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ALGORITHMIC COMPONENT IN INTEGRATED INNOVATIVE PROJECTS. (The Algorithmic Component in Integrated Innovative Projects: A Case Study of the Analysis of the Development of Fuel Mixture Modification Technologies)

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Abstract

Based on the current state of development of a new technological direction related to the creation of efficient thermodynamic technologies for optimizing fuel mixtures of various types, primarily intended for industrial and individual energy applications, it is advisable to apply a step-by-step scheme of sequential actions aimed at forming basic intellectual property objects in the above-mentioned technological areas. This strategic approach makes it possible to minimize the costs of research and development while ensuring maximum protection of technical solutions underlying the invention.

The paper considers an algorithm for integrating local technical solutions, each having the level of an invention, into a single integrated technical solution that provides a complex technological effect. A structural analysis of a group of technical solutions underlying the design of a device for dynamic mixing and activation of fuel mixture components, including a main liquid component, additional liquid components, and an activating gaseous component, has shown that the integrated technical solution in the presented design version includes a number of interrelated local technical solutions that ensure increased efficiency of mixing, activation, and subsequent use of fuel mixtures.

Keywords: *Technical level qualification of the project; Algorithm for integration of local technical solutions; Device for dynamic mixing of heterogeneous fuel mixture components; Processes and technologies with active monitoring of quality aspects of processes and materials; Regenerative electrolytic recirculation system*

Introduction

The algorithmic component in complex innovation projects is considered using the example of analyzing the development of technologies for the modification of fuel mixtures. The qualification of the technical level of a project, as exemplified by the evaluation and qualification of a complex project - a device for dynamic mixing of heterogeneous components of fuel mixtures and their subsequent activation - has a distinctly expressed algorithmic component.

At the present time, the project is at a stage of readiness corresponding to the manufacturing and completion of the first stage of production testing of an industrial prototype of the product — a device for dynamic mixing of heterogeneous components of fuel mixtures and their subsequent activation.

Figure 1. *Device and its components*

There is one specific feature that must be analyzed in order to ensure the required level of online interaction between all components and structural elements of the system. To enable participation in processes and technologies with active monitoring of qualitative aspects of processes and materials, as well as sufficiently high-speed automatic control and management systems, it is necessary, in addition to devices for dynamic online mixing and homogenization of process fluids in real time, to use high-speed electronic boards whose performance is comparable to that of modern computer motherboards.

For systems that are controlled and managed within standard aerial survey processes, the performance requirements are even more stringent. Such electronic boards include, first of all, the so-called RITM boards manufactured using dimensional selective metal etching technology.

The main distinguishing feature of such boards is that a steel strip made of special steel containing aluminum (38KhMYuA steel) is used as the base carrier material. The thickness of such a strip is only 50 microns, which makes it possible, compared to conventional carriers made of getinax or fiberglass laminate, to significantly reduce the distance between structures on both sides of the board.

Since the manufacturing process of such boards differs significantly from conventional printed circuit boards, it is advisable to consider this specific technology in more detail. The technological stages for manufacturing such boards should be considered taking into account all features and specific differences.

To manufacture such boards, the following operations must be performed:

- preparation of the surface of the steel strip (coil) (instead of steel, a metal strip may be used if it provides the properties and characteristics equivalent to steel grade 38KhMYuA); during surface preparation, it is advisable to use reagent-free technologies and disinfection using water with adjusted acidity and alkalinity levels;
- application of photoresist; production volume plays an important role here, and depending on production scale, different photoresist application methods may be selected; several well-established and similar application methods exist, which also differ depending on the type of photoresist and specific production conditions;
- development of the photoresist; there is experience in using serial conveyor-type photoresist development lines with full recirculation of process solutions and complete regeneration of all consumables, water, and chemical reagents;
- high-speed jet electrochemical nickel plating (2–3 microns thick). This type of electrochemical coating is the subject of a separate invention and is currently under development in electronics and microelectronics manufacturing technologies. The main dis-

tinguishing features of this invention include rotating anodes located in a plane parallel to the metallized surface and containing soluble elements within the working volume in front of the injection plate; an extremely small distance between the anode plane and the cathode (metallized surface); injection of electrolyte through the injection plate of the anode module perpendicular to the metallized surface (cathode). In this configuration, the metallization rate is ten times higher compared to conventional metallization;
- high-speed jet electrochemical copper plating (25–35 microns thick). This type of coating is similar to nickel plating and has the same distinguishing features, but is fundamentally new and requires additional explanation.

It can be stated that this type of coating and its sequential technological processing is, to a certain extent, a technological phenomenon. Since this technological phenomenon forms the main fundamental difference and provides a set of significant advantages of the method, it is necessary to provide an explanation of this phenomenon.

To qualify all distinguishing features of this process, the following definition is proposed:

– A complex technical solution is proposed, representing a combination of technological stages and operations, materials, and tools, including high-speed jet electrochemical deposition — a galvanic process carried out directly in the metallization zone under specific conditions with the following distinguishing features and technological characteristics.

– First of all, a clear definition of the nature of the formed electrolyte flow is required. It is initially defined that the metallization process is carried out in a selectively oriented electrolyte flow, in which the electrolyte is directed and injected onto the metallized surface, while the electrolyte flow rate is strictly controlled in order to eliminate negative edge effects on the cathode (the coated surface).

– It is also defined that the metallization process is carried out in a directed electrolyte flow, with the direction of the electrolyte jets being perpendicular to the metallized surface.

– It is further defined that the metallization process is carried out using a constant regenerative electrolyte recirculation system.

The recirculation system includes:

1. A container with electrolyte having specific operating parameters, such as:

- defined nickel and copper concentration values ensuring maximum efficiency and optimal deposited layer density without edge effects and with uniform thickness across the entire topology of the RITM board;
- defined electrolyte temperature values;
- defined electrolyte acidity or alkalinity values;
- defined electrolyte density values;
- defined electrolyte electrical conductivity values.

It should be particularly noted that due to the advantages of this technology, there is no need to use organic additives or activating materials, which significantly simplifies the electrolyte recirculation processes.

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- a method for summation of the kinetic energy of liquid and gaseous working media flows during their dynamic mixing in a hermetically sealed volume;
- a system consisting of a method and a device for increasing the turbulence level in a gaseous working agent flow through geometric structural transformation of the flow cross-section and an increase in its linear velocity;
- a method and a device for forming an annular low-pressure zone in a pneumatic pipeline;
- a method and a device for converting a directed liquid flow into a directed aerosol flow;
- a device for separating liquid and gas flows before mixing and combining them after mixing;
- a device for separating liquid and gas flows before mixing and combining them after mixing into a vortex flow;
- a method and a device for forming a double low-pressure zone in a hydraulic pipeline when connected to a pneumatic pipeline;
- a method and a device for connecting hydraulic and pneumatic flows during their dynamic mixing;
- a method and a device for changing the direction of movement of the working agent flow in a pipeline.

All of the listed solutions collectively make it possible to form a number of general technological solutions, which in turn are part of integrated solutions within the specified technology and its application variants.

These solutions include:

- a method and a device for preliminary mixing of liquid fuel components in a fuel pipeline.

The algorithm and logistics of the project development process for integrating a device for dynamic mixing of fuel components into fuel supply systems of thermal equipment, including boilers of all types, are considered. For boiler applications, the device must include a nozzle to ensure a higher level of compatibility with fuel supply systems to the combustion chamber or burner. The development of the nozzle is one of the components of the project. At the same time, the device itself may be presented as a standalone product or as a compact burner. This applies equally to boilers that use diesel fuel as well as boilers that use natural gas as fuel.

All variants and working versions of the device and its application technology may be developed simultaneously in parallel.

For devices intended for dynamic mixing of fuel components in which liquid fuel plays a dominant role, a number of phenomena occur that can be described as technological paradoxes.

The first paradox is that in a pipeline, with the same cross-section, the same initial pressure, and the same initial flow rate of an incompressible liquid component, an annular vacuum zone is formed without additional energy consumption. This zone acts as a boundary between the incompressible liquid and the compressible mixture of this liquid with gas, in this case air.

The second paradox is that within the same pipeline, the liquid entering the pipeline changes its physical properties from an incompressible working medium to a compressible working medium.

The third paradox is that at the point where the flow changes its physical properties, the liquid and gaseous component flows are coaxial, with the liquid component flow surrounding the gas component flow.

The fourth paradox is that in the zone that forms the boundary between the incompressible part of the flow and the compressible part of the flow, deep rarefaction or vacuum occurs under conditions where two coaxial flows each create an annular rarefaction zone, one created by the incompressible liquid flow and the second created by the compressible air flow. Both zones are coaxial, and the flow thickness in these zones does not exceed 100 micrometers for the liquid and 25 micrometers for the gas. The linear velocity in each of the flows in the rarefaction zone exceeds 100 meters per second, without the use of any additional energy sources.

The fifth paradox is that the mixture flow accumulates the kinetic energy of the flows of all components, and the kinetic energy of the mixture exiting the device exceeds the kinetic energy of the liquid component entering the device.

The sixth paradox is that under conditions of deep rarefaction and high linear flow velocity, in the boundary zone separating the incompressible liquid region and the compressible mixture region, a large number of composite fuel capsules are formed — more than 27 million spherical capsules with a diameter not exceeding 50 micrometers per liter of mixture or fuel composite.

The seventh paradox is that, if necessary, an additional liquid component of the fuel composite, for example water, may be drawn into the boundary zone between the compressible and incompressible parts of the flow. In this case, no additional energy is required to draw water into the liquid fuel flow and mix with it — only the energy of the liquid fuel flow itself is used.

The application of dynamic mixing technology for fuel mixture components in vehicle engines corresponds to an original algorithmic model. The technology of preliminary mixing and activation of fuel mixture components includes two main basic variants.

The first variant involves preliminary mixing of gasoline or diesel fuel with the amount of air necessary for optimal combustion conditions. After mixing, the mixture must be injected into the engine cylinders at the optimal time in order to avoid engine power losses associated with overcoming dead points of the engine motion conversion mechanism.

Currently, overcoming these losses in an engine consumes at least 62% and up to 70% of the fuel. The first variant of modernization of the internal combustion engine fuel system makes it possible to obtain equivalent engine torque while consuming at least 55% less fuel compared to currently produced standard engines.

In terms of distance traveled by a vehicle, if an engine currently consumes 1 gallon of fuel per 20 miles, then when using preliminary dynamic fuel component mixing technology, the engine should consume 1 gallon of fuel per at least 40 miles.

Tests of preliminary dynamic mixing technology in diesel fuel boilers have demonstrated high efficiency in reducing the concentration of toxic substances in exhaust gases. The reduction should exceed 40% compared to conventional engines.

Algorithm for Technology Verification

To test the effectiveness of the proposed technology, it is necessary to equip an internal combustion engine with a device for preliminary mixing of fuel mixture components, which must be designed and manufactured according to the specific parameters of the particular engine.

The size of the device must be equivalent to the fuel consumption rate required for engine operation under normal operating conditions.

To connect the device, it is necessary to design and manufacture injectors that must take into account the specific features of the engine and the capabilities of the device for preliminary dynamic mixing of fuel components.

For testing, a compressor must be prepared that is capable of providing the required amount of air at the required pressure, as well as all necessary instruments for measuring flow rate and pressure in all four compressed air supply lines to the device, which must also be designed and manufactured.

Pipelines must be installed from the device to each engine cylinder, and these pipelines must be equipped with pressure and flow measurement instruments, as well as safety valves; this system must be designed and manufactured.

An electronic sequential injection control system for each cylinder must be developed and manufactured, allowing fuel injection and ignition to occur at the moment when the engine motion conversion mechanism is not in one of the dead center positions. An algorithm and the necessary software must be developed for this system.

Figure 2. *Product size range: device for online optimization of fuel mixtures*

The engine fuel system must be modified, manufactured, and installed in order to provide the ability to control fuel flow rate and pressure before the device for preliminary dynamic mixing of fuel components. A fuel pump with adjustable pressure and flow rate and the necessary control equipment must be installed.

Control Parameters

During testing, the following main parameters must be monitored:

- engine torque;
- engine operating time at a specified torque;
- fuel consumption over a controlled engine operating time at a specified torque;
- concentration of toxic substances in exhaust gases (in accordance with environmental standards);
- auxiliary control parameters are not significant when comparing test results of the engine equipped with the device and the standard engine configuration.

Second Variant of the Technology

The second variant differs from the first in that water is added to the mixture in a proportion of 15% water to 85% organic fuel. In this case, fuel savings increase by 15%, and the distance per gallon increases to 46 miles.

Preparation for testing must additionally include the design and manufacture of a water supply system, which must include components for water purification, storage, water supply to the device, and instruments for monitoring water pressure, flow rate, and electrical conductivity.

The control parameters fully correspond to the control parameters in the first variant.

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