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Kosmii Mykhailo Mykhailovych,
Candidate of Law, Associate Professor, Dean
King Danylo University
E-mail: kosmiy.lud@gmail.com

SYSTEMATIZATION OF REGULATORY ACTS IN THE FIELD OF URBAN DEVELOPMENT IN UKRAINE

Abstract. The article deals with the systematization and classification of Ukrainian legislation in the field of urban development. It determines the factors influencing the spatial structure of the city. Regulatory acts are considered as intangible factors of city development.

Keywords: urban development, legislation, spatial structure, state regulation, architectural activity.

In the last three decades, nearly a hundred regulatory acts dealing with urban development were drawn up and practically implemented. The existence of such volume of regulatory framework doesn't always evidence its effectiveness. On the contrary, there are a lot of conflicting points in the current legislation that impede the effective development of the urban development system. On the other hand, the norms of law are an important intangible factor affecting the spatial structure of a city, which allows it to be streamlined and harmonious with respect to the environment and the needs of the people.

Among the Ukrainian scientists who dealt with the problems of legal regulation of urban development, we would like to highlight the studies of L. Dmytrenko, T. V. Kryshtop, N. Kuzin, A. I. Ripenko, V. P. Suvorov, M. A. Khvesyk and others.

The purpose of our study is to systematize the main regulatory framework for urban development in Ukraine.

The legislative framework is an important intangible factor affecting the urban development system. Its main task is not only to ensure proper planning and development of territories, but also to create comfortable living conditions for people.

It is generally accepted that the Ukrainian legal field of urban development consists of the Constitution of Ukraine, codes, laws, resolutions of the Verkhovna Rada and the Cabinet of Ministers, as well as decrees of central executive bodies registered with the Ministry of Justice [2].

Given the considerable volume of regulatory acts, we consider it necessary to distinguish three groups of legal sources of urban development regulation.

The first group regulates procedural issues related to the exercise of powers of the executive authorities, local self-government bodies, other subjects of urban development in this sphere. The second group contains the basic industry-specific requirements for the content, procedure for development, approval and implementation of urban development documentation. The third group regulates related activities, but also contains requirements related to urban development or provides for the creation of information that is relevant to the preparation of urban development documentation [2].

While characterizing each of these groups, it should be noted that the first one contains primarily the Laws of Ukraine "On Local Self-Government in Ukraine", "On Local State Administrations", "On the Basics of Urban Development", "On Regulation of Urban Development", "On Architecture Activities", "On Responsibility for Offenses in the Field of Urban Development", Code of Ukraine on Administrative Offenses. A negative domestic trend is that certain provisions of these laws do not contain unambiguous interpretations, and sometimes even contradict each other.

One example of such legal contradictions is the lack of a single term to determine the subject of regulation of these laws.

The second group of legislative and regulatory acts includes the Laws of Ukraine "On the Basics of Urban Development", "On the Regulation of Urban Development", "On the General Scheme of the Territory Planning of Ukraine", "On the Comprehensive Reconstruction of City Blocks (Neighborhoods) of Obsolete Housing", "On Construction Norms"; Resolution of the Verkhovna Rada of Ukraine № 1359-XIV dated December 24, 1999, "On Approval of the Concept of Sustainable Development of Settlements", Resolution of the Cabinet of Ministers of Ukraine № 870 dated October 31, 2005, "On the Procedure of Transmission of Documents to the State Environmental Expertise", № 1391 dated December 15, 1997, "On Approval of the List of Settlements of Ukraine Referred to as Resorts", from № 878 dated June 26, 2001, "On Approval of the List of Historical Settlements of Ukraine (Cities and Small Towns)", № 318 dated March 13, 2002, "On Approval of the Procedure for Determining the Limits and Regimes of Using Historic Areas of Settlements, Restricting Economic Activity on the Territory of Historic Areas of Settlements", № 1291 dated August 29, 2002, "On Ensuring the Implementation of the Law of Ukraine "On the General Scheme of the Territory Planning of Ukraine", № 548 dated May 25, 2011, "On Approval of the Procedure of Examination of Urban Development Documentation", № 555 dated May 25, 2011, "On Approval of the Procedure of Public Hearings on Public Interests Consideration during Drafting of Urban Development Documentation at the Local Level", № 556 dated May 25, 2011, "On the Procedure of Exchange of Information between the Urban Development and State Land Cadastres", № 559 dated May 25, 2011 "On the Urban Development Cadastre"; orders of the Ministry of Regional Development № 64 dated June 2, 2011 and registered with the Ministry of Justice on June 24, 2011 under № 781/19519 "On Approval of the Procedure for Development of Historical and Architectural Basic Plan of the Settlement"; № 103 dated July 05, 2011, and registered at the Ministry of Justice on July 22, 2011, under № 902/19640 "On Approval of the Procedure for Issuing a Construction Certificate for Development of a Land Plot"; № 108 dated July 7, 2011, and registered at the Ministry of Justice on July 22, 2011, under № 903/19641 "On Approval of the Model Provision on Architecture and Urban Development Boards"; № 109 dated July 7, 2011, and registered with the Ministry of Justice on July 22, 2011, under № 912/19650 "On Approval of the Procedure for Provision of Urban Development Conditions and Restrictions on Land Development, their Composition and Content"; № 170 dated September 1, 2011, and registered with the Ministry of Justice on November 07, 2011, under № 1268/20006 "On Approval of the Procedure of Urban Development Monitoring"; № 290 dated September 16, 2011, and registered with the Ministry of Justice on December 20, 2011, under № 1468/20206 "On Approval of the Procedure for Development of Urban Planning Documentation".

The third group of regulatory acts dealing with activities related to the field of urban development is the most voluminous. These include, in particular, the Land Code of Ukraine, the Water Code of Ukraine, the Forest Code of Ukraine, the Air Code of Ukraine, the Subsoil Code of Ukraine, the Laws of Ukraine "On State Forecasting and Development of

Programs of Economic and Social Development of Ukraine", "On Stimulating the Development of Regions", "On the Protection of Cultural Heritage", "On the Protection of the Archaeological Heritage", "On the National Program of Formation of the National Ecological Network of Ukraine for 2000–2015", "On the Fundamental Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2020", "On the Protection of the Environment", "On the Protection of the Natural Air", "On Ensuring the Sanitary and Epidemiological Safety of the Population", "On Resorts", "On Tourism", "On Nature Reserve Fund", "On the Legal Regime of the Territories that Have Been Exposed to Radioactive Contamination as a Result of the Chornobyl Disaster", "On the Legal Basis of Civil Protection", "On Protection of the Population and Territories from Emergencies of Technogenic and Natural Character", "On State Social Standards and State Social Guarantees", "On Fire Safety", "On Drinking Water and Drinking Water Supply", "On Heat Supply", "On Electricity", "On Roadway Network", "On Transportation", "On Railway Transport", "On Pipeline Transportation", "On Use of Defense Land", "On Improvement of Settlements", "On State Land Cadastre", "On Land Management", "On Land Evaluation", "On Land Reclamation", "On Private Agricultural Household", "On Alienation of Land Plots, Other Privately Owned Objects of Immovable Property Placed There for Public Needs or from Public Necessity", Resolution of the Cabinet of Ministers of Ukraine № 15 dated January 12, 1993, "On the Procedure of Keeping the State Land Cadastre", № 106 dated July 23, 1991, "On the Organization of Implementation of the Resolutions of the Verkhovna Rada of the Ukrainian SSR on the Procedure for Enacting the Laws of the Ukrainian SSR "On the Legal Regime of the Territory that Has Been Exposed to Radioactive Contamination as a Result of the Chornobyl Disaster" and "On the Status and Social Protection of Citizens Affected by the Chornobyl Disaster", № 1107 dated August 25, 2004, "On Approval of the Procedure for Development and Approval of Standards of Drinking Water Supply", № 502 dated May 13, 1996, "On Approval of the Procedure for Use of Lands of Water Fund", from 08.05.96 № 486 dated May 8, 1996, "On Approval of the Procedure for Determination of Area and Boundaries of Water Protection Zones and the Regime of Conducting Economic Activities Within", № 2024 dated December 18, 1998, "On the Legal Regime of Zones for Sanitary Protection of Water Bodies", № 815 dated July 20, 1996 "On Approval of the Procedure for State Water Monitoring", № 413 dated April 8, 1996, "On Approval of the Procedure for Keeping the State Water Cadastre", № 1747 dated November 16, 2002, "On Approval of the Rules of Protection of Main Pipelines", № 1045 dated August 01, 2006, "On Approval of the Procedure for Removal of Trees, Shrubs, Lawns and Flower Beds in the Settlements", № 1279 dated November 17, 1997, "On the Size and Procedure for Determining Compensable Losses of Agricultural and Forestry Production", № 827 dated December 12, 1994, "On Approval of the Lists of Subsoil Assets of National and Local Importance", № 75 dated January 31, 1995, "On Approval of the State Accounting of Deposits, Reserves and Manifestations of Subsoil Assets", № 423 dated June 13, 1995, "On Approval of the Regulation on the Management of Geological Information", № 33 dated January 17, 1995, "On Approval of the Regulation on the Procedure for the Construction on Areas with Subsoil Assets Deposits of National Importance", № 213 dated March 23, 1995, "On Approval of the Methodology of Monetary Valuation of Agricultural Land and Settlements", 30.05.97 № 515 dated May 30, 1997, "On Approval of the Methodology of Monetary Valuation of Non-Agricultural Land (Other than Settlement Lands)", № 554 dated July 27, 1995, "On the List of Activities and Objects of High Environmental Risk", № 733 dated May 16, 2007 "On Approval of the Procedure for Division of Forests into Categories and Allocation of Particularly Protective Forest Areas", the Order of the State Committee of Ukraine on Land Resources № 548 dated July 23, 2010, and registered with the Ministry of Justice of Ukraine on November 1, 2010 under № 1011/18306 "On Approval of the Classification of Types of Specific Land Purpose"; State Classifiers DK 009–96 "Classification of Economic Activities", DK 018–2000 "State Classifier of Buildings and Structures", DK 005–96 "Classifier of Waste", DK 008:2007 "Classifier of Subsoil Assets".

The main obstacle to urban development is the retardation of free development of territories, which ultimately does not facilitate attraction of significant investment in the national economy. The need to solve existing problems, to reduce negative factors and influences necessitates finding optimal ways of developing state regulation of land matters in the field of urban development [8].

Thus, urban development legislation in Ukraine requires a clear system of unification. This is due to both practical and theoretical reasons. On the one hand, the existence of a large number of laws and regulatory acts leads to a variety of statements on the same issue. The legal contradictions are especially pronounced concerning the sphere of subordination of the system of urban development, drafting of general layouts, etc.

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Koval Lidiya,
Associate Professor, PhD in Art History,
Doctorate in the Department of Architectural Structures
Kyiv National University of Construction and Architecture
E-mail: likocolor@gmail.com

DEFINING OF PARAMETERS OF ILLUMINANCE FROM LEDS WITH DIFFERENT EXPANSION ANGLES

Abstract. The article deals with defining of parameters of illuminance from LEDs with different expansion angles. A defining has been made which enables comparing luminous properties of LED of different types, and, among mentioned luminous properties, those that intermediately influence the design of different types of lighting. Among these types of lighting: balancing lighting of diffuse surface, local lighting, accent lighting of objects, and side lighting of surfaces – have been singled out.

Keywords: LEDs, expansion angle, types of lighting, lighting design.

Problem formulation. In general, in design theory they distinguish the following stages of design process: the stage of planning, involving planning, distinguishing the sphere of application and formulating – at this stage project parameters are defined and studies; the stage of research, consolidation and scoring effects of design – at this stage design and its effects are analyzed by means of immersion and design-ethnography; the stage of idea adaptation and pilot model creation which includes participation and generative activity of a designer; the stage of evaluation, perfection and production which embraces multiple testing and feedback; the stage of launching and monitoring – at this stage quality of design is checked, which allows to guarantee its readiness for the market and public use, and in-process revision and analysis are done in order to make adjustments to the chosen direction, should the need occur [1, 7]. So, design travels a long way before the pilot model production, and in many ways it is the width of scope at the exploration phases which is responsible for the success and relevance of the pilot model. This aspect is peculiar of all types of designing activity, however, it is especially essential in the sphere of lighting design, since it is conceptual foresight of the interrelation of a luminaire shape and its luminous intensity distribution, which the duration and cost of stages taking place after pilot model production depend on.

Analysis of recent research and publications. "LED technology has dramatically improved the efficiency of lighting" [2], that is why different countries of the world gradually switch to the use of LED luminaires for different types of both decorative and functional lighting. In particular, in Ukraine since March, 2019 National building regulations have been applied [3], that enable the use of LED luminaires for both external lighting of urban spaces and for general lighting of premises. This tendency **actualizes** the need to study the properties of LED in the context of design of LED-based lighting. Essential scientific methods, employed while researching for the present paper, embrace analysis, synthesis, generalization, and graphic analytical method. All calculations in the framework of the present paper were performed without the use of any special calculation programs, according to the mentioned in the next chapter commonly applied formulas [4, 141–144; 5, 118–122], or by formulas derived from commonly used physical formulas.

The purpose of the article. The main purpose of this work is to defining of parameters of illuminance from LEDs with different expansion angles.

Results. Low-powered LEDs (< 1 W) have diverse diagrams of angular luminous intensity distribution [6], that is why defining of luminous parameters of LEDs with primary optics were performed for some characteristic values of luminous intensity distribution angle. Still, the elaborated set of methods and algorithm of calculations can be used for estimation of luminous parameters of LED with any value of luminous intensity distribution angle.

Then we trace differences between sizes of light spots from LEDs with different expansion angles and with difference between the length of beam light from different LEDs on condition of equal luminous flux. For this, we first calculate corresponding solid angle of light expansion for every LED.

Calculation of solid angle requires the notion of steradian. If you take spherical sector of such dimensions that its spherical surface area (its basis) S is equal to the square of the radius of an orb r^2, in the center of which there is the apex of this sector, the volume of this figure is called steradian (Figure 1).

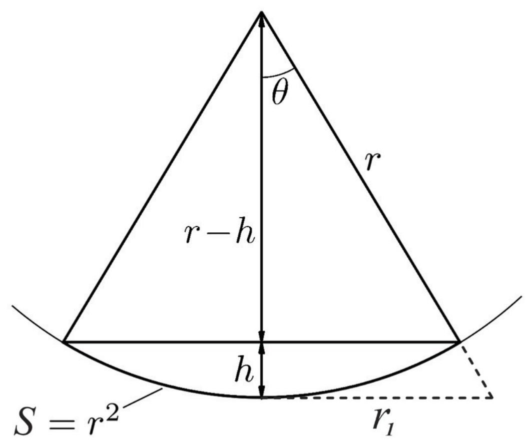

Figure 1. Angle of expansion of circular cone 2θ with solid angle of 1 steradian

The surface of an orb, if viewed from the center, makes solid angle 4π steradian. The direction of luminous flux distribution from point source is assigned by the solid angle. A LED is a conditionally point source, and light of LEDs with primary optics which are point rotationally symmetrical sources, is distributed in the solid angle. This enables defining the solid angle of luminous distribution of a LED by face angle at the apex of the circular cone, created by the luminous flux of that LED (by the expansion angle of the cone of light of the LED). It is known that solid angle is calculated according to the formula:

$$\Delta\Omega = \frac{\Delta S}{r^2}, \qquad (1)$$

where Ω – solid angle; S – spherical surface area of a spherical sector; r – radius of an orb, in the center of which there is the apex of this sector. Herewith, total superficial area of an orb is calculated with the formula:

$$S = 4\pi r^2, \qquad (2)$$

where S – superficial area of an orb; r – radius of an orb, and lateral surface of a spherical sector is calculated with another formula:

$$S = 2\pi rh, \qquad (3)$$

where S – lateral surface of a spherical sector, h – height of a spherical sector.

Figure 1 graphically represents the notion of steradian, by the example of axial cutover of a solid angle in the shape of a circular cone. As it is obvious from Figure 1, further calculations of h can be performed with the use of geometrical properties of right-angled triangle, the height $r – h$ of which will be calculated according to the formula:

$$r - h = r\cos\theta. \qquad (4)$$

Assuming the value of radius of an orb r = 1 m, and in this case formula (4) presumes that $h = 1 - \cos\theta$, according to this we transform formula (3) and get a formula for calculation of lateral surface of a necessary segment of an orb:

$$S = 2\rho(1 - \cos\theta), \quad (5)$$

Afterwards according to the formula (1) we calculate solid angle, with the assumed value of radius of an orb $r = 1$ m.

Since solid angle of LED light is determined by its face angle at the apex of its light cone, the value of corresponding face angle is employed for the convenience of indication of this parameter, especially in catalogues of LED producers.

So, angle θ (according to Figure 1) for LEDs with angle of luminous distribution 60 º, 30 º, 10 º will correspondingly equate 30 º, 15 º, 5 º, and solid angle will correspondingly make: 0.84152 sr; 0.214148 sr; 0.023864 sr.

Then we will define radius of light spot from LED r_1 at the distance r (1 m):

$$r_1 = r\tan\theta, \quad (6)$$

and this enables calculating the area of this spot:

$$S_1 = \pi r_1^2. \quad (7)$$

For LEDs with angle of luminous distribution 60 º, 30 º, 10 º at the distance of 1 m the value of radius of light spot of the LED will correspondingly equate 0.5774 m; 0.2679 m; 0.0875 m; and the value of light spot area with rounding off to thousandth will correspondingly make: 1.047 m^2; 0.225 m^2; 0.024 m^2.

Performed calculations of areas of light spots from different LEDs on the plane, which is perpendicular to luminous flux direction, are important for maintaining proportionality of its lighting which is usually regulated by means of distance between LED centers on condition of their uniform allocation on the mounting surface. This issue is especially topical for design of illumination devices with the use of diffusers located at certain distance from LEDs, parallel to mounting surface, as such materials visually detect the tiniest manifestations of unbalance in lighting. Figure 2 (dashed line marks boundaries of light spots of LEDs) demonstrates the variant when regular allocation of LEDs maintains tangency of their light spots, and the distance between LEDs centers a correspondingly makes $2r$.

It is obvious from (Figure 2) that in this framework there is a dark spot in the center of the cell between four LEDs. In order to prevent this, one can either install LEDs in the center of those nominal cells, thus making the process of mounting technologically complicated (this allocation of LEDs is called delta-like), or change the distance between LED centers a up to the state, when their light spots overlap, touching edges in places of perpendiculars from LED centers (Figure 3).

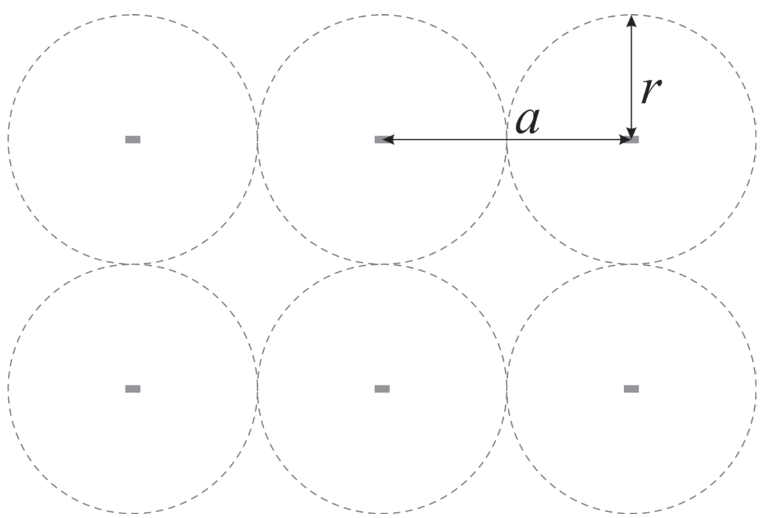

Figure 2. Regular allocation of LEDs, when proportional illuminance of the surface at certain distance from them is not secured

In this case proportionality of lighting will be secured, and minimum essential distance between LED centers *a* equates to radius of light spot *r* at the given distance from the mounting surface.

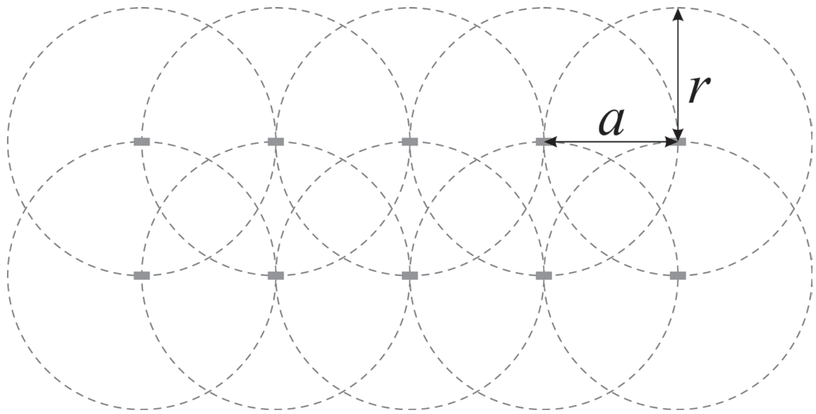

Figure 3. Regular allocation of LEDs that secures proportional lighting of the surface at certain distance from LEDs

Using formula (6), it is possible to calculate radius of light spot and to define the essential pitch between LED centers for proportional lighting of the plane at any distance from the mounting surface. Performed analysis and calculations demonstrated that diameter and area of light spot from different LEDs allocated at the same distance depend only on the value of solid angle, which is determined by the expansion angle of the light cone of LEDs.

Afterwards, we view interdependence between such luminous quantities as luminous intensity, solid angle and luminous flux, in order to analyze differences between the length of light beams in the presence of similar luminous flux. In general, luminous intensity of a source is defined as luminous flux, which it forms in a single solid angle. If a source creates luminous flux $\Delta\Phi$ in solid angle $\Delta\Omega$, luminous intensity of a source **I** equates to:

$$I = \frac{\Delta\Phi}{\Delta\Omega}. \tag{8}$$

It becomes obvious that LEDs of the same luminous intensity but with different solid angles of light will have different luminous flux. Luminous intensity of LEDs with the same luminous flux and different solid angles of light will also be different. This aspect has no relation to the cases when similar LEDs with the same solid angle value are used in an illumination device, but this can have significant impact on luminous intensity distribution of luminaires which contain LEDs with different solid angles of lighting.

Then we admit that the value of luminous flux is the same for each LED, namely Φ = 1 lm, and calculate, according to formula (8) luminous intensity of each LED in accordance with the value of its luminous intensity distribution angle. In such conditions, luminous intensity **I** of LEDs with luminous intensity distribution angles 60 º, 30 º, 10 º will correspondingly equate to: 1.188 cd; 4.673 cd; 41.904 cd.

Illuminance *E* is generally viewed as ration of luminous flux $\Delta\Phi$, that falls on the surface ΔS, to the value of this area. Guided by this, according to formula (9) we calculate illuminance within the boundaries of the light spot at the distance of 1 m from the source (grounding on preliminary calculated area of the light spot for each LED). Determination of this parameter is an appropriate measure in designing luminaires for local lighting. Calculation is performed in condition of similar luminous flux of each of these LEDs Φ = 1 lm. Thus, within the boundaries of light spot at the distance of 1 m from LEDs with luminous intensity distribution angle 60 º, 30 º, 10 º illuminance E will correspondingly equate to: 0.955 lx; 4.444 lx; 41.667 lx.

$$E = \frac{\Delta \Phi}{\Delta S}. \qquad (9)$$

Then we determine differences between the outstretch of light beams from different LEDs at the same luminous flux $\Phi = 1$ lm. For this we define at which distance from the LED illuminance of the surface will equate to 1 lx at the point of falling of a perpendicular beam on it. We assume that a LED is a point source, transform formula (10) into formula (11) and use preliminary calculated values of luminous intensity for each LED. So, the sought value of distance *r* for LEDs with luminous intensity distribution angle 60 º, 30 º, 10 º will correspondingly be equal to: 1.090 m; 2.162 m; 6.473 m.

$$E = \frac{I \cos\theta}{r^2}, \qquad (10)$$

$$r = \sqrt{\frac{I \cos\theta}{E}}. \qquad (11)$$

This parameter is significant for predicting light beam outstretch from a LED with a certain angle of light cone expansion while designing LED luminaires made for accent lighting of objects, as well as for side lighting of surfaces (when light beam is directed parallel to the surface, if illumination device is mounted close to it).

Conclusions. In the course of the research the photometric parameters of LEDs, parameters of their interaction with the space and directions of their use while designing illumination devices were determined:

– radius of light spot at a certain distance from a source determines necessary pitch **a** between centers of LEDs during their mounting in order to secure proportional lighting of diffusing surface which is located at the same distance;

– illuminance level within light spot from a source at a certain distance from it is important for designing local lighting;

– distance from a source, at which in the point of incidence of perpendicular beam on the surface, illuminance will equate to 1 lx, is significant for design of accent lighting of objects and side lighting of surfaces.

Prospects for further research. In the future, it is advisable to explore of on peculiarities of construction of diagram of luminous intensity distribution of LEDs with different solid beam angles.

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Kravtsov Dmytro Serhiyovich,
PhD Student of Department of Architecture of Buildings and Structures
Odessa State Academy of Civil Engineering and Architecture
E-mail: kravtsovdima27@gmail.com

OPTIMIZATION TOOLS FOR ARCHITECTURAL AND PLANNING ORGANIZATION OF UNIVERSITY SPORTS COMPLEX

Abstract. The article raises the issue of the need to improve the efficiency of the architectural and planning organization of the university's sports complex. Means of optimizing the structure of this type of objects are being considered.

Keywords: sports complex, university, sports space, optimization, universalization.

Кравцов Дмитрий Сергеевич,
Аспирант, кафедра архитектуры зданий и сооружений
Одесская Государственная Академия Строительства и Архитектуры
E-mail: kravtsovdima27@gmail.com

СРЕДСТВА ОПТИМИЗАЦИИ АРХИТЕКТУРНО-ПЛАНИРОВОЧНОЙ ОРГАНИЗАЦИИ СПОРТИВНОГО КОМПЛЕКСА ВЫСШЕГО УЧЕБНОГО ЗАВЕДЕНИЯ

Аннотация. В статье поднимается вопрос необходимости повышения эффективности архитектурно-планировочной организации спортивного комплекса вуза. Рассматриваются средства оптимизации структуры данного типа объектов.

Ключевые слова: спортивный комплекс, вуз, спортивное пространство, оптимизация, универсализация.

Учитывая исторические тенденции, случилось так, что большинство вузов тяготеет к центральным районам города. Чаще всего это вызывает определенные трудности при проектировании новых и реконструкции существующих спортивных комплексов (СК) вузов в условиях плотной застройки центральных районов города и отсутствия свободных городских территорий [2, 118]. Этот тип объектов также должен постоянно адаптироваться под меняющиеся потребности общества, современные тенденции и потребности области физического воспитания. В нем должны учитываться особенности программы физического воспитания, которые, как правило, обеспечивают широкий спектр форм и видов занятий спортом, а также интенсивное использование спортивных объектов. Обеспечение постоянного заполнения залов является серьезной проблемой эффективной эксплуатации СК вуза [1]. Решение этой проблемы тесно связано с потребностями вуза и города, частотой проведения культурных и массовых мероприятий, нормативами спортивных залов и зрительских мест, и т.д.

Поскольку одним из важнейших вопросов спортивной индустрии является максимальная эффективность использования спортивных пространств и учитывая вышеперечисленные факторы, нужно отметить следующие тенденции в строительстве СК вузов: универсализация спортивных пространств; эксплуатация СК несколькими учреждениями; применение компактных архитектурных и планировочных решений СК за счет увеличения этажности и создания открытых спортивных площадок на эксплуатируемой кровле.

Одним из основных способов универсализации и повышения рентабельности спортивных объектов является *использование специализированного оборудования для трансформации спортивных пространств*. Такое оборудование позволяет организовать многофункциональное пространство пригодное как для спортивных занятий, так и для культурно-массовых мероприятий. Системы трансформации спортивных пространств можно разделить на следующие два типа:

Предусмотренные в процессе проектирования – реализуются за счет дополнительной площади и помещений, предусмотренных в объёмно-планировочном и конструктивном решениях объекта.

Возможные для использования в объемах уже существующих спортивных объектов без вмешательства в их несущий остов – их применение позволит частично решить проблему эффективности использования спортивных пространств существующего СК ЗВО. Также рациональным является учёт данного типа средств трансформации при проектировании новых СК сети вузов, так как они значительно улучшат их функциональность и эффективность режима эксплуатации. Средства трансформации этого типа включают: системы разделения залов, мобильные трибуны и партер, сборный подиум, защитное покрытие, средства трансформации ванн бассейнов и т.д.

Примером реализации этого средства оптимизации СК ЗВО является проект EMÜ Sports Hall Эстонского университета естественных наук (Тарту, Естония). Универсальный спортивно-зрелищный зал СК содержит телескопические трибуны и универсальную разметку площадок для различных спортивных игр и соревнований с учетом трансформации трибун. Для создания наилучших условий для академических занятий и тренировок также применяются: система разделения залов; подвесная механическая система спортивного оборудования (баскетбольные корзины); мобильные элементы спортивного снаряжения игровых видов спорта; в одном из малых залов СК также есть система разделения залов с зеркальным покрытием для тренировок по хореографии и гимнастике.

Еще одним из средств оптимизации СК вуза является его *кооперированное использование*. Эта тема поднимается во многих научных трудах, но полноценного нормативного обоснования не имеет. Отмечается только возможность создания спортивных комплексов кооперированного использования. СК вузов кооперированного использования можно разделить на следующие группы в зависимости от обслуживаемых учреждений и групп населения:

СК кооперированного использования несколькими учебными заведениями – кооперированная эксплуатация структурных элементов (спортивный комплекс, в том числе) несколькими учебными заведениями позволяет снизить требуемую площадь земельных участков вуза почти на 25% [1, 145]. Формирование номенклатуры помещений эксплуатируемого спортивного комплекса основано на увеличении и поочередном использовании самых дорогих и технически сложных конструкций. Архитектурно-планировочная организация таких комплексов предполагает сочетание параллельных функциональных зон. Отмечается необходимость обособления ряда элементов комплекса (административно-сервисные, услуги для посетителей, хранение инвентаря) при формировании расширенного комплекса для тех же и смежных видов спорта. Расчет обслуживающих помещений осуществляется с учетом общей прогнозируемой пропускной способности спортивных пространств. В условиях реконструкции спортивных комплексов нескольких прилегающих вузов целесообразно сформировать компенсирующий СК, который будет покрывать потребности этих учреждений в спортивных пространствах [1]. При формировании такого компенсирующего комплекса следует иметь в виду, что дублирование спортивных пространств рассчитывается на общую требуемую пропускную способность учреждений, которые кооперируются.

СК кооперированного использования вузом и работниками смежных предприятий – в случаях вузов технического профиля, близких к соответствующим научно-исследовательским институтам или промышленным предприятиям, целесообразно сформировать СК на базе физкультурно-оздоровительного центра предприятия. При этом типе сотрудничества следует учитывать график рабочих смен предприятия и академических занятий вуза. Проведение предусмотренных программой физического воспитания академических занятий не должно пересекаться с физкультурно-оздоровительными занятиями работников предприятий. В качестве расчетной величины для помещений той же или связанной спортивной деятельности эксплуатируемого СК необходимо выбрать самую большую из следующих: требуемую пропускную способность СК вуза, или расчетную величину физкультурно-оздоровительных помещений предприятия с учетом возможности эксплуатации его жителями прилегающих территорий. Кроме учреждений технического профиля, которые тяготеют к промышленным объектам и НДИ, есть и другие случаи, которые создают условия для кооперированной эксплуатации СК. Примером является эксплуатация городских стадионов и СК как населением, так и студентами вузов спортивного профиля, или малыми вузами не имеющими собственного СК для проведения академических занятий.

СК вуза с кооперированной эксплуатацией студентами и жителями окружающих жилых массивов. Данный вид сотрудничества имеет следующие требования к СК: доступность для различных слоев населения – особенно важно в условиях закрытой территории учебного заведения; визуальная выразительность и мотивационная способность СК; расширение группы социальных пространств, рекреации и активного отдыха [3, 285–288]. Среди указанных форм кооперированной эксплуатации СК вуза данная является наиболее распространенной и в современных условиях ее можно определить как обязательную.

Использование многоуровневых архитектурно-планировочных решений для формирования СК вуза – способствует лучшей организации образовательного процесса, более интенсивной загрузке учебных зданий и сокращению времени, затрачиваемого на транспортное сообщение между структурными элементами вуза [2]. Одним из основных элементов СК служащих базой для проведения академических занятий, являются залы игровых видов спорта, которые в основном отличаются своими большими размерами и требованиями к высоте спортивных пространств. С учетом этого фактора можно выделить два направления при строительстве многоуровневых спортивных комплексов: СК с увеличением размеров спортивных пространств к вершине здания (например, Институт Кодокан, Токио, Япония); СК с отдельными многоэтажными блоками малогабаритных спортивных пространств (например, СК Университета Анд, Богота, Колумбия) [6].

Организация открытых спортивных пространств на эксплуатируемой кровле позволяет экономить значительные городские пространства и, как следствие, повышает эффективность эксплуатации СК, упрощает организацию образовательного процесса и уменьшает время затрачиваемое на связь между структурными элементами СК.

Как правило, такие архитектурно-планировочные решения комплекса закладываются на стадии проектирования. Это средство оптимизации сильно зависит от региона проектирования и строительства СК, а именно от его природно-климатических условий. В условиях реконструкции организация открытых спортивных площадок на крыше связана с определенными трудностями, а именно: необходимость расчета существующих конструкций на предполагаемую нагрузку, в том числе динамическую, возникающую в процессе эксплуатации; наличие достаточного пространства для организации спортивных площадок; и т.д. В частности, в случае несоответствия существующих конструкций требованиям проектируемых площадок дальнейшая реконструкция кровли во многих случаях становится невозможной или осложняется тяжестью и большой себестоимостью работ по укреплению несущих конструкций существующих конструкций. Исследованиям проблемы диагностики и укрепления несущих конструкций зданий и сооружений посвящены труды А. И. Мальганова, А. А. Шилина, И. Ушакова, Д. Л. Лазовского и других.

В проектировании открытых спортивных площадок на эксплуатируемой кровле можно выделить два направления: *кровля с непрямой связью с улицей; кровля с прямой связью с улицей*.

Примером реализации первого подхода является São Luís Sports & Arts Gymnasium, Сан-Паулу, Бразилия – расположенный в плотной городской застройке СК содержит на кровле универсального спортивно-зрелищного зала футбольное поле. Для безопасности площадка ограждена сеткой, которая предотвращает попадание игровых снарядов за границы поля [4].

Примером реализации иного подхода к формированию спортивного комплекса можно считать СК промышленного центра «Облачный город», Ханчжоу, Китай [5]. Зеленая крыша СК напрямую соединена с пешеходным тротуаром и содержит не только легкоатлетические беговые дорожки с открытыми спортплощадками, но и зоны отдыха и социальной активности. Такое решение кровли СК положительно влияет как на его эффективность, так и на его привлекательность и мотивационную способность, что в современных условиях очень важно.

Применение при формировании архитектурно-планировочного решения СК вуза приведенных средств оптимизации позволит значительно повысить эффективность эксплуатации комплекса. Внедрение средств трансформации спортивных пространств значительно увеличит адаптивность спортивных пространств к потребностям процесса физического воспитания. Кооперированная эксплуатация СК имеет как позитивные социально-экономические эффекты, так и позволяет экономить драгоценные городские территории. Применение многоэтажных решений СК и организация открытых спортивных пространств на эксплуатируемой кровле также позволяют сделать архитектурно-планировочное решение комплекса более компактным, а использование застраиваемого участка более интенсивным способствуя улучшению организации учебного процесса.

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Section 2. Mathematics

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Slobodynska Tamara Stepanovna,
Doctor of Philology, Professor,
Communal Higher Education Institution
“Vinnytsia Humanities Pedagogical College”
E-mail: slobodynska@ukr.net

MATHEMATICS AS THE BASIS OF THE METATHEORETICAL LEVEL OF KNOWLEDGE

Abstract. The article is devoted to mathematics as one of the fundamental disciplines, which has a number of meta-scientific characteristics and allows other sciences to implement a systematic approach to solving the pressing problems of the modern integrated world.

Keywords: meta-science characteristics, criteria for self-identification, ideal objects, mathematical tools.

Слободинская Т. С.,
доктор филологических наук, профессор,
Коммунальное учреждение высшего образования
«Винницкий гуманитарно-педагогический колледж»,
E-mail: slobodynska@ukr.net

МАТЕМАТИКА КАК ОСНОВА МЕТАТЕОРЕТИЧЕСКОГО УРОВНЯ ПОЗНАНИЯ

Аннотация. Статья посвящена математике как одной из фундаментальных дисциплин, которая имеет ряд метанаучных характеристик и позволяет другим наукам осуществлять системный подход к решению насущных задач современного интегрированного мира.

Ключевые слова: метанаучные характеристики, критерии самоидентификации, идеальные объекты, математический инструментарий.

Наука … Что она собой представляет? Каковы ее определяющие черты? Если вы планируете изучать бег, отмечал в свое время А. Г. Маслоу, вам стоит изучать бег олимпийского чемпиона [1]. Если задачей является изучение речи как структурно-функционального компонента деятельности, то объектом анализа должен стать наиболее развитый вид деятельности. Наиболее развитой во всех аспектах деятельности является фундаментальная или наука «в чистом виде» – общественное по своей природе и мотивированное не частным интересом, а потребностями всего общества производство научных знаний. Центральным компонентом в структуре научного знания, составляющей, которая соответствует основному назначению науки «в чистом виде», является научная теория. Учитывая это, уровень развития науки (отдельной дисциплины или интердисциплинарного комплекса) определяется не объемом собранного эмпирического знания, а уровнем развития применяемых в определенной области познания научных теорий. По этому критерию лидером среди фундаментальных наук следует признать математику, которая еще во времена Аристотеля и Евклида открыла и использовала преимущества аксиоматического метода построения теории. Сегодня она демонстрирует не только образцы эксплицитного построения идеальных конструктов, но и связь теоретических исследований с анализом гносеологических основ науки. Математика раньше других наук вышла на метатеоретический уровень познания и приступила к исследованиям своего собственного знания. Благодаря, прежде всего, достижением в области метаматематики, современная математика приобрела ряд метанаучных характеристик, которые имеют «базовое» значение для фундаментальной науки в целом.

1. На сегодня математика лучше, чем другие науки, защищена от паранаучной мифологии. Если, например, психологам приходится бороться против парапсихологии, то математики лишены подобных проблем, потому что параматематики просто не существует. «Технический» аппарат математической логики, предназначенный для борьбы со скрытыми противоречиями и синкретизмом теоретических построений, используется для «охраны» математического знания от различных мифологем и фантомов иррационального мышления.

2. По сравнению с другими науками, математика имеет в своем арсенале наиболее четкие критерии самоидентификации. Ее предметная область уникальна, ибо математика представляет собой множество идеальных конструкций, построенных с чрезвычайно абстрактных «элементарных объектов» с помощью мислительных операций, выбор которых обоснован классической или интуиционистской (конструктив-ной) метаматематикой. Иными словами, математика отличается от других наук тем, что ее понятийная система отражает не материальный мир, а «мир» ее собственных идеальных объектов (поэтому философы имеют основания называть математику «демонологией рационального мышления»). Образно говоря, математика производит и создает аналитический инструментарий, который может быть использован в различных областях научного познания и технического творчества. Математическое моделирование используется во всех науках, но сама математика оперирует только собственными «теоретическими объектами» (В. С. Степин).

3. Математическое знание лишено внутреннего раскола и междупарадигмальних конфрон-таций, свойственных многим социогуманитарным наукам. Между классической и конструктивистской парадигмами в математике нет такого противостояния, которое хранится, например, между психоанализом и бихевиоризмом в психологии. Бихевиористы до сих пор ставят под сомнение научный статус психоанализа, а психоаналитики считают, что «поведенческая» психология не способна раскрыть глубинных структур человеческой психики. В математике ситуация существенно отличается, поскольку в значительной степени благодаря метаматематике, «классицисты» правильно понимают, признают и оценивают все, что происходит сегодня в конструктивной математике, а «конструктивисты» не отрицают достижений и перспектив математики классической. Обе парадигмы не противоречат, а дополняют одна другую, поэтому можно утверждать, что современная математика – это единственная наука, которая имеет единое рациональное самосознание.

4. Современное математическое знание обозначено такими эпистемологическими характеристиками. Это, прежде всего, такие параметры:

Обьективированость. Математическое знание, в отличие от обычного, не зависит от особенностей субъективного восприятия, от психологических установок, от субъективного предпочтения и собственных оценок; в отличие от философского знания, оно не является подвластным социокультурной детерминации. Поэтому математика одна и та же для всех людей, культур и народов.

Предметность. В отличие от художественных идей, все математические идеи подаются в предметной форме, то есть как системы абстрактных объектов. Предметную форму представления знаний имеют не только исходные объекты математики (множества, числа, геометрические фигуры), но и все свойства, отношения, операции и преобразования объектов, а также свойства отношений, отношения между свойствами, свойства преобразований и тому подобное.

Эксплицитность. В математике декларативное знание сводится к минимуму (декларативными есть только аксиомы теории множеств и некоторые принципы, например, базовый принцип классической математики: «существуют актуально бесконечные множества»). Остальные математические знания (кроме минимального декларативного компонента) являются доказательными, поскольку представлены как эксплицитные процедуры построения соответствующих абстрактных объектов. При этом существование абстрактного объекта в математике является доказанным лишь при условии, когда доказана непротиворечивость математичес-кой теории, которая содержит определенный объект как свой конструктивный элемент. Итак, благодаря точным и логично строгим инструкциям, содержание всех недекларативных теоретических конструкций – понятий, утверждений и доказательств – разумеется однозначно, без призывов к интуиции и без привлечения какого-либо нематематического знания.

Системная связь (интегриро-ванность). Первым шагом на пути интеграции математического знания стал открытый Р. Декартом «универсальный способ перевода вопросов геометрии на язык алгебры и решения их собственно алгебраическими и аналитическими методами» [2, С. 562]. Сегодня все разделы математики связаны между собой концептуально, логично совместимы и дополняют друг друга в методологическом аспекте. Кроме того, исследования системных взаимосвязей между различными математическими дисциплинами открывают, по мнению акад. А. Н. Колмогорова, широкие перспективы для новых теорий, для обобщения понятий и совершенствования доказательств [2, с. 560–564]. Интеграция является естественным направлением развития математики, поскольку системность органично присуща математическом знанию на всех уровнях ее организации. Во-первых, системными характеристиками обладают все математические теории и все математические дисциплины, а исследовательская работа во всех областях математики проводится в строгом соответствии с принципами общенаучной системной методологии. Во-вторых, такие математические дисциплины как, например, общая теория систем, синергетика и математическая кибернетика, исследуют, по сути, различные аспекты понятия «система» и вносят свой вклад в развитие системного подхода в научном познании. В-третьих, математика вообще представляет собой «крупную» информационную систему и в этой функции является предметом современной теории «крупных» систем. Характерно, что никакое открытие в современной математике не может разрушить эту систему или хотя бы снизить уже достигнутый уровень системности знания, поскольку обоснование новых результатов как раз и заключается в доведении их непротиворечивости относительно уже построенных теорий. Примерами формирования новых направлений в математической науке может быть, в частности, открытие в XIX веке неевклидовых геометрий, внутренне непротиворечивых и таких, которые не противоречат евклидовой геометрии, или же открытый

А. Робинсоном в 1960 году нестандартный анализ, обоснование которого состояло в доведении его непротиворечивости относительно «стандартной» теории действительных чисел. В математике четче, чем в любой другой науке, оказываются все функции языка научной теории. Поэтому анализ используемых в математике языковых средств позволяет раскрыть ряд «базовых» характеристик языка фундаментальной науки в целом. Язык современной математики – структурированная множество знаково-символьных систем, содержащих фрагменты естественного языка,– есть не стихийным образованием, а продуктом познавательной деятельности многих поколений ученых.

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Section 3. Machinery construction

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Miroshnikov Vitaly,
Kharkiv National University of Construction and Architecture, Ukraine,
PhD in Technical sciences, Department of Construction Mechanics
E-mail: m0672628781@gmail.com

DETERMINATION OF THE STRESS STATE OF A LAYER WITH A CYLINDRICAL CAVITY, LOCATED ON AN ELASTIC BASE AND GIVEN BOUNDARY CONDITIONS IN THE FORM OF DISPLACEMENTS

Abstract. The spatial problem of the theory of elasticity is solved for a layer that is located on an elastic base and has a longitudinal circular cylindrical hole. Displacements are specified on the cavity and on the upper boundary of the layer. The solution of the spatial problem of the theory of elasticity is based on the generalized Fourier method with respect to the system of Lame equations.

Keywords: cylindrical cavity in a layer, coupling condition, generalized Fourier method.

1. Introduction. When designing road surfaces, building structures, as well as in mechanical engineering, one has to deal with design schemes in which the layer lies on an elastic base and has a stress concentrator in the form of a cylindrical hole. When solving such problems, it is necessary to have a method that, with the necessary accuracy, would allow determining the stress values in the designed structure.

In scientific publications there are works close to the problem posed. So in [1], on the basis of the Fourier series expansion method, stresses in a layer with a cylindrical cavity are determined. In [2], using the method of superposition of general solutions, the problem for a layer with a circular hole was considered. Using the method of homogeneous solutions and the Bubnov-Galerkin method, analytical-numerical solutions were obtained for a layer with a cavity perpendicular to the boundaries of the layer [3].

For problems with multiple boundary surfaces, a generalized Fourier method is used [4]. So, based on this method, problems for a half-space with cylindrical cavities in displacements [5], in stresses [6–8] are solved, and a problem with contact type conditions is mixed [9]. For a cylinder based on the generalized Fourier method, the problem with cylindrical inclusions in stresses is solved [10]. For a layer with a longitudinal cylindrical thick-walled pipe the problem is solved in [11].

In this paper, we propose a solution to an essentially spatial problem with an analytical-numerical approach based on the generalized Fourier method. Taking into account the influence of boundary conditions on surfaces is based on addition theorems relating basic vector solutions of the Lame equation in Cartesian and cylindrical coordinates.

2. Formulation of the problem. A homogeneous elastic layer is rigidly adhered to a homogeneous elastic half-space. In the layer, parallel to its surfaces, there is a cylindrical cavity of radius R. We will consider the layer and half-space in the Cartesian coordinate system (x, y, z), we will consider the cavity in a cylindrical coordinate system (ρ, ϕ, z), combined with the coordinate system of the layer. Layer boundaries are spaced $y = h$ and $y = -\tilde{h}$.

It is necessary to find a solution to the Lame equation $\Delta\vec{U}_j + \left(1-2\sigma_j\right)^{-1}\nabla div\vec{U}_j = 0$, where $j = 1$ – corresponds to the layer, $j = 2$ – half-space. At the top of the layer $y = h$ and on the surface of the cavity $\rho = R$ given are the displacements:

$$\vec{U}_1\left(x,z\right)_{|y=h} = \vec{U}_h^0\left(x,z\right),\ \vec{U}_1\left(\phi,z\right)_{|\rho=R} = \vec{U}_R^0\left(\phi,z\right),$$

where

$$\begin{aligned}\vec{U}_h^0\left(x_1,z_1\right) &= U_x^{(1)}\vec{e}_1^{(1)} + U_y^{(1)}\vec{e}_2^{(1)} + U_z^{(1)}\vec{e}_3^{(1)},\\ \vec{U}_R^0\left(\phi,z\right) &= U_\rho^{(R)}\vec{e}_1^{(2)} + U_\phi^{(R)}\vec{e}_2^{(2)} + U_z^{(R)}\vec{e}_3^{(2)}\end{aligned} \qquad (1)$$

are known functions; $\vec{e}_j^{(k)}, j = 1, 2, 3$ – are the unit vectors $(k=1)$ and cylindrical $(k=2)$ coordinate systems.

On the flat contact surface of the layer and half-space, the boundary coupling conditions are satisfied

$$\vec{U}_1\Big|_{y=-\tilde{h}} = \vec{U}_2\Big|_{y=-\tilde{h}}, \qquad (2)$$

$$F_1\vec{U}_1\Big|_{y=-\tilde{h}} = F_2\vec{U}_2\Big|_{y=-\tilde{h}}, \qquad (3)$$

where $\vec{U}_1$ – displacement in the layer; $\vec{U}_2$ – displacement in half space;

$F_j\vec{U}_j\Big| = 2G_j[\dfrac{\sigma_j}{1-2\sigma_j}\vec{n}\,\mathrm{div}\,U_j + \dfrac{\partial}{\partial n}\vec{U}_j + \dfrac{1}{2}(\vec{n}\times rot\vec{U}_j)]$; $G_j = \dfrac{E_j}{2(1+\sigma_j)}$; σ_j, E_j – Poisson's ratio and modulus of elasticity of the layer $(j = 1)$ or half-spaces $(j = 2)$.

The specified functions will be considered as rapidly decreasing from the origin of coordinates along the z axis for the cylinder and along the z and x axes for the layer boundaries.

3. Solution method. Choose the basic solutions to the Lamé equation for the Cartesian and cylindrical coordinate systems in the form [4]:

$$\begin{aligned}&\vec{u}_k^{\pm}\left(x,y,z;\lambda,\mu;\sigma\right) = N_k^{(d)}e^{i(\lambda z+\mu x)\pm\gamma y};\\ &\vec{R}_{k,m}\left(\rho,\phi,z;\lambda;\sigma\right) = N_k^{(p)}I_m\left(\lambda\rho\right)e^{i(\lambda z+m\phi)};\\ &\vec{S}_{k,m}\left(\rho,\phi,z;\lambda;\sigma\right) = N_k^{(p)}\left[s_m\left(\rho;\lambda\right)\cdot e^{i(\lambda z+m\phi)}\right]; k = 1,2,3;\end{aligned} \qquad (4)$$

$$N_1^{(d)} = \frac{1}{\lambda}\nabla;\ N_2^{(d)} = \frac{4}{\lambda}\left(\sigma-1\right)\vec{e}_2^{(1)} + \frac{1}{\lambda}\nabla\left(y\,\cdot\right);$$

$$N_3^{(d)} = \frac{i}{\lambda}\mathrm{rot}\left(\vec{e}_3^{(1)}\,\cdot\right);\ N_1^{(p)} = \frac{1}{\lambda}\nabla;$$

$$N_2^{(p)} = \frac{1}{\lambda}\left[\nabla\left(\rho\frac{\partial}{\partial\rho}\right) + 4\left(\sigma-1\right)\left(\nabla - \vec{e}_3^{(2)}\frac{\partial}{\partial z}\right)\right];$$

$$N_3^{(p)} = \frac{i}{\lambda}\mathrm{rot}\left(\vec{e}_3^{(2)}\,\cdot\right);\ s_m\left(\rho;\lambda\right) = \left(\mathrm{sign}\,\lambda\right)^m K_m\left(|\lambda|\rho\right);$$

$$\gamma = \sqrt{\lambda^2+\mu^2},\ -\infty < \lambda,\mu < \infty,$$

where $I_m\left(x\right)$, $K_m\left(x\right)$ – modified Bessel functions; $\vec{R}_{k,m}$, $\vec{S}_{k,m}$ – are, respectively, the internal and external solutions to the Lamé equation for the cylinder; $\vec{u}_k^{(-)}$, $\vec{u}_k^{(+)}$ – are the solutions to the Lamé equation for the layer.

We will present the solution to the problem in the form

$$\begin{aligned}\vec{U}_1 &= \sum_{k=1}^{3}\int_{-\infty}^{\infty}\sum_{m=-\infty}^{\infty}B_{k,m}\left(\lambda\right)\cdot\vec{S}_{k,m}\left(\rho,\phi,z;\lambda;\sigma_1\right)d\lambda +\\ &+\sum_{k=1}^{3}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(\begin{array}{l}H_k^{(1)}\left(\lambda,\mu\right)\cdot\vec{u}_k^{(+)}\left(x,y,z;\lambda,\mu;\sigma_1\right)+\\ +\tilde{H}_k^{(1)}\left(\lambda,\mu\right)\cdot\vec{u}_k^{(-)}\left(x,y,z;\lambda,\mu;\sigma_1\right)\end{array}\right)d\mu d\lambda,\end{aligned} \qquad (5)$$

$$\vec{U}_2 = \sum_{k=1}^{3}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(H_k^{(2)}\left(\lambda,\mu\right)\cdot\vec{u}_k^{(+)}\left(x,y,z;\lambda,\mu;\sigma_2\right)\right)d\mu d\lambda, \qquad (6)$$

where $\vec{S}_{k,m}\left(\rho,\phi,z;\lambda;\sigma_j\right)$, $\vec{u}_k^{(+)}\left(x,y,z;\lambda,\mu;\sigma_j\right)$ and $\vec{u}_k^{(-)}\left(x,y,z;\lambda,\mu;\sigma_j\right)$ – are the basic solutions, which are given by formulas (4), and the unknown functions $H_k^{(1)}\left(\lambda,\mu\right)$, $\tilde{H}_k^{(1)}\left(\lambda,\mu\right)$, $H_k^{(2)}\left(\lambda,\mu\right)$ and $B_{k,m}\left(\lambda\right)$ need to be found from boundary conditions (1) and conjugation conditions (2), (3).

We use formulas to make basic solutions between coordinate systems [11].

To satisfy the boundary conditions at the upper boundary of the layer, we equate vector $\vec{S}_{k,m}$ in (5), using the transition formulas (11, formulas (7)), in the Cartesian coordinate system through the basic solutions $\vec{u}_k^{(-)}$. We then equate the resulting vector (при $y = h$) to the given one $\vec{U}_h^0\left(x,z\right)$, represented via the double Fourier integral. So we get three equations (one for each projection) with nine unknowns $H_k^{(1)}\left(\lambda,\mu\right)$, $\tilde{H}_k^{(1)}\left(\lambda,\mu\right)$, $B_{k,m}\left(\lambda\right)$.

Satisfying the coupling conditions at the boundary of the layer and half-space in displacements, substitute in (2) right parts (5) and (6). At the same time, writing down the expression $\vec{U}_1\left(x,z\right)_{|y=-\tilde{h}}$, you must use the transition formulas from solutions $\vec{S}_{k,m}$ cylinder to solutions $\vec{u}_k^{(+)}$ (11, formulas (7)). Similarly, we can write three additional equations for stresses (3).

Having obtained a system of nine infinite equations, we express the functions $H_k^{(1)}(\lambda,\mu)$, $\tilde{H}_k^{(1)}(\lambda,\mu)$ and $H_k^{(2)}(\lambda,\mu)$ through $B_{k,m}(\lambda)$.

The determinant Δ of this system has the form

$$\Delta = -\frac{16\cdot\gamma^6\cdot e^{-3\gamma(h+\tilde{h})}\cdot\Phi(\gamma)}{\lambda^6},$$

where $\Phi(\gamma)$ – cumbersome function and as a result is omitted. The study $\Phi(\gamma)$ found that, with $\gamma > 0$, it has only positive values and is not zero. Since $\Delta > 0$, this system of equations has a unique solution.

To satisfy the boundary conditions on the cylinder $\rho = R$, using transition formulas from decisions $\vec{u}_k^{(+)}$ and $\vec{u}_k^{(-)}$ to decisions $\vec{R}_{k,m}$ (11, formulas (8)), right side (5) we rewrite in a cylindrical coordinate system through basic solutions $\vec{R}_{k,m}$, $\vec{S}_{k,m}$. we rewrite in a cylindrical coordinate system through basic solutions $\vec{U}_R^0(\phi,z)$, represented by the integral and the Fourier series. Instead $H_k^{(1)}(\lambda,\mu)$ and $\tilde{H}_k^{(1)}(\lambda,\mu)$ substitute the previously expressed functions through $B_{k,m}(\lambda)$. As a result, we obtain a set of three infinite systems of linear algebraic equations for determining unknowns $B_{k,m}(\lambda)$. These infinite systems have the properties of equations of the second kind and, as a consequence, the reduction method can be applied to them.

After determination $B_{k,m}(\lambda)$, we can find the values of unknowns $H_k^{(1)}(\lambda,\mu)$, $\tilde{H}_k^{(1)}(\lambda,\mu)$, $H_k^{(2)}(\lambda,\mu)$, which we previously expressed through $B_{k,m}(\lambda)$. So all unknown expressions (5) and (6) will be found.

4. Numerical studies of stress. The cylindrical cavity is located in a layer of isotropic material, ideally linked to an isotropic half-space. Physical characteristics of the layer (concrete): Poisson's ratio $\sigma_1 = 0.16$, elastic modulus $E_1 = 3250$ kN/cm². Physical characteristics of half-space (clay): $\sigma_2 = 0.3$, E_2=10 kN/cm². The radius of the cylindrical cavity R = 5cm. Layer thickness $h+\tilde{h}$ = 20 cm. The distance from the upper boundary of the layer to the center of the cylindrical cavity h = 10 cm.

At the upper boundary of the layer, displacements in the form

$$U_y^{(1)}(x,z) = -10^8\cdot\left(z^2+10^2\right)^{-2}\cdot\left(x^2+10^2\right)^{-2},$$

$U_x^{(1)} = U_z^{(1)} = 0$, on the surface of the displacement cylinder $U_\rho^{(R)} = U_\phi^{(R)} = U_z^{(R)} = 0$.

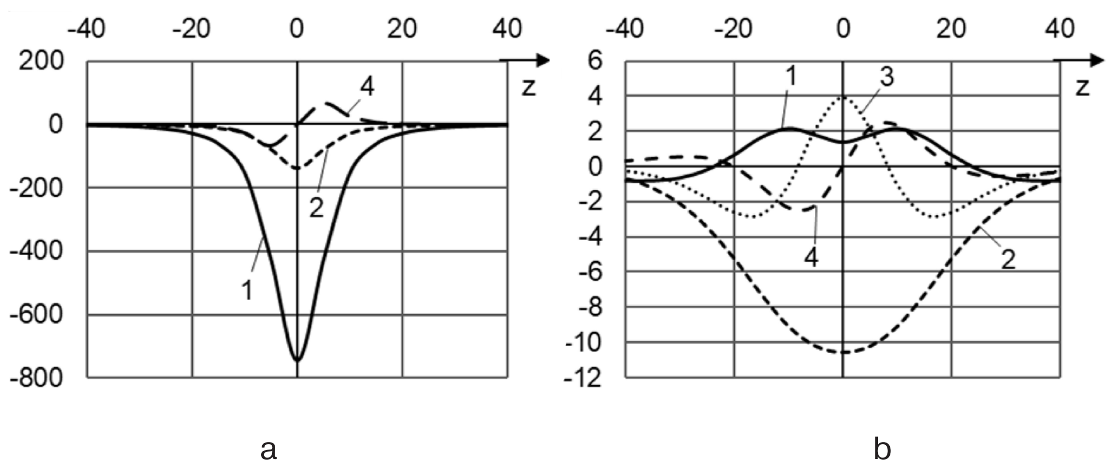

Figure 1. Stresses along the z axis in kN/cm²: a – on the upper boundary of the layer; b – at the bottom of the layer; 1 – σ_ρ, 2 – σ_ϕ, 3 – σ_z, 4 – $\tau_{\rho z}$

The infinite system was truncated to the parameter $m = 10$. The integrals are calculated using Philon's quadrature formulas (for oscillating functions) and Simpson's ones (for functions without oscillations). The accuracy of the boundary conditions, for the specified values of m and given geometric parameters, is 10^{-3}.

Figure 1 shows the stress state on the upper and lower surfaces of the layer along the z axis, at $\phi = \pi/2$. At the upper boundary of the layer, the stresses σ_z

almost coincide with the stresses σ_ϕ (Fig. 1 a, line 2), therefore, the stresses σ_z are not shown on the graph.

It can be seen from (Fig. 1) that, at high stresses at the upper boundary of the layer (Fig. 1a), a hole with a rigid fastening significantly reduces stresses at the lower boundary of the layer (Fig. 1b). Moreover, the stresses at the lower boundary of the layer σ_ϕ (Fig. 1 b, line 2) have compressive values, which is not typical for a layer without a cavity.

Figure 2 shows the stresses on the isthmuses between the upper boundary of the layer and the cavity (Fig. 2 a), as well as between the lower boundary of the layer and the cavity (Fig. 2 b) at $z = 0$.

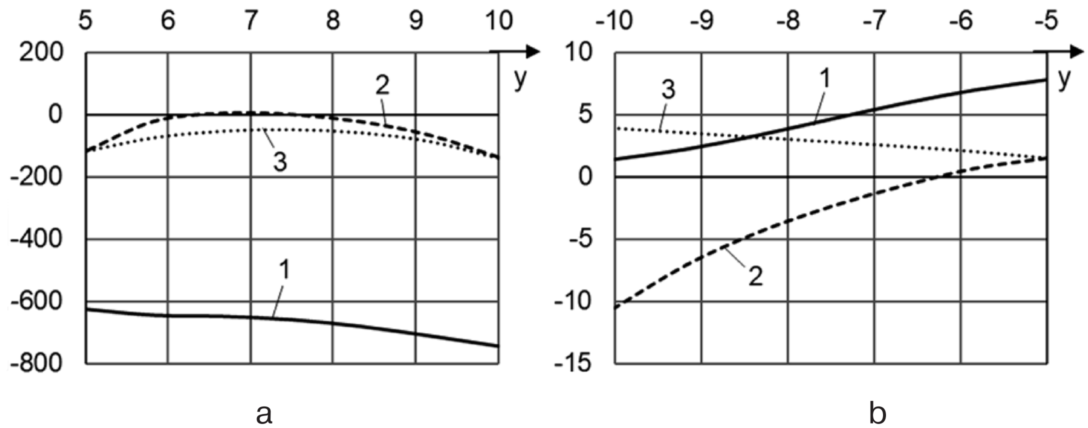

Figure 2. Stresses on the isthmuses along the *y* axis in kN/cm²: a – between the upper boundary of the layer and the cavity; b – between the lower boundary of the layer and the cavity; 1 – σ_ρ, 2 – σ_ϕ, 3 – σ_z

Stresses σ_ϕ and σ_z on the upper isthmus (Fig. 2a, lines 2 and 3) at the beginning and at the end have the same values, while the stresses σ_ϕ between the upper layer and the cavity decreases to zero values. In the lower isthmus, the stresses σ_ρ (Fig. 2 b, line 1) decrease as they approach the lower boundary of the layer, the stresses σ_z increase, and the stresses σ_ϕ turn from positive to negative, gradually increasing.

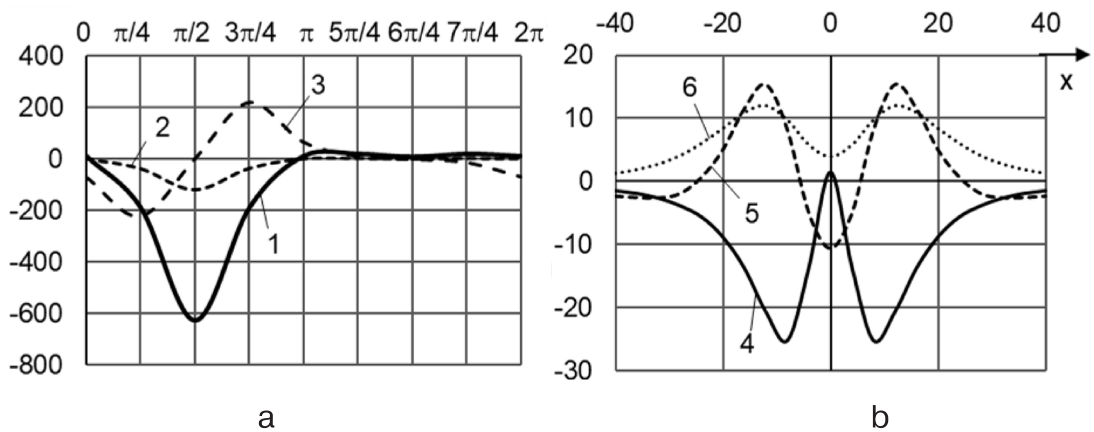

Figure 3. Stresses in kN/cm²: a – on the surface of the cylinder along an angle φ; b – at the bottom of the layer along the *x* axis; 1 – σ_ρ, 2 – σ_ϕ, 3 – $\tau_{\rho z}$, 4 – σ_y, 5 – σ_x, 6 – σ_z

In (fig. 3a) shows the stresses on the surface of the cavity along the angle φ, at $z = 0$. The stresses σ_z coincide with the stresses σ_ϕ (Fig. 3 a, line 2), therefore, the stresses σ_z are not shown on the graph. Almost all stresses are concentrated in the upper zone of the cavity surface ($\phi = 0 .. \pi$), only shear stresses $\tau_{\rho z}$ slightly extend beyond these limits (Fig. 3 a, line 3).

Figure 3b shows the stresses at the lower boundary of the layer along the x axis, at $z = 0$. In contrast to the stresses along the z axis (Fig. 1 b), the stresses along the x axis under the cavity have minimum values, with maximum values outside the cylinder.

5. Conclusions. The proposed method for solving the spatial problem of the theory of elasticity based on the generalized element for the layer, the stiffness of adhesion to the elastic half-space and having a longitudinal crystalline cavity. The problem is reduced to an infinite system of linear algebraic equations that allows the application of the truncation method to it. The numerical studies give grounds to assert that with this method the solution to the problem can be found with any accuracy, which is confirmed by the high accuracy of fulfilling the boundary conditions.

The problem is reduced to an infinite system of linear algebraic equations that allows the application of the truncation method to it.

The problem is reduced to an infinite system of linear algebraic equations that allows the application of the truncation method to it.

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Section 4. Agricultural sciences

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Salmanov Babek Zakir oglu,
Imanova Natavan Mobile gizi,
Agaeva Shagane Zakir gizi,
Azerbaijan State Agrarian University
E-maill: tagiyev.asau@gmail.com

THE STUDY OF SOME PHYSICAL AND MECHANICAL CHARACTERISTICS OF RAW MATERIALS FOR THE PREPARATION OF LIQUID MILK REPLACER

Abstract. The article presents the physico-chemical characteristics of skim milk, skim milk and whey. Also given are graphs of the dependence of the amount of sediment on time, the dependence of the initial resistance on the shelf life of the material, changes in the density and kinematic viscosity of sunflower oil depending on temperature.

Keywords: milk replacer, physical and mechanical characteristics, density, kinematic viscosity, amount of fat phase, coefficient of internal friction, coefficient of external friction.

ИССЛЕДОВАНИЕ НЕКОТОРЫХ ФИЗИКО-МЕХАНИЧЕСКИХ ХАРАКТЕРИСТИК СЫРЬЯ ДЛЯ ПРИГОТОВЛЕНИЯ ЖИДКОГО ЗАМЕНИТЕЛЯ МОЛОКА

Салманов Бабек Закир оглы,
Иманова Натаван Мобил гызы,
Агаева Шагане Закир гызы,
Азербайджанский Государственный Аграрный Университет
E-maill: tagiyev.asau@gmail.com

Аннотация. В статье приведены физико-химические характеристики обезжиренного молока, обрата и молочной сыворотки. Также приводятся графики зависимость количества осадка от времени, зависимость начального сопротивления от срока хранения материала, изменения плотности и кинематической вязкости подсолнечного масла в зависимости от температуры.

Ключевые слова: заменитель молока, физико-механическая характеристика, плотность, кинематическая вязкость, количество жировой фазы.

При восстановлении сухого цельного, или обезжиренного жидкого молока следует оптимизировать процесс дозировки растворения молочного порошка в воде. Для этого необходимо располагать данными о физико-механических характеристиках продукта [1]. С этой целью были изучены и отражены в таблице 1 физико-механические характеристики сухого молокозаменителя.

Таблица 1. – Физико-механические характеристики сухого молокозаменителя

№	Показатели	Единица измерения	Сухой заменитель молока		
			"Молога-2001"	Граулак	Спрейфо Рэд-15
1.	Плотность	кг/м^3	600	513	564
2.	Влажность	%	5,6	5,1	6,0
3.	Средний размер частиц	мм	0,20	0,31	0,32
4.	Угол распыления	градус	76	73	70
5.	Естественный динамический наклон	градус	50	55	55
6.	Естественный статический наклон	градус	30	30	30
7.	Коэффициент внутреннего трения		0,51	0,51	0,56
8.	Наружный коэффициент трения: – по стальной пластинке; – по пластиковой пластинке.		 0,37 0,47	 0,38 0,45	 0,40 0,40

В зависимости от хозяйственных возможностей, при производстве заменителя молока можно пользоваться технологией изготовления этого продукта: из сухого заменителя молока, из обезжиренного молока, обрата и молочной сыворотки. Физико-химические характеристики перечисленных продуктов также были исследованы и приводятся в (таблице 2).

Таблица 2. – Физико-химические характеристики обезжиренного молока, обрата и молочной сыворотки

№	Сырьё	Плотность, кг/м^3	Вязкость, Па сек^{10}	Теплоём-кость, кДж/кгК	Поверхностное натяжение,	Кислотность	
						Мерцающая, °Т	Активная (pH) единица
1.	Цельное молоко	1027–1032	1,30–2,20	3,90	49	16–18	6,7–6,5
2.	Обезжиренное молоко	1020–1035	1,71–1,75	3,98	53	16–20	6,5–5,7
3.	Обрат	1027–1035	1,65	3,94	40	15–50	6,6–4,9
4.	Молочная сыворотка	1022–1027	1,55–1,65	4,80	52	13–75	6,5–4,5

При восстановлении сухого заменителя молока частички, не растворённые в воде постепенно превращаются в осадок. Поэтому при добавлении жира в обезжиренное молоко нужно использовать изготовленный продукт до появления осадка. С этой целью была определена скорость превращения в осадок нерастворённых частиц (рис. 1).

Следует отметить, что количество осадка, соответствующее значению 12–14% означает полное растворение сухого молокозаменителя. Этим показателем следует руководствоваться при производстве цельного молокозаменителя путём добавления жира в восстанавливаемое обезжиренное молоко, или же при планировании жирности продукта.

При производстве цельного молокозаменителя некоторые физико-механические и реологические характеристики начального сырья (сухое обезжиренное молоко, молочная сыворотка, растительный жир и т.д.) являются важными данными для контроля качества процесса их переработки и качества производимого продукта.

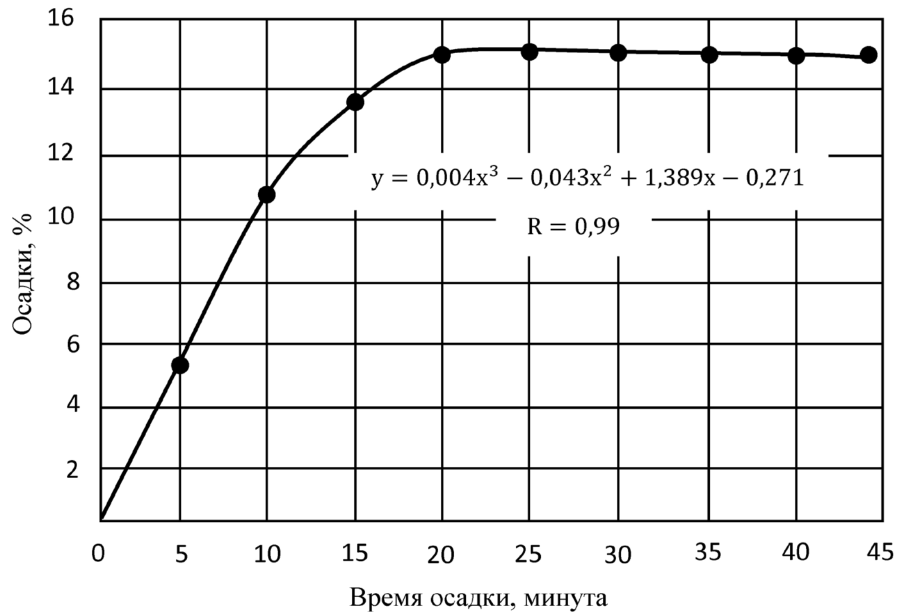

Рисунок 1. Зависимость количества осадка (%) от времени

Учитывая эти факторы были изучены первичное сопротивление к толчку на начало процесса в зависимости от процентного содержания жира в продуктовой смеси, плотность сухого материала в состоянии распыла а также коэффициенты внутреннего и наружного трения.

Эффект деформации дисперсных материалов при их трогании с места проявляется в технологическом процессе их транспортировки, смешивания и дозирования. При этом распределение частиц компонента оказывает значительное влияние на кинематику технологического процесса и качество продукции. Но вследствие малоизученности эффекта взаимодействия частиц, зачастую не представляется возможным прогнозировать ход данных процессов. С этой целью был исследован механизм трогания (запуска) процесса в дисперсной смеси, состоящей из сухого молока и смоделирован процесс взаимовлияния частиц, находящихся в движении.

Для потребителя немаловажное значение имеет ещё и факт изменения физико-механических характеристик сухой молочной смеси при хранении. На (рисунке 2) показано изменение начального сопротивления в сырье, имеющем разные значения жирности и находившемся под нагрузкой 9,81N.

Уменьшение сопротивления в зависимости от увеличения срока хранения сырья можно объяснить тем, что за время хранения жирность более равномерно распределяется между сухими компонентами и материал становится более однородным [2].

При опытах было использовано рафинированное подсолнечное масло. Были определены плотность этого растительного масла в зависимости от температуры и его кинематической вязкости. На основе полученных значений (таблица 3) был составлен график зависимостей (рис. 3).

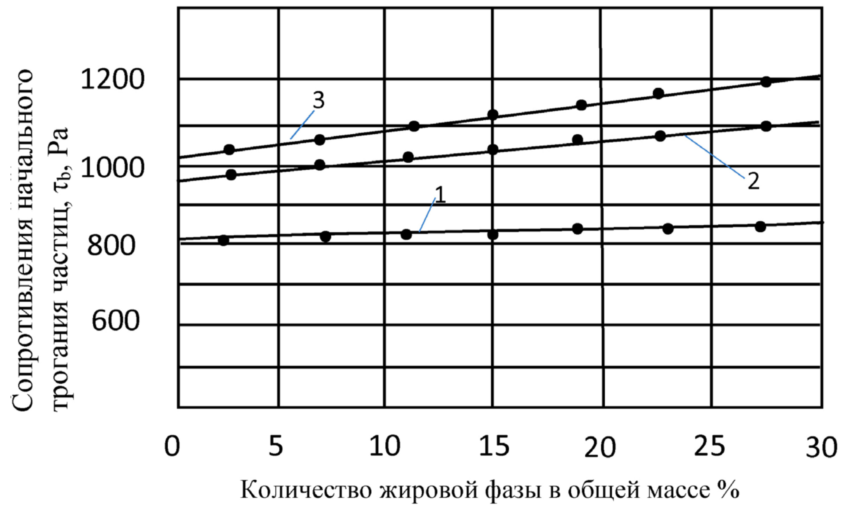

Рисунок 2. Зависимость начального сопротивления от срока хранения материала: 1–0 дней, 2–10 дней, 3–30 дней

Таблица 3.– Плотность и кинематическая сущность подсолнечного масла при разных температурах

№	Температура, t, °С	Плотность, ρ кг/м³	Кинематическая вязкость, υ см²/сек
1.	20	928,1	0,5236
2.	35	913,5	0,3684
3.	50	902,8	0,2487

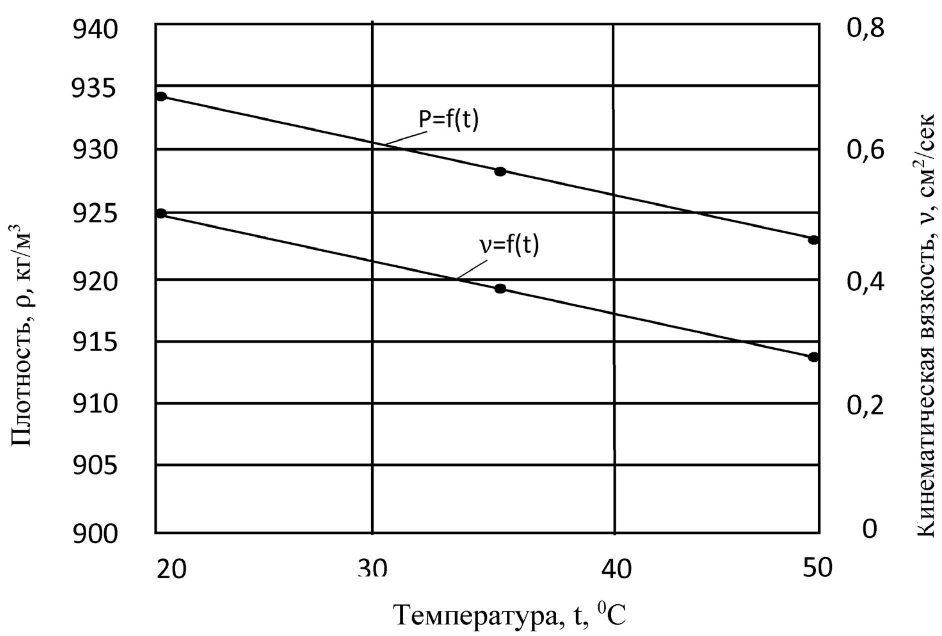

Рисунок 3. Изменения плотности и кинематической вязкости подсолнечного масла в зависимости от температуры

На основе построенных зависимостей были определены следующие эмпирические формулы:

Между плотностью и температурой:

$$\rho = -0,33t + 939,72, \quad R^2 = 0,83$$

Между температурой и кинематической сущностью:

$$\upsilon = -0{,}0084t + 0{,}6871, \quad R^2 = 0{,}98.$$

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Section 5. Technical sciences

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Popov Victor Vladimirovich,
Data Scientist, Opex Analytics, LLC, Chicago, USA
Master of Engineering in Computer Science, Cornell University,
New York, United States of America
Bachelor's Degree in Mechatronics and Robotics,
Bauman Moscow State Technical University, Moscow, Russian Federation
Email: vp282@cornell.edu

DEVICE FOR COMPLEX ACTIVATION OF FUEL MIXTURE WITH ARTIFICIAL INTELLIGENCE IN CONTROL SYSTEMS

Abstract. In this publication author describes different structural components of the suggested device for complex activation of the fuel mixture with elements of artificial intelligence in control systems. Main attention is focused on the interconnections of the discussed components ensuring the device operation as a full system. The author also describes aerodynamic foam generator, which is one of the main elements of the suggested device. Besides this, various options of artificial intelligence systems usage in control systems of different device nodes are considered. The author also provides the instance of the assembly of the device for aerodynamic foam activation in the standard diesel engine.

Keywords: robotics, activated fuel mixture, artificial intelligence, aerodynamic foam generator.

Попов Виктор Владимирович,
Data Scientist, Opex Analytics, LLC, Чикаго, США
Магистр Компьютерных Наук,
Корнелльский Универститет, Нью Йорк, США
Бакалавр Мехатроники и Робототехники,
МГТУ им. Н.Э. Баумана, Москва, Российская Федерация
E-mail: vp282@cornell.edu

УСТРОЙСТВО ДЛЯ КОМПЛЕКСНОГО АКТИВИРОВАНИЯ ТОПЛИВНОЙ СМЕСИ С ЭЛЕМЕНТАМИ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В СИСТЕМАХ УПРАВЛЕНИЯ И КОНТРОЛЯ

Аннотация. В данной рукописи подробно рассматриваются отдельные составные компоненты предложенного устройства для комплексного активирования топливной смеси с элементами

искусственного интеллекта в системах управления и контроля. Особое внимание уделено взаимодействие представленных компонентов, обуславливающих работу устройства как системы в целом. Также автор описывает аэродинамический генератор пены, являющийся одним из основных элементов предложенного устройства. Помимо этого, приводятся варианты использования систем исскусственного интеллекта в различных узлах. Также автором приводится пример установки устройства для аэродинамической активации топливной смеси в стандартном дизельном двигателе.

Ключевые слова: робототехника, активированная топливная смесь, искусственный интеллект, аэродинамический генератор пены.

Введение

Данная статья является первой из цикла статей, в которых будет детально описана предложенная комплексная технология воздействия на топливную смесь, перед её подачей в камеру сгорания, которая предполагает использование только известных и многократно проверенных физических принципов и законов, воплощённых в компактном интегральном конструкторском решении. Целью процесса активирования является: – повышение концентрации воздуха в объёме топливной смеси, подаваемом каждый цикл в камеру сгорания;- снижение расхода топлива; – повышение удельной теплотворной способности топлива; – повышение уровня равномерности горения топлива; – повышение уровня сгорания топлива; – снижение концентрации токсичных газов в выхлопе из камеры сгорания; получение максимальной энергетической отдачи от сгорания топлива; – снижение уровня вибрации и аэродинамического шума при сгорании топлива; – надёжное дистанционное управление процессом горения и активирования топливной смеси перед её подачей в камеру сгорания; полное влияние контролируемых и регулируемых параметров на результаты горения топливной смеси в камере сгорания. Для начала исследования обозначеной проблематики рассмотрим отдельные составные компоненты предложенного устройства.

Структурный состав устройства для комплексного активирования топливной смеси

1) 2)

Рисунок 1. Детали и элементы устройства для комплексного активирования топливной смеси

На рисунке 1 показаны детали и элементы устройства для комплексного активирования топливной смеси, после трансформации их формы и размеров от элементов и деталей аэродинамического генератора пены;

2) показаны детали и элементы устройства для комплексного активирования топливной смеси, дизайн которых прошёл все необходимые стадии и этапы трансформации от аналогичных про принципу деталей и элементов аэродинамического генератора пены.

В состав предложенной технологии входит система управления (которая может быть расширена в том числе и на вариант управления искусственными нейронными сетями), контроля и регулирования параметров, базирующаяся на минимальном количестве контрольных и регулируемых параметров процесса, имеющих прямую зависимость и непосредственное влияние на уровень эффективности как процесса активирования топливной смеси, так и на уровень эффективности самой смеси в процессе её сгорания и получения необходимых энергетических и экологических результатов.

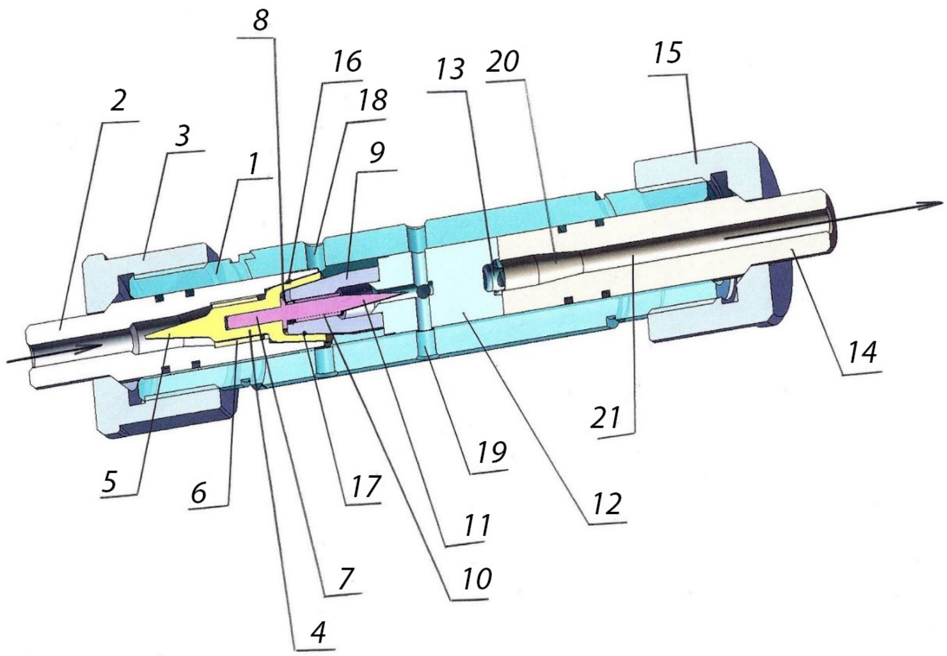

Рисунок 2. Модель в сечении устройства для аэродинамической активации топливной смеси

Цифрами на рисунке обозначены: 1 – корпус-суппорт устройства; 2 – первая гидродинамическая секция; 3 – первая крепежная гайка; 4 – первая часть гидродинамического интерфейса-трансформера; 5 – первый конический рефлектор интегрированного интерфейса-трансформера; 6 – многоканальная секция первого конический рефлектор интегрированного интерфейса-трансформера; 7 – направляющий штифт интегрированного интерфейса-трансформера; 8 – фланцевый суппорт первой и второй гидродинамических секций устройства; 9 – вторая гидродинамическая секция устройства; 10 – многоканальная секция второго конического рефлектора интегрированного интерфейса-трансформера; 11 – Второй конический рефлектор интегрированного интерфейса-трансформера; 12 – Интегрированный коллектор; 13 – вихревой генератор интегрированного коллектора; 14 – выходная секция устройства output section of the device; 15 – вторая крепежная гайка; 16 – наружный конический канал устройства; 17 – внутренний конический канал устройства; 18 – входной канал метанола; 19 – входной канал второй порции дизельного топлива; 20 – конический канал для сбора эмульсии произведенной в устройстве; 21 – выходной канал устройства.

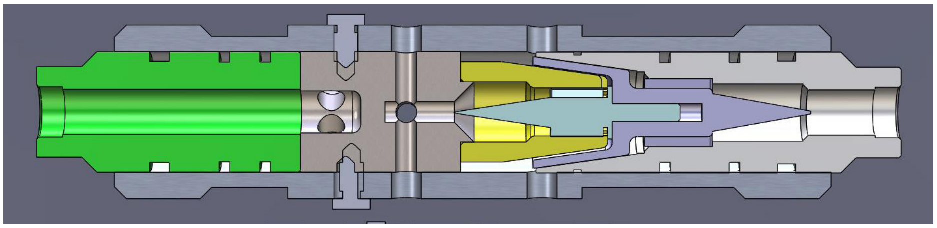

Рисунок 3. Устройства для аэродинамической активации топливной смеси, в правой части, – трансформированные элементы генераторов пены

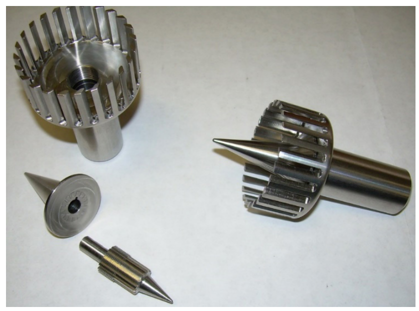

Рисунок 4. На рисунке показаны детали и компоненты аэродинамического генератора пены, которые при переходе к аэродинамическому гомогенному активированию топливных смесей трансформируются по геометрии, сохраняя соответствие основным конструктивным принципам

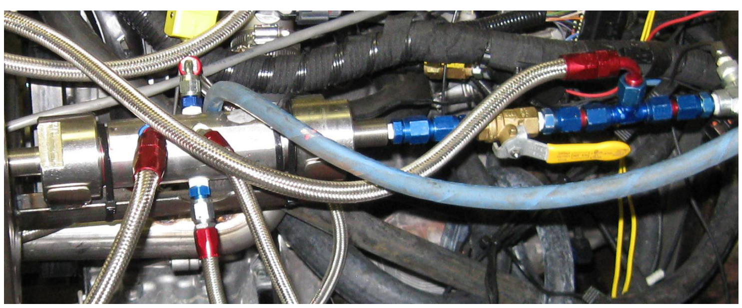

Рисунок 5. На рисунке показан пример установки устройства для аэродинамической активации топливной смеси в стандартном дизельном двигателе

Описание последовательности проведения сборочных операций

Как видно из модели и чертежей, устройство спроектировано таким образом, что корпус устройства 1 (в дальнейшем все обозначения по модели) имея внутренний диаметр 40 миллиметров выполняет очень важную функцию позиционирования и ориентирования всех элементов устройства, имеющих наружный диаметр 40 миллиметров;

Корпус 1 также выполняет функции линейного позиционирования всех элементов устройства по отношению к вводным отверстиям для компонентов смеси или эмульсии. В корпусе 1 все элементы имеют свободу независимого вращения вокруг своей оси и после завершения процесса трёхмерной ориентации всех элементов относительно друг друга их фиксация осуществляется при помощи фиксирующих гаек 3 и 15.

При сборке устройства первой в корпус 1 устанавливают первую гидродинамическую секцию 2, предварительное положение которой фиксируют гайкой 3 и ориентируют торец секции 2 по отверстию 18 таким образом, что бы торец находился по центру отверстий 18, которых в устройстве имеется два и в которые вводится метанол.

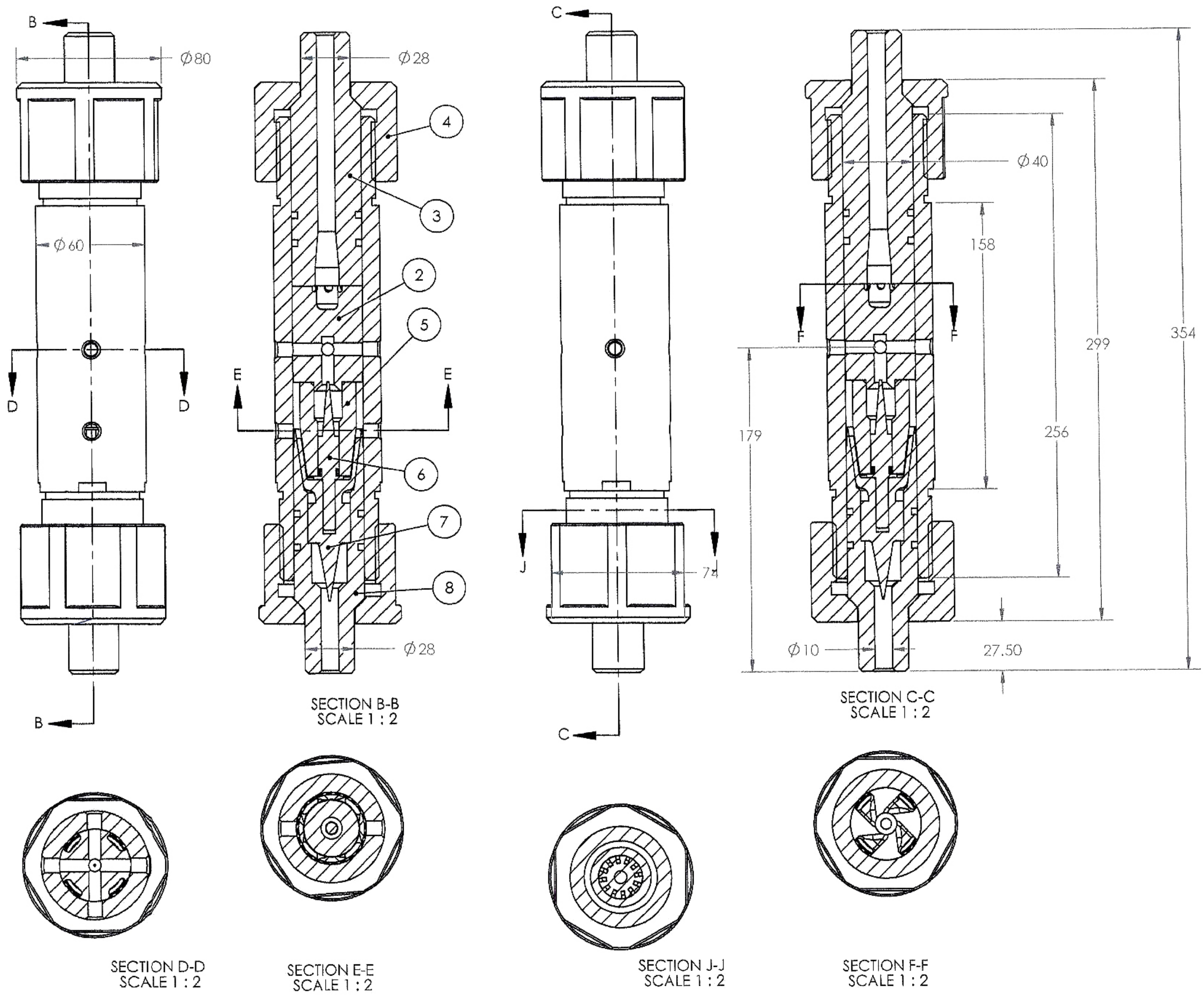

Рисунок 6. На рисунке показано устройство для аэродинамической активации топливной смеси с деталями прошедшими трансформацию по отношению к аэродинамическому генератору пены

После этого производится сборка интегрального интерфейса, состоящего из деталей 4, 9 и 10. Рефлекторы 5 и 11 направлены в противоположные стороны, а фланец 8 определяет такое расстояние между деталями, которое позволяет получить в конических кольцевых каналах 16 и 17 необходимое расстояние между формообразующими коническими поверхностями, в канале 16–100 микрон и в канале 17–25 микрон.

После этого в корпус вводится коллектор 12, имеющий вихревой генератор 13. Коллектор 12 ориентируется относительно корпуса 1 по отверстиям 19, которые должны быть концентричными соответствующим отверстиям в коллекторе 12. Таких отверстий имеется 4 в каждое из которых подводится 10% от общего количества дизельного топлива. После этого в корпус вводится выводная секция 14, которая фиксируется гайкой 15.

Процесс формирования эмульсии из дизельного топлива и метанола

В осевое отверстие секции 2, под давлением от 3 до 7 бар, вводится 60% от всего количества дизельного топлива (систему управления датчика, котролирующего данную пропорцию рекомендуется реализовать на искусственных нейронных сетях для достижения большей точности выполнения поставленной задачи), предназначенного для смешивания с метанолом.

Поток дизельного топлива при помощи конического рефлектора 5 и соответствующих поверхностей секции 2 из цилиндрического преобразуется в кольцевой; При этом уровень турбулентности в этом потоке становится более однородным, так как более низкий уровень турбулентности в центре цилиндрического потока становится равным по уровню турбулентности периферии потока.

После этого кольцевой поток вводится в капиллярные каналы 6 в которых поток разгоняется, после чего вводится в конический кольцевой канал с расстоянием между коническими формообразующими поверхностями в 100 микрон. В этом канале линейная скорость для этого потока дизельного топлива достигает максимума и при этом одновременно возникают два явления,– при движении в канале образуются разрывы, вызванные кавитацией и в то же время формируется зона пониженного давления в соответствии с теоремой Бернулли; В эту зону через отверстия 18 вводится поток метанола, который заполняет разрывы, вызванные кавитацией и вся эта предварительная смесь соединяется с ещё более турбулентным кольцевым потоком второй порции дизельного топлива в 40% от всего количества.

Этот поток под давлением от 3 до 7 бар вводится в 4 радиальных канала в отверстия 19, после чего меняет направление, и преобразовывается на рефлекторе 11 в кольцевой, затем вводится в капиллярные каналы 10 и в секции 9 меняет направление и вводится в кольцевой конический канал 17. В этом канале, расстояние между формообразующими коническими поверхностями в котором составляет 25 микрон, при давлении равном давлению в первом потоке, линейная скорость движения второго потока оказывается как минимум в 4 раза выше, что позволяет образовывать большее количество разрывов, вызванных кавитацией с меньшими размерами; Кроме того одновременно формируется вторая кольцевая зона разрежения в соответствии с положениями теоремы Бернулли.

В кольцевой зоне между секцией 9 и внутренним отверстием корпуса 1 встречаются два потока смеси в которых уровень турбулентности и частота разрывов, являющихся следствием кавитации являются более интенсивными в зоне канала прилегающей к поверхности секции 9.

Разрежение и наличие большого количества свободных разрывов, явившихся следствием кавитации, позволяют однородно распределить капли метанола по всему объёму смеси и в таком состоянии поток смеси входит в транзитные каналы коллектора 12. Из транзитных каналов коллектора 12 (всего имеется 4 канала) поток смеси вводится в вихревой генератор, где формируется вихревая труба, переходящая в конический канал 20 со стороны большего основания конуса. Смесь после этого, со стороны малого основания конуса канала 20, переходит в выводной канал 21 откуда выводится из устройства. Весь процесс смешивания и первого объёмного этапа гомогенизации уровня турбулентности смеси длится не более 0.1 секунды.

После первого этапа смешивания и гомогенизации остаточные размеры капель метанола в общем объёме дизельного топлива могут составить не более 1 микрона, при высоком уровне однородности распределения капель метанола в объёме дизельного топлива. После первого этапа смешивания и гомогенизации, при использовании насоса высокого давления для впрыска смеси в камеру сгорания размеры капель метанола могут уменьшиться до 100–150 нанометров.

Заключение

В данной работе были рассмотрены отдельные составные компоненты предложенного устройства комплексной технологии воздействия на топливную смесь, перед её подачей в камеру сгорания, которая предполагает использование только известных и многократно проверенных физических принципов и законов, воплощённых в компактном интегральном конструкторском решении. Данная технология и устройство для её реализации, позволяют применить их в реальных системах внутреннего сгорания, без малейшего изменения или модификации их конструкции или малейшего изменения принципа работы.

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TS Hoang Ngoc Hai,
University of Fire Ministry of Public Security of Vietnam
E-mail: hung.police114@gmail.com

ASSURANCE OF TECHNICAL INFRASTRUCTURE SYSTEM ON FIRE PREVENTION AND FIGHTING MEETING THE SUSTAINABLE DEVELOPMENT REQUIREMENTS FOR INDUSTRIAL TOOLS ON THE AREA OF HA NOI CITY, VIETNAM

Abstract. Technical infrastructure system for industrial complexes in general, including technical infrastructure system for fire prevention and fighting is very important in maintaining and promoting sustainable development. sustainably industrial clusters in general and industrial clusters in Hanoi city in particular. The article goes into detail the theoretical basis of technical infrastructure system on fire prevention and fighting, the situation of technical infrastructure system on fire prevention and fighting for industrial clusters in Hanoi city. Thereby, proposing a number of solutions to promote the sustainable development of industrial clusters in the City.

Keywords: technical infrastructure system; fire prevention and fighting; industrial clusters; Hanoi.

1. Set the problem

The capital of Hanoi is in the process of integration and is constantly evolving where buildings, hotels, office complexes continue to be built, industrial clusters, cottage industries and handicraft villages continue to develop. Along with the mechanical increase in population and means of transport, production, business and service activities are also increasing with many economic sectors, electric power sources, petrol, oil, gas, chemicals … are used more and more diversified, potentially causing fire and explosion, causing serious consequences on people and properties. In particular, in recent years, there has been strong investment, planning and development of industrial clusters with a variety of production types to meet the needs of people in the city, as well as nationwide and export.

Technical infrastructure system of fire prevention and fighting in general and for industrial clusters in particular has great significance in the management and organization of fire prevention and fighting activities. According to statistics, every year in the city, there are over 700 fires and explosions, causing dozens of deaths and injuries, damage to property worth hundreds of billion VND, not including thousands of fire incidents small and timely detected and handled by the people and grassroots fire prevention and fighting forces. Besides, the conditions for fire fighting and rescue work such as: transport infrastructure, fire-fighting water supply are still inadequate, outdated and degraded (there are no more than 1.200 lanes of fire trucks access conditions; water pillars, wharves only reach about 50% of the demand) [3]. This is a big issue raised in ensuring the technical infrastructure system of fire prevention and fighting, contributing to promoting the sustainable development in Hanoi city in general and industrial complexes in Hanoi city in particular.

2. Theory of technical infrastructure system on fire prevention and fighting meeting the requirements of sustainable development of industrial clusters in Hanoi city, Vietnam

The concept of industrial cluster has been clearly specified in the Government's Decree No.68/2017/ND-CP of May 25, 2017, according to which the industrial cluster is a place to produce and perform services for production. industries, handicrafts, with defined geographical boundaries, not populated by people, invested and built in order to attract and relocate small and medium-sized enterprises, cooperatives and cooperative groups at the beginning. production and business investment. The industrial cluster has an area size not exceeding 75 hectares and not less than 10 hectares. Particularly for industrial clusters in mountainous districts and craft village industrial clusters, the area and area must not exceed 75 hectares and not less than 5 hectares [2].

Technical infrastructure of the Industrial Complex includes internal road system, water supply and drainage system, wastewater treatment, waste, power supply, public lighting, internal communication, operator, protection and other works in service of industrial cluster activities [1]. In fire prevention and fighting, the planning of technical infrastructure system poses two major issues: transportation system for fire fighting and water supply system for fire fighting. These are two technical systems which are very important in ensuring safety in fire prevention and fighting in general and for industrial clusters in Hanoi city in particular. Requirements and regulations on traffic systems serving firefighting, water sources serving firefighting are complied with the law on fire prevention and fighting, standards and technical regulations on fire prevention and fighting. Firefighting regulations are very specific.

The term sustainable development is a broad term, but it always implies stability in the dynamic, effective for both present and future. In developing the technical infrastructure system for industrial clusters, this meaning is even more practical because the infrastructure is like a vascular system that feeds the body of the industrial cluster. Efficiency does not stop a minute, the flexibility, persistence in the operation of blood vessels is vital to the human body is the same meaning as the infrastructure for urban so. The socio-economy of a country is called sustainable when it achieves some social and economic goals as follows: An economy considered sustainable must meet the following requirements: 1) GDP growth and GDP per capita are high; developed countries with high incomes still have to keep the growth rate, the poorer the lower income countries, the higher the growth rate; developing countries in the current situation need GDP growth of about 5%/year to be able to see the expression of sustainable economic development; 2) GDP structure is also a criterion for evaluating economic sustainability; Only when the ratio of industry and services to GDP is higher than agriculture will growth be sustainable; 3) Economic growth must be a highly efficient growth, it does not accept growth at all costs. Social sustainable development is assessed by criteria, such as HDI, income equality, education, health, social welfare and cultural enjoyment criteria. In addition, social sustainability is the guarantee of harmonious social life; There is equality between social strata and gender equality; the gap between rich and poor is not too high and tends to approach; There is not much difference in life between regions.

For industrial clusters, on March 14, 2018, the Hanoi People's Committee issued Decision No.1292/QD-UBND on approving the planning on development of Hanoi industrial cluster till 2020, with considering to 2030, with the following main contents: Development oriented viewpoints; Development Goals; Planning content; Solutions to implement the planning; Organization of planning implementation. Identify and plan the development of industrial clusters to ensure the implementation of the city's socio-economic development objectives, contributing to the decision on industrial and service growth, restructuring the Capital's economic structure towards public direction. industrialization and modernization. To form a system of industrial clusters on the basis of studying the adjustment, merger and expansion of industrial clusters that have been planned or existed before; at the same time with the new planning of industrial clusters on the basis of compatibility with the general construction planning of the Capital and relevant plannings. Create a land fund for development of industries, cottage industries and handicrafts in conformity with development stages in order to meet the needs of expanding production ground, attracting capital and technology resources … to thrive industry, associating production with the market, raw material areas, labor, solving environmental pollution issues, contributing to the city's socio-economic development [4]. Also according to Decision No.1292/QD-UBND dated March 14, 2018 of the Hanoi People's Committee, by 2030, Hanoi City will have 159 industrial clusters with a total area of 3.240.97 ha. According to the Document No.11175/BCT-CTĐP dated November 27, 2017 of the Ministry of Industry and Trade on the agreement on the planning for development of industrial clusters up to 2020, with a vision to 2030 in Hanoi city.

3. Actual situation of technical infrastructure system on fire prevention and fighting in industrial clusters in Hanoi city, Vietnam

Industrial clusters are places where crowded people always exist a large number of goods, machinery and equipment for production and business processes, so there is always a lot of potential risk to fire, explosion occurred. According to the statistics of the Hanoi Department of Industry and Trade, there are 70 industrial clusters in Hanoi city, however, according to the basic statistics of the City Police, there are 18 industrial clusters in Hanoi industrial clusters; The remaining 54 industrial clusters according to the Department of Industry and Trade's statistics are on the list of trade villages and the list of production establishments and warehouses in the residential area of the City Police. The total number of establishments belonging to industrial clusters: 364, of which: 306 manufacturing facilities, 58 commodity warehouses [3]. The statistics show that the inconsistency between the two agencies in the statistics of industrial clusters in the city.

Being aware of the significance and importance of technical infrastructure system on fire prevention and fighting in general and for industrial clusters in Hanoi city in particular, the Ha Noi fire police force has continuously made efforts and actively in advising and proposing the City Party Committee and People's Committee of matters related to the city fire prevention and fighting, especially issues related to the planning of urban technical infrastructure systems, residential areas, industrial parks, industrial complexes, … to ensure safety for fire prevention and fighting. In fact, through the statistics of the Hanoi Police Department's Fire Prevention and Rescue Department, as of June 2019, the technical infrastructure system of fire prevention and fighting of the industrial clusters in Hanoi city are as follows [3]:

– The work of approving the design and the collection of fire prevention and fighting of the industrial cluster: Number of industrial clusters that have been appraised and approved for the design of fire prevention and fighting for the technical infrastructure: 04/18 the cluster, which is Thanh Oai Industrial Cluster, Ngoc Hoi Industrial Cluster, Ha Binh Phuong Industrial Cluster, Tu Liem Industrial Cluster; Number of approved industrial clusters but not yet tested on fire prevention and fighting for technical infrastructure: 00/18 clusters; Number of industrial clusters that have not yet been approved for design, have not been tested for fire prevention and fighting for technical infrastructure: 14/18 clusters;

– Traffic in service of fire fighting in industrial clusters: Number of industrial clusters to ensure transportation for fire fighting: 17/18 clusters; 01/18 clusters have roads to ensure width for fire engines to operate, however, during the production process, business households have renovated, built and welded roofs and flanged roofs leading to many sections. roads not up to the height and width of roads running for fire engines are Phung Xa Industrial Cluster;

– Water supply source for fire fighting in industrial clusters: 11 out of 18 industrial clusters have been equipped with fire fighting water supply systems, including pump systems, pipelines and fire hydrants; 02/18 industrial clusters have ponds and lakes to ensure there is a wharf to take water for fire fighting, including: Ngoc Hoa Industrial Cluster, Lai Yen Industrial Cluster; 05/18 industrial clusters that do not ensure water sources, do not have wharves for fire engines to serve fire fighting are: Phung Xa Industrial Cluster, Dong Anh Industrial Cluster, Hapro Industrial Cluster, Bat Trang Industrial Cluster.

The main reasons leading to the above situations are: awareness and responsibility of District-level industrial cluster development center; District Industrial Cluster Management Board; Public non-business units directly under the Department of Industry and Trade are still limited, not fully aware of the importance of technical infrastructure in fire prevention and fighting, so they have not paid much attention. Investing in fire prevention and fighting has not been proactively complying with the requirements and recommendations of the Fire Prevention and Fighting Police Agency and the concerned State management agencies, leading to many shortcomings and limitations mentioned above.

4. Solutions to ensure the technical infrastructure of FPF to meet the requirements of sustainable development of industrial clusters in Hanoi, Vietnam in the coming time:

– Completing the theory, further clarifying and more specifically the functions and tasks of technical infrastructure management, especially technical infrastructure for fire prevention and fighting for industrial clusters and relationships. relationship between the managing agencies of ministries, branches and People's Committees of districts, ministries with specialized departments and the city's management decentralization and People's Committees of rural districts with industrial clusters and the fire prevention and fighting police agency. and rescue. Complete the system of laws and sub-law regulations on management of construction of industrial complexes in general, management of construction of technical infrastructure systems for fire prevention and fighting for industrial complexes in particular. Complete the content of state management of fire prevention and fighting in the field of technical infrastructure in general and for industrial clusters in particular starting from the stage of planning, building, using, exploiting and renovating, repair, upgrade, maintenance, maintenance and protection of technical infrastructure works. The construction, using, exploitation, maintenance and maintenance of technical infrastructure for fire prevention and fighting must strictly comply with current regulations and construction planning approved by competent authorities browser;

– Improving the efficiency and quality of construction planning, including technical infrastructure planning on fire prevention and fighting, which must be one step ahead. Renovating and improving the content quality of technical infrastructure on fire prevention and fighting in construction planning projects paying special attention to wide-area infrastructure areas with inter-regional relations. Projects to build new industrial clusters need to pay attention to the unified and synchronous technical infrastructure planning within the boundaries and larger outside areas in the fields of transportation and water supply, electricity, water. In the industrial cluster, it is necessary to map the current status of technical infrastructure systems on fire prevention and fighting, organize the planning of underground works to serve as a basis for construction management, encouraging the promotion of compulsory requirements for the construction of technical tunnels and ditches at the main axes in the industrial complex to arrange lines and pipelines to restrict digging when building, renovating and repairing;

– Focusing on developing investment plans, developing technical infrastructure on fire prevention and fighting for the industrial cluster. Investment programs and projects must be approved by competent authorities. Construction investment must be synchronized according to planning and construction order must be uniform. Managing and developing industrial clusters according to a common and uniform standard for all industrial clusters throughout the country. A construction plan is a set of projects in which the projects must be eligible to be included in the plan. Using multi-sector investment planning method to coordinate and set up priority investment projects. Based on the approved plan, the State should allocate sufficient capital according to the project implementation schedule for projects funded by the state capital, and projects from other sources of capital must be inspected and supervised from the time of asking for permission and starting construction to ensure a uniform coordination between projects built in the same area. Renewing policies and mechanisms for investment in development of technical infrastructure for fire prevention and fighting, including policies to encourage and support investment as well as benefit from investment in technical infrastructure works on fire prevention. and fire fighting in the area of management. To socialize investment capital sources for development of technical infrastructure on fire prevention and fighting in general and for industrial complexes in particular;

– For People's Committees of districts in Hanoi city, where managing industrial clusters, it is necessary to uphold their spirit and responsibility in the planning of construction of industrial clusters, especially regulations. plan on building technical infrastructure system for fire prevention and fighting for industrial clusters. Lead and direct the relevant units to strictly implement the provisions of the law on management and development of industrial clusters, especially the provisions of the law on fire prevention and fighting. To closely coordinate with the fire prevention and fighting police agency in approving the planning on construction of industrial complexes in their respective localities;

– For the Fire Force, it is necessary to be more active in advising and guiding the District People's Committee on matters related to fire prevention and fighting such as the planning of construction of technical infrastructure systems. at the industrial clusters to ensure traffic, water resources, distance on fire prevention and fighting; … guide the district-level industrial cluster management boards in managing and organizing fire prevention and fighting activities. fire at industrial clusters in accordance with the provisions of the law on fire prevention and fighting. Since then, the work of fire prevention and fighting in industrial clusters in Hanoi city will be more streamlined, ensuring more safety in fire prevention and fighting, contributing to promoting and attracting investment. of domestic and foreign investors investing in and developing in industrial clusters in Hanoi city, the capital of the Socialist Republic of Vietnam.

4. Conclusion

The synchronous investment in technical infrastructure system for fire prevention and fighting in industrial clusters has great significance in ensuring fire prevention and fighting safety. Managing the synchronous construction of technical infrastructure for fire prevention and fighting is a very complicated issue related to many industries and fields, depending on the awareness of the builders, operators and users. In order to ensure the technical infrastructure system of fire prevention and fighting for industrial clusters outside the fire prevention and fighting police force, it is a system of agencies with major professional responsibilities, requiring closely coordinate, together with relevant branches and levels, from the planning stage to the stage of construction construction, putting works into exploitation and use. If all the above solutions are implemented in a synchronized manner, not only ensures safety in fire prevention and fighting but also a reliable address to attract domestic and foreign investment in the near future.

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Section 6. Chemistry

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Rakhmatov Shokirjon Botirovich,
Fayzullaev Normurot Ibodullayevich,
Bukhara medical institute, Samarkand State University
E-mail: xurshiduz@yandex.ru

TECHNOLOGY FOR THE PRODUCTION OF ETHYLENE BY CATALYTIC OXYCONDENSATION OF METHANE

Abstract. The paper presents the results of studying the kinetic laws of the reaction of methane oxycondensation in a flow-through differential reactor. As a result of the study, the following optimal conditions were chosen: cat: $(Mn_2O_3)_x \cdot (Na_2MoO_4)_y (ZrO_2)_z$; P_{total} = 0.1 MPa, $P_{methane}$ = 0.033 MPa, P_{oxygen}= 0.014 MPa, T = 750 ° C, W_{total} = 1000h^{-1}. Based on the results obtained, a reaction mechanism was proposed and a kinetic equation was derived. An energy and resource-saving technological scheme for producing ethylene from methane was also proposed.

Keywords: flow differential reactor, methane, ethylene, oxidative dimerization of methane, technological scheme.

Introduction

One of the essential tasks of the catalytic research is finding new methods of the catalytic processing of methane by oxycondensation and development of existed methods. The most perspective methods of processing of methane are methanol, formaldehyde synthesis, aromatization and oxcaondensation reactions. There 156 mln, ton ethylene synthesized annually worldwide and has been increasing for 4.5% year by year. Ethylene is an impoirtant product of petroleum and gas chemistry, and is used to produce polyethylene, polyvinylchloride, polystyrene, alkylbenzenes, ethyleneoxide, and more. Current perspective and alternative methods of ethylene production is catalytic oxycondensation reaction of methane and the process is carried out in one step at normal atmospheric pressure [1–4].

It has been more than 30 years has passed since the oxycondensation reaction of methane developed, however the process is not implemented to the industry because of lack of the catalyst with high activity and high yield. For this reason it is essential to develop catalysts with high efficiency and energy saving technologies in order to obtain task-specified products [5–10].

Experimental part

In order to study kinetic regularities of oxycondensation reaction of methane laboratory instrument with differential reactor was developed. It is quartz tube with the length 650 mm and inner diameter 8 mm. Catalyst size is 0.25–0.5 mm. 0.1 g catalyst was added to the reactor. Methane with 99.9% purity and technical grade oxygen were used for the reaction. Contact gas from the reactor was cooled with cooler-separator.

The reaction temperature was changed from 700 to 850 °C. At this conditions methane conversion changed from 1 to 35% and oxygen conversion changed from 4 to 98%. Selectivity for the reaction product changed from 30 to 70%.

Gas products of the reaction were analyzed in a chromatographic method using "Gazokhrom 3101" chromatograph with thermochemical detector and an additional thermostat. Temperature of column thermostat is kolonka termostati 100 °C, carrier gas (air) consumption is 35 ml/min, column packed with activated charcoal is – 1m, inner diameter is – 3 mm. Quantitative analysis was carried out using an absolute scaling.

Catalyst for C_2-hydrocarbon synthesis is prepared using two methods: precipitation and sorption.

In precipitation methods aqueous solutions of manganese acetate and sodium molybdate were used to prepare the catalyst. The support – silica was prepared by adding sulfuric acid solution to sodium silicate solution. The precipitate was filtered, dried at 130 °C and calcined for 5 hrs at the temperature range 800–1100 °C in a muffle furnace. Consequently aqueous solution of manganese acetate and sodium molybdate were added. After 3 hrs obtained catalyst was dried and calcined ate 800–1300 °C. Aqueous solution of zirconyl nitrate with required mass was added. The catalyst was filtered, dried and calcined consequently as described above.

Amorphous structure of the catalyst was characterized using XRD (DRON-3 CuK_α radiation), porous structure was characterized using the analysis of absorption curves of nitrogen thermosorption method, the surface area of samples was characterized using S_{sol} BET method, volume of micropore and mesopore were characterized using the BJH method. Dispers properties of the catalyst was analyzed using the scanning electron microscope JSM-6510 LV.

Results and discussion

Oxycondensation reaction of methane is consists of the following steps (Tab. 1). As shown in the table, 1st and 2nd reactions and important and side reactions also takes place during the process.

Table 1.– Gibbs free energies and enthalpies of the reaction methane and oxygen

Reaction	ΔG^0_{298} (kJ/mol)	ΔH^0_{298} (kJ/mol)
$CH_4 + 1/2O_2 \rightarrow 1/2C_2H_4 + H_2O$	–143.0	–140.4
$CH_4 + 1/4O_2 \rightarrow 1/2C_2H_6 + 1/2H_2O$	–64.0	–87.8
$CH_4 + 3/2O_2 \rightarrow CO + H_2O$	–543.0	–518.7
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	–800.0	–801.3

Table 2.– Activation energies of methane oxycondensation reactions based on phenomological models and experimental results

No.	Reaction	Kinetic equation	E_a kJ/mol
1	**2**	**3**	**4**
1.	$4CH_4+O_2 \rightarrow 2C_2H_6+2H_2O$	$w_1 = k_1 \cdot P^2_{CH_4} \cdot P_{O_2}$	29.86
2.	$2C_2H_6+O_2 \rightarrow 2C_2H_4+2H_2O$	$w_2 = k_2 \cdot P_{C_2H_6} \cdot P_{O_2}$	21.42
3.	$2CH_4 +O_2 \rightarrow C_2H_4 +2H_2O$	$w_3 = k_3 \cdot P_{CH_4} \cdot P_{O_2}$	31.35
4.	$C_2H_6 \rightarrow C_2H_4 +H_2$	$w_4 = k_4 \cdot P_{C_2H_6}$	21.46
5.	$C_2H_6 +2C_2H_4 +0{,}5O_2 \rightarrow 2C_3H_6 +H_2O$	$w_5 = k_5 \cdot P^{1.36}_{CH_4} \cdot P^{0.723}_{O_2}$	64.85
6.	$CH_4+2O_2 \rightarrow CO_2 + 2H_2O$	$w_6 = k_6 \cdot P_{CH_4} \cdot P_{O_2}$	64.85
7.	$C_2H_4+2O_2 \rightarrow 2CO+2H_2O$	$w_7 = k_7 \cdot P_{C_2H_4} \cdot P_{O_2}$	51.45
8.	$CH_4+O_2 \rightarrow CO +H_2O+H_2$	$w_8 = k_6 \cdot P_{CH_4} \cdot P_{O_2}$	72.11

1	2	3	4
9.	$C_2H_4+2H_2O \rightarrow 2CO+4H_2$	$w_9 = k_{99} \cdot P_{C_2H_4} \cdot P_{H_2O}$	54.6
10.	$CO_2+H_2 \rightarrow CO+4H_2O$	$w_{10} = k_{10} \cdot P_{CO_2} \cdot P_{H_2}$	6.47
11.	$C_2H_4+3O_2 \rightarrow 2CO_2+2H_2O$	$w_{11} = k_{11} \cdot P_{C_2H_4} \cdot P_{O_2}$	37.59
12.	$2CO+O_2 \rightarrow 2CO_2$	$w_{12} = k_{12} \cdot P_{CO} \cdot P_{O_2}$	7.23
13.	$C_2H_6+2H_2O \rightarrow 2CO+5H_2$	$w_{13} = k_{13} \cdot P_{C_2H_6} \cdot P_{H_2O}$	54.6

*Note:** $K = \exp\left(K_0 - \frac{E_\alpha}{RT}\right)$; $\ln k_i = A_i - \frac{E_i}{RT}$

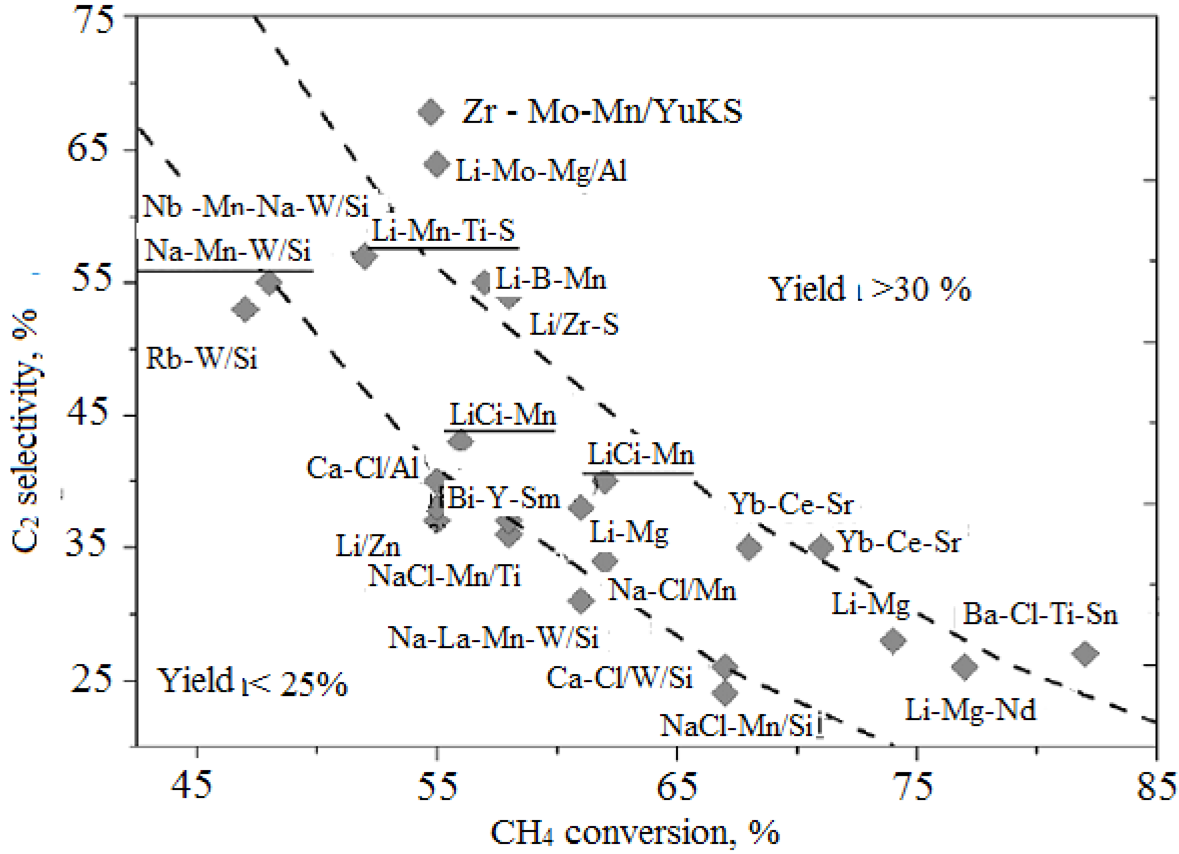

Figure 1. Catalyst for methane oxycondensation reactions with the yield higher than 25%. All catalysts at 700 ÷ 900ºC and CH_4/O_2 = 2 ÷ 8 ration, at normal atmospheric pressure

In (Fig. 1) results of studies for the catalytic activity of the oxycondensation reaction from references and current developed catalyst Zr-Mo-Mn/YUKS.

As shown in (Tab. 2), the reaction of ethane formation from methane is second order and formation of C_3 hydrocarbons are fractional according both methane and oxygen.

Rate constants were calculated by minimization the following function:

$$\min_{k_1 \dots k_n}\left(\sum_{i=1}^{N} C_{calc\,i}(k_1..k_n) - C_{\exp i}\right)^2$$

where *i*-component number; *N*-number of total components; $k_1 \dots k_n$ – rate constants of respective reactions; $C_{calc\,i}$ -*i*-calculated concentration for component *i*; $C_{exp\ i}$ – calculation of the experimental concentration of the component *i*. Activation energies calculated using the least quadratic method in temperature intervals. Using results of obtained kinetic parameters, conversion and selectivity for C_2 hydrocarbons were calculated. Adequacy of models were confirmed from methane conversion and the comparison of the selectivity for C_2 hydrocarbons from calculations and experimental results.

More than 10 catalysts activities were tested for methane oxycondensation reaction.

Catalytic activity of catalysts were studied in the stream differential quartz reactor at normal pressure and temperature ranges 750–850 °C. Prepared catalysts containing manganese show high catalytic activity in the reaction of oxidative dimerization of methane. The best results obtained with the complex $(Mn_2O_3)_x \cdot (Na_2MoO_4)_y \cdot (ZrO_2)_z$. When used catalysts prepared by abovementioned methods, methane conversion is 56.8%, selectivity for the task-specified products is 62.3%, selectivity for ethylene is 65.8% and yield of C_2-hydrocarbons is 35.4%.

Based on results of abovementioned and studied experimental results, it is essential to develop energy and resource saving, the best technologies of production ethylene from methane.

Main parameters to assess the development of valueble technologies are fulfilment of ecological and economical requirements. Technological parameter defines qualitatively the complexity of the organization of chemical technological process. Typically it is used the qualitative and quantitative parameters.

Table 3. – Essential parameters at the production of chemical products

Ecological cluster	Technological cluster	Economical cluster
1. Toxic fir human; 2. Global heating (climate change); 3. Toxic for water objects; 4. Acidification (acidic precipitate); 5. Destruction of ozone layer.	1. Selectivity; 2. Conversion; 3. Energy capacity; 4. Complexity of the process control and apparatus equipment; 5. Unit power of apparatus.	1.Net income; 2. Expenses of technological processes; 3. Expenses of purification systems.

It is known from references that development of worthy technologies; main parameters are calculated using the following formulae:

$$D_E = \frac{0.649}{T_1} + \frac{0.627}{T_2} + \frac{0.655}{T_3} + \frac{0.548}{T_4}$$

$$D_T = \frac{0.683}{T_1} + \frac{0.521}{T_2} + \frac{0.362}{T_3} + \frac{0.293}{T_4}$$

$$Deco = \frac{0.131}{T_1} + \frac{0.333}{T_2} + \frac{0.255}{T_3} + \frac{0.630}{T_4}$$

Based on abovementioned, it is proposed the energy and resource saving technologies of production of ethylene from methane.

According to the proposed technology, process takes place as following: natural gas containing 98% methane is sent to electric power plant at the rate of 60000 m^3/hour and it is heated up to 450 °C from recuperative heat exchanger "gas-gas" heat and sent to the input of the reactor. There part of methane is converted to ethylene and other compounds evolving heat.

In order to use heat of the reaction gases the initial natural gas is sent to tube section of the heat exchanger, whereas hot reaction gases are sent to the container as reverse stream. Oxycondensation reaction of methane is carried out with molar ration to oxygen from 2:1 to 10:1 in the reactor at the temperature range 700–900 °C. Gas stream from the reactor has a high heat capacity, also contained task-specific gas – ethylene, which is cooled and separated consequently. Where evolving heat from the apparatus spent to heat methane and the regeneration of high potential stream. Formed stream is utilized along with the unreacted methane formed in energy apparatus and heat from ignition of flammable gases. The reaction gas in apparatus is sent to the heat exchange apparatus, where main part is cooled down and separated as condensate. The reaction mixture then cooled down to 30 °C and sent via compressor to the purifier with ethanolamine where most carbon dioxide is separated. Stream then is washed in alkali media, dried, and then cooled down to –100 °C using "propylene-ethylene" cooling cycle. Gas mixture from the apparatus contains H_2, CO, N_2, remnants of O_2 and little amount of methane. This stream is throttled down to 0.3–0.5 MPa and sent to energy block via turbodetander. Column separates unspent methane in low temperature rectification and sent to energy block. C_2 hydrocarbons are sent to next column. The remaining mixture contains ethane, C_3 hydrocarbons and sent back to the reactor. Ethylene and small amounts of methane come from the upper part of the column. This mixture then separated to ethylene to production and unreacted methane. Electric power generation in apparatus based on methane is known. Any energy apparatus may be used in case of proposed process. Processing of ethylene consists of several parts, where ethylene is purified and became a product, or is sent to conversion reactors to form other products (liquid hydrocarbons, ethanol, and etc.). Utilization of evolving steam-heat from ethylene oligomerization, polymerization or copolymerization (polymers and plastics), hydration process products (ethanol), or alkylation process products (styrene, other monomers, fuel additives) is carried out along with the heat from the ignition of the unreacted methane and energy form the oxycondensation reaction.

Proposed method has particularities compared to alternative methods:

a) ethylene production as a primary product, gas preparation step to send energy block is added;

b) unreacted methane in ethylene synthesis reactor is not recirculated, disposed or flamed, but is sent to energy block in order to produce energy;

c) thermal energy (form as steam or other energy sources), heat from the ethylene formation is utilized along with heat from the apparatus charged with methane.

Proposed method of the production of ethylene and its products may be advantageous because of possibility of sending processed gases from the oxycondensation of natural gas to energy block compared to known technological processes. Production of ethylene and its products makes it feasible to cut the relative consumption of natural gas, and this is achieved because of utilization of heat from the processing steps. Thus makes it possible not adding low energy heat and electric generator.

Moreover absence of recirculation step of the unreacted methane in the process and oxycondensation of preliminary raw product with air or oxygen decreases the energy consumption. Specific process efficiency achieved by considering the natural gas both raw product and product. Merging the production with high value and production of electricity and thermal energy in energy block makes to correct of shortcomings of the production of ethylene and its products (overconsumption of methane in the production of the task-specified products, low efficiency). There advantageous – technologically simplicity, capital and operation expenses, using air as an oxidant is kept. Adding of the production of chemical products (ethylene and its products) to the scheme gives considerable income.

Gist of the method of production of ethylene and electric energy from the natural gas using the direct oxycondensation of natural gas is the natural gas is sent in ethylene synthesis and oxycondensated; this process is carried out in the presence of oxide catalyst at the temperature range 700 to 900 °C and 1 to 10 atmospheric pressure, where molar ration of methane and oxygen is 2:1 to 10:1. Then ethylene is separated from the reaction mixture and unreacted methane, hydrogen, carbon monoxide is sent to energy block and there electric and thermal power is generated.

Carbon dioxide formed from the reaction is used to obtain urea (carbamide):

$$CO_2 + 2NH_3 \longrightarrow H_2N-C(=O)-NH_2 + H_2O$$

But carbon dioxide is not used completely in urea synthesis. For this reason it should be organized to produce methanol in the processes evolving carbon dioxide:

$$CO_2 + 2H_2 \rightarrow CH_3OH + H_2O$$

Conclusions

1) The reaction kinetics of methane oxycondensation reaction is studied in the differential stream reactor.

2) Optimal reaction conditions is chosen: T = 750 °C, W_{yield} = 1000 hr^{-1}, catalyst: $(Mn_2O_3)_x \cdot (Na_2MoO_4)_y \cdot (ZrO_2)_z$; $P_{yield.}$=0.1 MPa, $P_{methane}$ = =0.033 MPa, $P_{koxygen}$ = 0.014 MPa. T = 750 °C, W_{yield} = 1000 hr^{-1}.

3) Effect of different parameters on the yield of the catalytical oxycondensation of methane, methane conversion and catalyst selectivity at the differential reactor conditions is studied, and kinetic equations for each process is derived.

4) Energy amd resource saving technologic scheme for ethylene production from methane is proposed.

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Section 7. Electrical engineering

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Monjengue David,
Engineer-Electronic from TUT South Africa
Independent researcher, Maputo – Mozambique
E-mail:

A SIMPLE TUNING MODEL-FREE CONTROLLER COMPARED TO PID AND FLC: CASE STUDY

Abstract. A simple model-free controller based on lag/lead compensator is proposed here, to reduce the design time requirements and the tuning effort, when designing controllers, thus increasing the efficiency. The proposed model-free controller, reduces the tuning complexity which are encountered with others controllers. The efficiency of this model-free controller relies on its fasten design and easy tuning. Besides its simplicity, the model-free controller has demonstrated better performances than PID controllers and similar performances of some advanced controllers such as Fuzzy logic Controllers.

Keywords: DC motor, Fuzzy logic controller (FLC), Kalman filter, Model-free controllers, PID controllers.

Introduction

Design a controller for any regulatory problem is a challenging task due to many aspects. To design a precise controller, an accurate mathematical model is required which can be obtained either from first principle model or from black box system identification experiment [1].

Apart from the mathematical model of the process, the system designer has to consider various other aspects like process uncertainties, measurement noise, and robustness of system while developing a controller [2].

The power generation industry has been slow in adopting certain advanced control applications, which have proven the ability to reach tight control requirements and fast response. Economic justification for advanced control projects has been reported as being the main barrier to entry, while a perception that these technologies are not yet proven in industry, and the requirement for high skilled personnel, also restrict adoption.

Design effort of automating the start up of a combined cycle HRSG takes about one year, while its implementation can take about three to four months [3]. These show that the design time requirements can be very time consuming.

A plant can have hundreds or even thousands of PIDs and no human group can monitor all PIDs and keep them controlling optimally all the time. Process changes, equipment changes, grade changes and others reasons can causes changes in system dynamics causing controllers to become oscillatory or sluggish. This is turn forces production rates to be reduced and control quality to be impacted. The absence of easy to use control monitoring tools, system identification tools and PID/APC tuning optimization tools results in poor control and missed opportunities in many chemicals plants and refineries [4].

The objective of this study is to overcome the above mentioned difficulties, by designing a model-free controller easy to implement, simple to use and still with good performances while compared to other controllers. In this study, we compare the model-free controller performances against PID and Fuzzy logic controllers.

There are already many applications of model-free controllers in the literature. Mingmei [5] used an adaptive model-free controller for a nuclear steam generator. Zhongsheng and Al. [6], were able to control SISO nonlinear system with a model-free controller. Model-free controllers techniques have been apply for, position control of a shape memory alloy active spring [7], adaptive control with disturbance observer [8], high performance Electro-Hydraulic system [9], HVAC control synthesis for data centers [10].

Although, these model-free controllers have been successfully implemented in real systems, they have not yet demonstrated their practicability and ability to reach similar performances as advanced controllers.

Model-free controller design (MFCL)

The below figure represents the proposed block diagram for the system and the model-free controller.

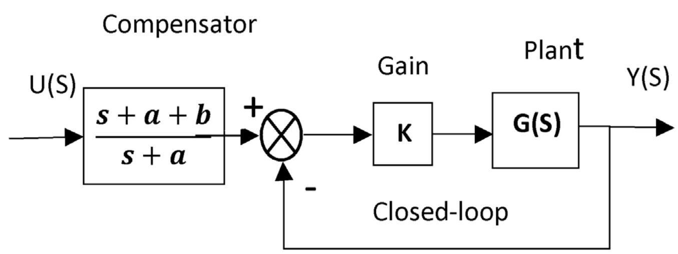

Figure 1. Block diagram of the system and the compensator

Hypothesis:

We assume that the initial system G(s) is stable.

Therefore, the closed loop system is also stable, and the overall system is stable if the compensator, external to the closed loop, is stable.

To control the system, we rely on the parameters **"a"**, **"b"** (from the compensator), and **"K"** (proportional gain). To simplify the tuning of the parameters, a mathematical relation between the parameters **"a"** and **"b"** has been derived.

Relation between parameters (a, b)

We apply the final value theorem to the system describes in figure 1.

$$\lim_{s\to 0} S.\frac{s+\alpha+b}{s+\alpha}\cdot\frac{K.G(s)}{1+G(s)}\cdot\frac{1}{s} = = \lim_{s\to 0} S.\frac{K.G(s)}{1+G(s)}\cdot\frac{s+\alpha+b}{s+\alpha} = V_f \quad (1)$$

$\frac{K.G(s)}{1+G(s)}$: is the final value of the closed loop system without the compensator. We will refer to it in the rest of this paper as **"L"**

Therefore, (1) gives:

$$V_f = \frac{L(\alpha+b)}{\alpha} \to V_f\,\alpha = L.\alpha + L.b \leftrightarrow b = \alpha.\frac{(V_f - L)}{L}. \quad (2)$$

If we want the output (V_f) to follow the reference input (V_{ref}), then (2) becomes:

$$b = \alpha.\frac{(V_{ref} - L)}{L}. \quad (3)$$

We choose to have **"b"** in function of **"a"**, because, as our hypothesis is to have the initial plant stable, in order to have the system plus the compensator stable, the compensator should be stable. Since **"a"** is the pole of our compensator, in order to guarantee the stability of the compensator, **"a"** should be positive.

From (3), it can be seem that, to find the value of **"b"**, that guarantee the tracking objective, we do not need to know the model of the system, only **"L"** is required to apply (3). But **"L"** can be determine just with one simple experiment, which consist of leaving the system operate without the compensator, with a unit step input and take the stable state value of the system. This stable state value of the free system is **"L"**, which, when applying to (3) gives **"b"**. We always start with **"a"**=1, then if the performances are not satisfactory, we increase or decrease **"a"** gradually.

Simulation

We choose a DC motor for our experimentation, since DC motor are widely used in home appliances, cars, airplanes, electrical machines, robots and factories. Improving the efficiency of DC motor will have a big impact on energy consumption. One way to reduce energy consumption and increase DC motor efficiency is by improving current control scheme of DC motors to make them have better response characteristics to do their intended work without oversizing the motors and their drive circuitries [11; 12].

The model-free controller was experimented to control the speed of a DC motor system describes in [13], with the following parameters:

Table 1. – DC motor parameters

Parameters	***Ra***	***La***	***Kb***	***Kt***	***Jr***	***Bm***
Value	2.25	4.65E-02	1.1	1.1	7.00E-02	2.00E-03

Al-Maliki [13], used the following parameters for the PID and The FLC-PID:

Table 2.– PID Parameters

PID Parameters	
Kp	2.51
Ki	9.724
Kd	–0.19185

The objectives defined in [11], were to have very small overshoot and improve the settling time of the PID controller which was Ts=1.07s.

Initial Model-free controller parameters: a = 1, b = 1.10 (from equation 3)

L = 0.475 (system closed loop without compensator final value)

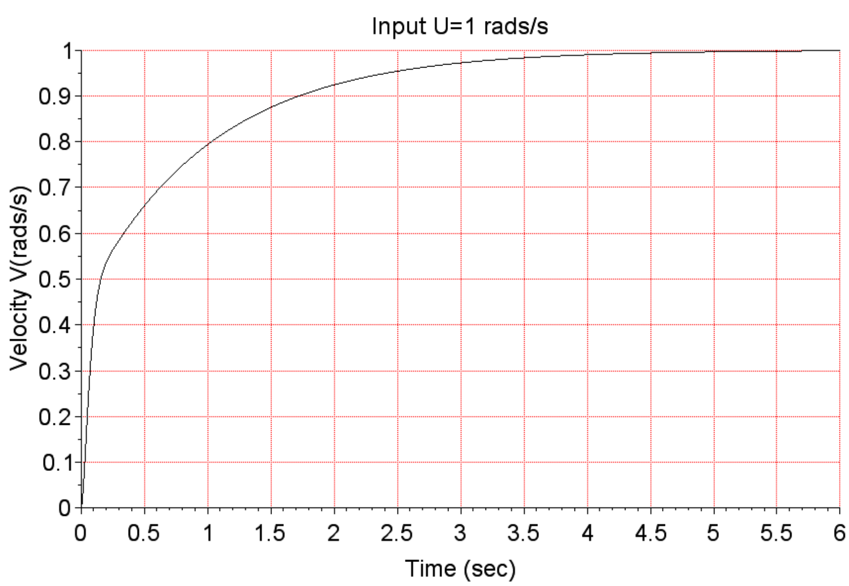

Figure 2. MFC unit step response before tuning

From the (figure 2) above, we obtained the following performance for the model-free controller:

Ts = 3.36s, with no "overshoot"

Although, the model-free controller, with the defined initial parameters, has achieved the "overshoot" requirement, the settling time is too high, consequently there is a need to tune its parameters.

The only rule is to increase/decrease the parameter **"a"** until the settling time requirement is achieve without losing the already acquired "overshoot" performance.

We used the following parameters for the model-free controller:

$a = 30$, $b = 33.12$ (from equation 3) and $L = 0.475$ (unchanged).

The below figure shows, the result obtained:

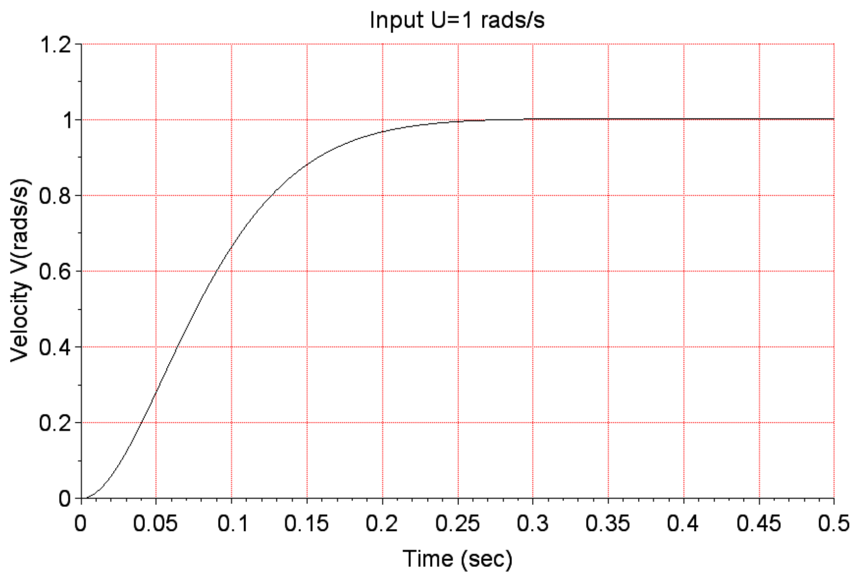

Figure 3. MFC unit step response after tuning

The below table shows a comparison of four different controllers for the system used:

Table 3. – Comparison of different controllers

Controllers	Ts(s)	OS(%)
PID (without Kalman Filter)	1.07	23.7
PID (with Kalman Filter)	0.635	8.01
FLC-PID (with Kalman Filter)	0.257	<0.5
MFC	0.25	No

The obtaining of parameters for the PID and the FLC-PID, from the (table 2), are not easy and the complexity is increased with the number of parameters to be found (three) and the signal that can be negative (case of D parameter). There is no simple tuning method for these controllers, thus their implementation will need the presence of specialist (to apply the Kalman filter or for the fuzzification/defuzzyfication).

With the model free controller, we start with the pole of the compensator at **"a"**=1, and then we increase it to 5, 10, 20, and 30. It is enlighten that these increases are trivial. The complexity is drastically reduce, because we avoid decimal values, the value such as: 1.455; 2.034, etc.

For the DC motor used here, we only needed to tune one parameter of the model-free controller, thus the design and tuning time to reach the defined parameter are small. The tuning can be done be non-specialists, since it is limited to increase the value of parameter **"a"** until reaching a satisfactory performances.

Conclusion

In this paper, we designed a simple an easy to implement model-free controller, for which the tuning rule is simple and can be implemented by non-specialists. This model-free controller is also low design requirements. There is no need for system analysis. However, the performances of this model-free controller, when applied to the DC motor used here, are better than those of advance controllers such as FLC-PID or PID with Kalman filter. The proposed model-free controller is easy to design, fast tuning and efficient in term of performances and requirements, making it suitable for any area such as home appliances, industries, factories, and laboratories.

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