of poor-quality gasoline in an injection power supply system of engines appear.

One of the basic requirements for ensuring operational reliability of an injection power supply system of engines is application of qualitative fuel and lubricants. However, at the time of the observations found that quality used car controlled engines, gasoline in most cases do not meet the requirements of the standard, particularly on the content of mechanical impurities in them, water and jet black. The fuel can also contain sulfur, oxygen and nitrogen compounds.

#### 2. The analysis of pollutants of gasoline

Gumming and asphalt substances (pitches, asphaltene's, etc.) belong to the complex cyclic compounds in which the molecule along with carbon and hydrogen is still composed of oxygen and sulfur.

Chemical structure of bituminous/asphalt substances have not yet been resolved, and therefore the classi-

fication is based on a different ability to dissolve in oil products. This classification distinguishes:

- neutral resin-high viscosity liquid or amorphous solid density about units, well dissolved in all liquid oil products;
- aromatic hydrocarbons in gasoline, with its high ant detonation properties, however, the content of more than 40% of sharply increased soot formation in the engine and the ability of a deposit to be kept (not to burn out) on a surface of details, strengthening possibility surface ignitions;
- asfalteny – the firm fragile substances painted in brown or black colour and possessing in density above unit;
- sour pitches in density above unit are outwardly similar to neutral pitches, and unlike the last sour pitches it is not enough soluble in the hydrocarbonic environment, but in gasoline at all soluble, therefore in process of formation they drop out of oil products and settle on details and power supply systems in the form of sticky adjournment.

Basic parameters driving the quality of motor gasoline are: density; octane number; content components

of the octane, the vapour pressure, the actual content of actual pitches and sulphur.

With rising temperature environment increases propensity of formation of pitch in gasoline.

### 3. Kinds of refusals of a power supply system of the engine

The use of leaded gasoline, even with bromic bear, leads to undesirable phenomena in operation [1–6]:

- Raised ash-forming in connection with increase in maintenance lead tetraethyl (80–85% of lead in a deposit on final valves and candles and 50–70% – on pistons and heads of blocks of cylinders);
- The raised propensity to surface ignition;
- To decrease in reliability of work of candles and final valves;
- To non-uniform distribution bear on cylinders which results raised ash-forming;
- Corrosion to action on metals in the presence of water;
- To decomposition lead tetraethyl at long storage that reduces detonation firmness of gasoline, etc.;
- To increase toxicity;
- To go up gumming.

### 4. Climatic features of the central asia

The main characteristic of operation of the cars the conditions of the Central Asia is high temperature and air dust content.

During the flight period day absolute maximum temperature of air in the conditions of the Central Asia (June-September) fluctuates from + 37 to + 470 Celsius. In a cabin of the car the temperature reaches from + 45 to + 480 Celsius, and under a cowl from + 80 to + 900 Celsius [3]. It leads to that oxidation and gumming gasoline in environmental conditions of the Central Asia is accelerated. As a result gasoline gets yellow-brown color, and on capacity walls at storage there is a layer of resinous substances.

At use of such gasoline on walls of a fuel tank, fuel of wires, the fuel pump, the filter of rough and thin clearing, an injector, a regulator of pressure and other details of a power supply system can be formed resinous adjournment in the form of a skintight brown layer similar unguent consistencies. At car operation on the gasoline containing a small amount of pitches (within norms, admissible the standard on gasoline), in an injection power

supply system it is formed only small adjournment which practically are not influencing for work of a power supply system, but in due course mechanical impurity in the form of a soil dust, grains of sand etc. being in gasoline are capable to stick to earlier formed adjournment in a power supply system and to adsorb on the surface new resinous substances. At use of gasoline with the raised maintenance of pitches it is possible formation of the adjournment, capable to cause infringement of standard work of a power supply system. The basic amount of refusals caused gumming are meeting in injectors.

Therefore for the purpose of reduction of influence of process of gumming by indicators of reliability of an injection power supply system of engines there was a task in view: to investigate gumming process in a power supply system of cars in laboratory-bench conditions.

By working out of laboratory installation, first of all, started with to provide identity of operating modes of elements of an injection power supply system of engines in laboratory-bench conditions with operational.

### 5. Designed of the laboratory stand

Designed laboratory facility for testing injection system engine power is a fixed installation (fig. 1 and 2), equipped with rotary flowmeter, with calorimeter and gauges of temperature 5, a manometer 6, a fuel tank 1. Fuel is fed into the system under pressure of 310 kPa with the help of the fuel pump 2. The fuel flowing through pipelines and 4 filter served to fuel a ramp, which has 7 injectors and pressure regulator 8. Fuel consumption is monitored using a flowmeter 5 and is determined by the fuel temperature, thermometer and pressure gauge is determined by using pressure in the pipes (fig. 2). Electric fuel pump and injector electric contacts are connected to the network through electric-transformer 1.

To change the temperature (T) power system operation mode is performed electrically, for which each injector fuel heaters are installed (figure. 1). Changes the pressure in the system can be achieved with an electric fuel pump to increase the pressure (P) in the system increases the pump output (Q), and to decrease-decrease.

Electrical wiring installation (fig. 1) worked under voltage: 220 v, to which it is connected to the general network via current converter.

In the process of conducting the experiment created high-temperature operating conditions the work

of injection system. To do this, the temperature of the gasoline in the food system has been changed in several ranges of temperature changes corresponding to different regions of operation of cars in Uzbekistan. Taking into

account its installation provides possibility of work of an injection power supply system of engines in various ranges of change of ambient temperature and gasoline, i. e. as ordinary, and high-temperature conditions.

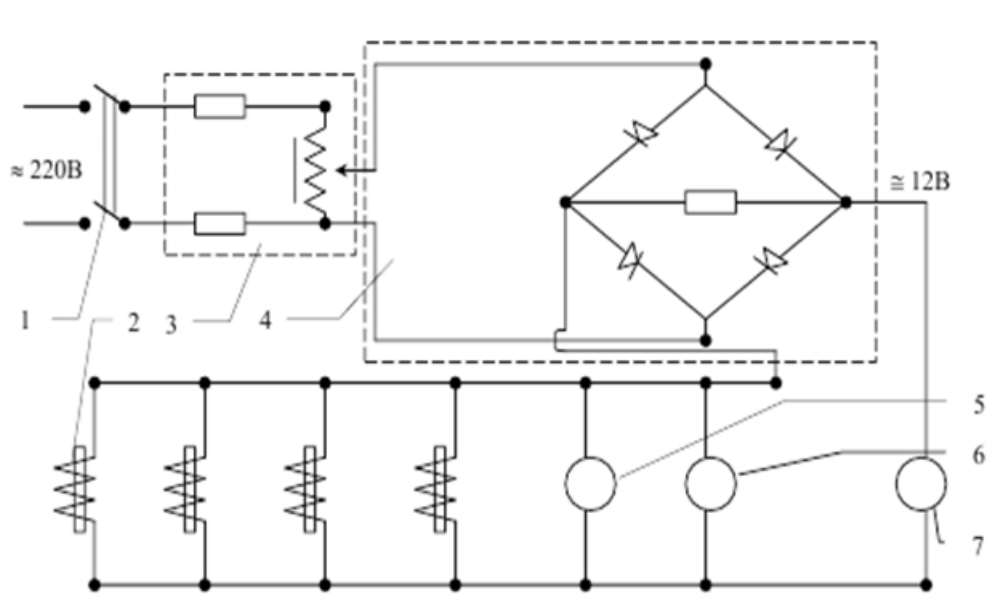


Figure 1. The electric scheme of laboratory-bench installation for test of an injection power supply system of internal combustion engines: 1 – switch; 2 – injectors; 3 – transformer; 4 – roadway the scheme of transformation of an electric current; 5 – electric motor of the fuel pump; 6 – voltmeter; 7 – amperimeter

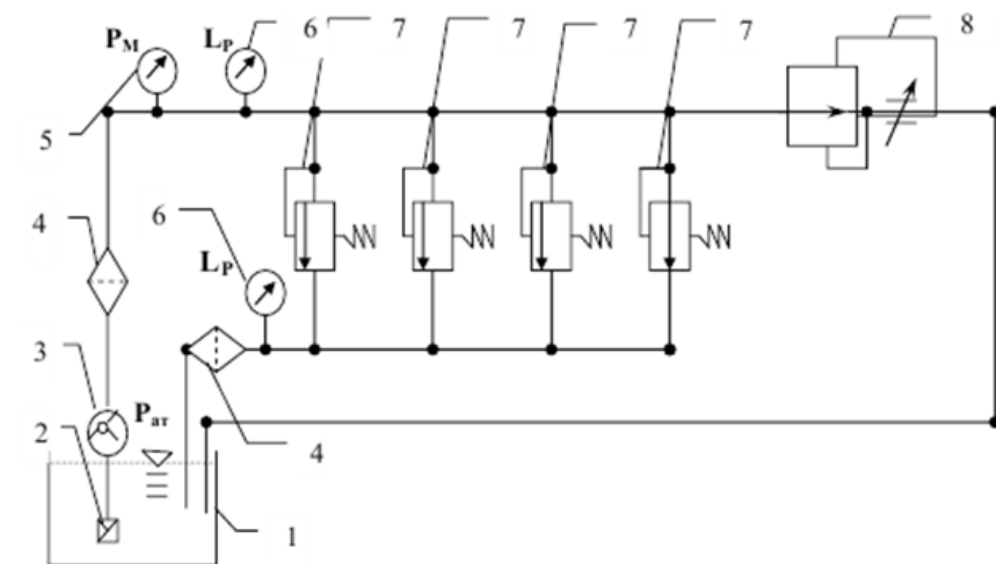


Figure 2. The hydraulic scheme of laboratory-bench installation for test of an injection power supply system of internal combustion engines: 1 – tank; 2 – the pump filter; 3 – fuel pump; 4 – fuel filter; 5 – manometer; 6 – flowmeter; 7 – injectors; 8 – regulator of pressure

### 6. Results of tests

Tests have shown that formations of resinous adjournment are rendered by the greatest adverse effect on

work of injectors. The greatest quantity of adjournment forming round dot apertures of injection of an injector, cases of overlapping of apertures were thus observed by

the resinous firm adjournment which were at the bottom of gradual stopping delivery of fuel.

Gumming adjournment, sticking to internal walls of an injector, lead to a motionless condition of its rod therefore there is an injector failure.

According to the results of the tests also revealed that there were cases clogging the resinous substances internal channels of the pressure regulator, leading to an increase in pressure in the fuel rail, which helps increase fuel consumption.

Research of different grades of gasoline has shown that character of course of process of gumming on all tested grades of fuel have about identical sequence. It follows from this that all grades applied in cars gasoline

during operation start to be oxidised with the subsequent formation gumming remitted on details fuel supply system engines.

### 7. Conclusions

Thus, results of tests have shown that at operation of cars with an injection power supply system of petrol engines in hot-environmental conditions territory of Uzbekistan cases of essential gumming in fuel supply system which reason is both applications of poor-quality grades of gasoline, and influence of high temperature of the environment, leading to acceleration of process of oxidation of gasoline and subsequently formations of resinous adjournment on power supply system details are observed.

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