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Investigation of spectral analysis of voltage and current harmonics of electric drilling complex

Ivano-Frankivsk National Technical University of Oil and Gas

It was investigated electric drill E215-8M operation at the depth of 362 meters with the help of software LABVIEW and developed programs. This drilling rig is situated in Yasenovets village of Rogniativ district of Ivano-Frankivsk region. It was realized data collection, such as voltage and current harmonics, electric drill start, active, reactive and apparent power consumption, power factor, phase current and voltage.

Key words: electric drill, electric drilling.

In the process of oil or gas well drilling its depth is grown. As a result the current lead length and its electrical resistance is increased too and it is expected growing of higher harmonics and asymmetry. Also the values of power components are unknown as well. That’s why further urgent problem is experimental determination of power components and higher harmonics level of power supply system of electric drill at the different drilling depth on purpose of their impact assessment on electric drill operation.

Power consumption parameters are effective values of current and voltage, active, reactive power and distortion power, power factor, higher harmonics, current and voltage asymmetry, load schedules and other parameters, which can be received thought digital processing of directly measured and registered instantaneous values of voltage and current of electric consumer.

Quantitative and qualitative information about power consumption parameters is necessary for compensation devise choice, losses assessment, technical diagnostics, energy efficiency assessment of power converters, energy audit. So specialists of power supply and electrical equipment of industrial plants department of Ivano-
Frankivsk National Technical University of Oil and Gas developed hardware-software complex for analysis of power consumption parameters [1]. This complex provides measure and registration of instantaneous values of currents in three phases and neutral conductor, three phase (or linear) voltage, electric drive rotation speed at the hard drive of computer.

Hardware part consists of voltage changer CV3-1000, commutator i3000s Flex, optic incremental encoder E25-24-8 as angular velocity transducer, 16-bit multi-channel AD converter NI USB-6210, laptop and UPS.

Software is developed in LabView (Laboratory Virtual Instrument Engineering Workbench). First, measured data is recorded in file and then mathematical treatment program is started.

![Graph showing time variations of active power, reactive shift power, apparent power and distortion power during process of electric drilling at the depth of 362 m (1 point – 1 second)](image)

**Fig. 1.** Time variations of active power, reactive shift power, apparent power and distortion power during process of electric drilling at the depth of 362 m (1 point – 1 second)

This developed digital measure complex was used for assessment of power consumption parameters at the drilling rig in Yasenovets village of Rogniativ district of Ivano-Frankivsk region. Results and data analysis are presented below.

There are time variations of active power $P$ (pink line), reactive shift power $Q$ (yellow line), apparent power $S$ (dark blue line) and distortion power $T$ (blue line) at figure 1. As we can see, electric drill operating graph is irregular – it operates under unloaded conditions in process of drill bit breaking-in and it operates under rated load.
conditions in process of drilling. Fig. 1 shows drilling process – from 1 to 254 m motor of electric drill operates under no-load conditions, from 255 m to 484 m drilling is taken place, then there is pause and drilling is continued. Part of reactive power is commensurable with apparent power. So reactive power should be compensated due to bank of capacitors.

**Fig. 2. Power factor (cosφ) of electric drill during process of drilling at the depth of 362 m (1 point – 1 second)**

At Fig. 2 there is dependence of power factor of electric drill. We can draw the conclusion that compensation of reactive shift power is advisable with the purpose to increase power factor.

**Fig. 3. Phase current and voltage of electric drill during process of drilling at the depth of 362 m (1 point – 1 second)**
Fig. 3 shows that phase current and voltage at the depth of 362 m is stable and its deviation is within allowable variation 5%.

![Graph showing phase current and voltage stability at 362 m depth]

Fig. 4. Voltage harmonics of electric drill during process of drilling at the depth of 362 m (1 point – 1 second)

Fig. 4 shows higher voltage harmonics of electric drill U2-U7 which were measured on the top of well. As we can see the 7th harmonic (19 V 350 Hz) and 5th harmonic (10 V 250 Hz) is the biggest, 2.35% and 1.3% accordingly. Active value of voltage is 810 V.

Experimental determined voltage harmonic factor is 2.5% (fig. 5).

So level of higher voltage harmonic at the beginning of current lead during process of electric drilling at the depth of 362 m is small. The purpose of following examination is to investigate harmonics during process of drilling of lower intervals.
Fig. 5. Harmonic factor of electric drill supply voltage during process of drilling at the depth of 362 m (1 point – 1 second)

Conclusion

Voltage deviation and spectrum of higher harmonics is within allowable variation during process of electric drilling of upper intervals of well.

 Reactive shift power is practically uniform in time and commensurable with apparent power when \( \cos \varphi = 0.5 \). So compensation of reactive shift power is advisable with the purpose to increase power factor.

Literature

The module of the analysis of graphic data for telecommunication training system

In this paper we consider a system of scan graphics, testing designed as a JavaApplet based on the programming language Java. The system features cross-platform, compact, intuitively interface, understandable characteristics made by analogy with the most popular CAD systems. This system can be used in any academic year for automated testing of students' knowledge on graphic disciplines.

Keywords: JavaApplet, analysis of graphical information, distance learning, descriptive geometry, engineering graphics.

The subject of educational process automation at various levels becomes more urgent from year to year. In addition to the traditional method of teaching remote is being actively developed. One elements are used not only for part-time correspondence, but also for full-time courses. Today, there are plenty of platforms that provide all the necessary tools for testing students. This is possible to carry out both a remotely, via the Internet browser window, and locally, directly at a study place. The latter case requires prior installation of appropriate software. The system provides several options for testing: statement of questions with the only correct answer, multiple choice test, put in logical-order test, as well as the possibility of a detailed answer well-grounded in the form of a text, which is marked by a teacher.

This system of organization of educational process is convenient and the most popular with the humanities. Despite the fact that many systems offer the possibility of including graphics tests, their application for adequate test of knowledge of graphic disciplines on technical specialties is impossible. The image included in the test, as a rule, bears several graphic objects, among which, in accordance with the task one should choose the right (one for example, the position locating of dot
projection). Another option of including graphics is the insertion of images directly into answer variants. However none of these ways of using images attains the necessary interaction of a user with test graphics. As in most cases to check the correctness is possible only by the way platting is done. Therefore, we can conclude that today, testing the graphic disciplines at Sciences Departments at existing platforms for distance learning can not be considered complete. Thus, it becomes apparent that the creation of the tool environment, based on which a teacher who does not have any additional programming knowledge can create interactive assignments is an urgent and necessary task.

To create a reliable, fast and compact system it is most convenient to use an object-oriented programming language Java. Java Applet is an application program written in Java, executed by the browser directly on the client side. It also adds the necessary application interactivity, impossible while using conventional means. The library of swing, is designed specifically for creating graphical user interfaces based on the language of Java. The inerrability in to the system of Moodle distance learning is implemented by writing server-section in PHP language. The module considered in the paper provides for utilizing tow types of users-students and teachers. But since the creation of tasks by teacher and solution of those by a student have no basic functional difference, the difference being only in user navigation, implemented by means of Moodle platform. The interface to of the two users is identical.

Functionally, the system is divided into two different blocks - a graphical editor (GR), responsible for visualizing the system, and the a mathematical apparatus (MA), checking the correct answer. Below there will be considered operations performed by the given module. The functions implemented by means of a Moodle platform will not be discussed. Let is consider the graphic editor interface, as shown in Fig.1.
A template of a future test has already been loader into the editor window. Here arise a problem of alignment of an image as to application coordinates. Thus, the user is supposed to indicate any vertical line on the image (eg, centerline, usually present in any figure). After that, the program will automatically adjust the image position in the window. Just for the convenience of handling all the effective applications area is covered with of 10x10 pixels a grid size. A user-developer is only to drow the necessary elements for the solution of a task (Fig.2).

Fig.1. “The interface graphics editor.”
Fig. 2 “Graphic elements of the solution”.

For these purposes all the necessary tools to be used in any CAD system have been developed. Consider the application toolbar (Fig. 3)

- "dot", puts a dot to on the a picture;

- "line", is intended to represent a segment or polyline. At a matching a final and initial dots a polyline, closes, and automatically shading appears;

- "circle", builds a circle with the the center and a given radius; pointed by a cursor

- "arc", builds a three-dot arc (indicating the beginning and the end of it);
- "hatch", the shading appears after you select a succession of lines, when they reach a closed loop;

- "vertical line", refers to auxiliary geometry, it draws an infinite vertical line from a given dot;

- "horizontal line", refers to auxiliary geometry it draws, an infinite horizontal line from a given dot;

- "line 45"; builds an infinite line at an angle of 45 °, for the construction of the third kind;

- "auxiliary circle"; refers to auxiliary geometry, it builds a circle with the center and radius specified by the cursor specified. From the, "circle" it differs line thickness, it is ignored, in to answer;

- "text", enter the text cursor at a specified place;

- "Eraser", deletes the selected shape;

- The command "edit", paints the selected shape in red and depending on the type of a figures enables to edit it.

In the lower right corner of the application are two buttons (see Fig 4)

![Buttons](image)

- answer - send off

**Fig. 4 Buttons to send finished solutions.**

The button "answer" – you are asked to select all the elements that make up an answer to the task. The button "send off" - sends the result to the server.

The above operation enable to solve such problems as:

• Construction of the third kind, by the two given one;
• Building a projection of a dot belonging to the surface;
• Drawing simple and complex profiles;
• Building and carrying out sections;
• Construction of the intersection line of two surfaces of revolution;
• Etc.

After sending the results by the user-developer to the server, they are stored in a data array containing all the necessary information on task. "Answers" table and the table with the information about the image templates stored on the server with each other through one to one, external key. While a student performs a task, the data array is transmitted to the server as coded messages. MA program compares the student coordinates array with the existing array on the server. After finding errors a decision on the correctness of execution is taken and transmitted to Moodle. The result was a fast, compact, interactive system that can meet the needs for remote testing of students' knowledge on graphic disciplines. In order to use it only a one-time Java-plugin to user computer and to the internet access are required. Thanks to cross-platform Java technology with little code modification the application can be used for mobile devices in particular or tablet PCs.

Literature


Bayneva I.I., Baynev V.V.

MODELING OF THERMODYNAMIC STRUCTURE OF TUNGSTEN-HALOGEN CYCLE IN HALOGEN FILAMENT LAMPS

N. P. Ogarev Mordovian State University

Abstract:

This article describes the model and results of approbation for research on how a kind and pressure of halogen additives and an inert gas influences on the organization of the effective tungsten-halogen cycle in the halogen incandescent lamps.

Keywords: halogen, cycle, lamp, thermodynamic modeling, program, halogen additive, tungsten, incandescent body, reaction, pressure, phase, inert gas.

The nature of the halogen has a significant influence on the work of halogen lamps. Depending on the type of halogen, amount of the halogen-containing additives and the impurity compounds in the tube, there are different cycles of transportation of tungsten. They have an opposite directions of tungsten transportation on the temperature gradient in the direction of temperature increasing or decreasing.

Tungsten-halogen cycles are possible when they used as a carrier for any of the four halogens - iodine, bromine, chlorine, fluorine. First of all, two systems of reactions are formed. Its are tungsten-oxygen and tungsten-halogen. Then the tungsten-oxygen-halogen system may be formed, which can be penetrated by the hydrogen with the formation of hydrohalic compounds and water. At the same time the carbon may join to the reaction with the formation of halogen-hydrocarbons, carbon monoxide and hydrocarbons.

The method of thermodynamic modeling were used in order to solve the problems. It provides valuable information about the possibility of orientation of processes in halogen lamps, the optimal ratio of halogen-containing additives and filling gas.
The most general parameter, that determines the state of thermodynamic equilibrium, is a maximum entropy of an isolated system, which is the basis for the calculation of the partial pressures of the components [1].

Using thermodynamic data the modeling of chemical processes in halogen lamps was performed in a wide range of temperatures and pressures of filling inert gas. The partial pressures of vapor species and composition of the condensed phase for the tungsten-xenon-halogen additives were calculated, where the compounds \( CH_nX_{4-n} \) \((n=0÷4)\) were investigated as the halogen compounds.

Halogen additive is the most reasonable from the viewpoint of the transfer of tungsten from the walls of the flask to the halogen lamps in the body of filament. They are containing bromine: \( CH_3Br, CH_2Br_2, CHBr_3, CBr_4 \), which is consistent with the data of other authors.

The influence of the number of bromine atoms in the halogen additive was explored and it was shown that its increase shifts the minimum of the total partial pressure of tungsten halogenide in a high-temperature region and has positive influence on the organization of tungsten-halogen cycle. This is confirmed by his own experimental researches on the example of ACS 12-55-1 lamps: at end of life the flux fall of the lamps with \( CBr_4 \) was reduced by 15-20% than that of lamps with \( CH_2Br_2 \).

Bibliography:

ONE OF THE APPROACHES TO THE CREATION OF SOCIAL NETWORKS TO PROMOTE GOVERNMENT AND PUBLIC SERVICES

National Research University “Higher School of Economics”

In the research we considered one of the possible approaches to the creation of state social network, based on the conception of multifunctional analytical portal (MAP), that includes in its basic functionality business intelligence (BI) tools, allowing performing of the public services most rational promotion to civil society.

Key words: Information technologies, social networks, government, corporate networks, public services, portal, business intelligence, analytics, society.

One of the main tasks of modern socially oriented state is the organization of the effective public services promotion system to involve society. The solution of this problem via the Internet, through the creation of the social websites (or social networks), has practically become a tradition. This approach helps citizens to obtain necessary information and solve different social problems by themselves. For this purpose, informational websites, which have already become popular among population, are created and launched. These websites are about education, they include consulting websites about medicine, healthcare and law, as well there websites about other social areas. However the majority of such websites are created using the technology of popular “advertising” and “entertainment” web portals, with weakly developed functions that permit receiving a feedback from the consumers of the informational services. Generally, this feature defines the main trend of the eventual losing of interest towards such state websites. For example, the analysis of governmental website takzدورво.ru has shown that its traffic trend is steadily declining (Figure 1. The diagram was made using Rambler Statistic tool, the trend was made using the standard statistic tools of Microsoft Excel).
Obviously, to stabilize the state social website traffic trend, it is necessary to provide certain mechanisms for its content management and functionality, which will regularly stimulate the activation processes of the public services users. One of the most effective means to manage a social website, promoting public services, is the creation of powerful feedback channel quickly reacting to the main web events of the social network, and reflecting the changes of the content parameters. Using such a feedback channel, based on the modern business intelligence tools (BI)[1], the main task of improvement of the public services promotion through the social network, created and functioning in the Internet, can be successfully solved.

The research [1] considers the creation of corporate websites, based on the concept of multifunctional analytical portals (MAP), containing as a basic component of its structure a relational database, registering the main web events and saving the content of all the informational messages incoming to the website. The main web events on the social website may include: exchange of email messages among actors of the network (these messages form the basis of the content), registration of visits to the various web pages of the website, time spent in the network, surveys and trainings, use of certain website services, etc. Information about all of these events is registered and stored in the database from which analytical data, forming the new knowledge about the dynamic processes occurring in the social environment, can be later extracted.
This research proposes to apply MAP concept to the creation of the state social networks, adding in concept scheme of the tool set of the website a supplementary important component. It is proposed to add a new component that will actualize the functionality of business intelligence (BI functionality) on a collective portal. This component is responsible for the data collecting procedures, processing and displaying of analytical information using special data warehouse. The version of the modified conceptual scheme of the government social network is shown in Figure 2.

![Figure 2. The conceptual scheme of state social network.](image)

Thus, according to the conceptual scheme shown on the Figure 2, data accumulated in the database are the source of information for the completion of ‘multidimensional’ data warehouse, which is then used to form analytical ‘landscape’, allowing adequately react to the changes of social network. Generally data are uploaded to the multidimensional cube type data warehouse through the specially developed ETL subsystem. Further analytical data are processed using the known methods of statistical analysis, and then they are displayed in convenient for analysis form. The convenient display facilities are tables, graphs, and key performance indicators provided in various forms can be used.

Worth noting, that besides standard means of statistical analytics, in the block of ‘displays’ it is reasonable to use methods allowing reflecting structure changes of the network parameters. These parameters can be conveniently obtained using algorithms built on the methods of the Graph theory. Analytics based on the methods of Graph theory, allows visualization of such parameters as: number of 'intense' peaks, a
possibility to distinguish ‘weakly bound’ parts of the graph, to monitor structural changes, etc. To implement the calculations using graphs it is convenient to use MAPLE package. Monitoring of the structure parameters permits to timely identify causes of the decrease of the network actors’ activity and analyze their impact and effectiveness of methods for their activation.

The main conclusions:

1. In the research the concept of the creation of social portals on the basis of modified structure, MAP, for the needs of government agencies was considered.
2. Research proposes to use the multidimensional cube, on which are based modern BI tools, as a warehouse for analytical data.
3. As an alternative analysis of structural changes in the social network, it is proposed to use the algorithms of Graph theory.

Thus, analytical tools increase the manageability of the state social network and allow more effectively solving the tasks of the public services promotion. Moreover, the state social networks may become an essential component unifying the ‘Electronic Government’ and civil society.

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PROJECTING THE DATA MINING MODULE FOR DISTANCE LEARNING SYSTEM

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This report examines the theoretical foundations of data mining on the Internet (Web Mining), a module designed for this analysis in a distance learning system, describes the data for the implementation of the module.

Keywords: data mining, web mining, distance learning, information model, unified modeling language UML.

Currently, all the more prevalent Data Mining - a technology that is designed to find large amounts of data are not clear, objective and useful in practice patterns [1]. Obviously, such an analysis module can be a very useful and indispensable element of any information system. Variety of Data Mining, designed to analyze data on the Internet, called Web Mining, and, in turn, is divided into categories:

– Analysis of the use of Web resources (Web Usage Mining) - identifying the preferences of visitors of various network resources;
– Analysis of web content (Web Content Mining);
– Analysis of web structures (Web Structure Mining).

At the same time solve such problems Data Mining, as classification, clustering, association rules and the search (or search for consistent associations).

Рассматриваемая система дистанционного обучения [2] в процессе своей деятельности обеспечивает ведение следующих файлов данных:

The considered system of distance learning [2] includes the following data files:

– entry.dat – Information about visitors to the system (the date of visit to the site, name, group, level of access, IP-address);
– messages.dat – Information about messages that are exchanged between users of the system;
– testlist.dat – Information about the list of tests (both in general and available for testing);

– testresult.dat – information about users of the system passes test.

For the design of the data mining module we will use notation language UML [3]. The use case diagram that shows the work of the administrator is shown in Fig. 1. The structure of the designed module in a class diagram is shown in Fig. 2.

**Fig. 1. Use case diagram**
Fig. 2. Class diagram

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Pustovalova N., Avdeenko T.

FRAME-BASED TECHNOLOGY FOR REQUIREMENT ENGINEERING

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The paper describes method for requirements engineering based on frame technology. This is brief description concerns common issues of work in progress.

Key words: requirements engineering, frames, conflicting and duplicating requirements.

Abstract

The paper describes the work in progress for developing a requirement engineering method that will allow for a software that precisely meets user’s needs. The technology integrates tools from different methods and disciplines with recent developments in the field of requirements engineering. It provides a complex solution for the problems which usually emerge in the process of software development: requirement acquisition and formalization, verification and validation procedures, management and implementation, quality control and assurance [1,2].

Technology

The method is based on the following approach (related to how a human mind works). When one thinks of an object, its concept first becomes actualized in one’s mind. Then it is enriched with additional detail. The process of detalization runs along associative vectors. The information grouped along the vectors may be classified as core or peripheral, depending on its importance. This representation of the thinking process perfectly agrees with the Frames Theory [3] and reflects the procedure of image requirement acquisition and formalization. First, the most significant elements of a system being designed (that is, business requirements) are actualized. They are further classified into user requirements, which are, in turn, classified into function-level requirements and technical requirements. It is therefore possible to present the system of project requirements as a frame hierarchy. Its nodes are frame instances, their slots holding information about a requirement (see figure
1), as well as about the costs of project development and management, about requirement traceability, quality control and assurance etc. All nodes are interconnected by three types of predefined relationships: parent-child, duplication, and contradiction. The frame hierarchy is thus constructed, which reflects all the requirements and relationships between them.

<table>
<thead>
<tr>
<th>Slot’s name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>Consists of level number and requirement number. Used for frame instances addressing tracing and tree walking.</td>
</tr>
<tr>
<td>Parents</td>
<td>Parent number</td>
</tr>
<tr>
<td>Children</td>
<td>Children numbers</td>
</tr>
<tr>
<td>Requirement name</td>
<td>Common text requirement’s definition. Images as requirement’s name in hierarchical view.</td>
</tr>
<tr>
<td>Objective</td>
<td>Indicator which must be achieved in requirement’s realization process</td>
</tr>
<tr>
<td>Indicator for objective achievement</td>
<td>Shows indicator value for requirement’s realization</td>
</tr>
<tr>
<td>Full text requirement</td>
<td>Used for create textual representation (GOST 34, SRS). Due to domain area’s ontology creation.</td>
</tr>
<tr>
<td>Described objects</td>
<td>Define domain area’s objects and relations in between. Due to domain area’s ontology creation.</td>
</tr>
<tr>
<td>Described process</td>
<td>Related with business process and list’s descriptions.</td>
</tr>
<tr>
<td>Duplicating requirements</td>
<td>Index of duplicated requirements</td>
</tr>
<tr>
<td>Conflicting requirements</td>
<td>Index of conflicted requirements</td>
</tr>
<tr>
<td>Requirements owner</td>
<td>Owner’s full name and job title</td>
</tr>
<tr>
<td>Software specialist</td>
<td>Executor’s full name and job title</td>
</tr>
<tr>
<td>Related forms</td>
<td>Screen forms related with requirement implementation.</td>
</tr>
<tr>
<td>Related functions</td>
<td>Functions needed for requirement implementation.</td>
</tr>
<tr>
<td>Related modules</td>
<td>Modules that contains code for requirement implementation.</td>
</tr>
<tr>
<td>Software, hardware and technologies</td>
<td>Software, hardware and technologies are needed for requirement implementation</td>
</tr>
<tr>
<td>Lead time</td>
<td>Plan and actual values of time spending for requirement implementation.</td>
</tr>
<tr>
<td>Implementation costs</td>
<td>Plan and actual values of costs for requirement implementation.</td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1. Example of frame structure.**

Such a representation is expected to provide young specialist with methodological help make development process clearer for the customer. Storing the requirement system as a frame hierarchy allows for its convenient transformation into different views for the needs of other team members involved in development process. The procedural character of the frame model of knowledge representation makes it possible to connect individual slots in the frame structure with certain components of other representation templates. For example, the frame model can be easily transformed into an SRS specification, as all the data elements that need to be
placed within the text document structure and their relationships are known. The technology assumes the following representations: text-based specifications, such as SRS and GOST 34. Use Cases. A domain model, for instance, an ontology. Hierarchies of objectives and indicators of their achievement. The latter representation is introduced for the purposes of project management, quality assurance and matching requirements and the final software product to user needs.

**Conclusion and future work.**

CLIPS [4] was selected as the implementation language. The application contains elements of decision support system to control for duplicating and conflicting requirements. At first, the procedure identifies relations between full text requirements, objects of domain area presented as ontology, and technical elements of software development process. It next compares and analyses requirements investigated in the first step with the dictionary of project terms and restricted constructions [5,6].

A software embodying this technology is being developed. It provides for specifying and storing project requirement trees and information on their implementation that can be later reused. The repository is designed for that purpose. The software also provides for shaping the aforementioned representations, automatic verification procedures (possibly using text mining tools), and a sub-system for methodological help.

**Acknowledgment**

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Elena A. Tyrycheva

UNIVERSAL ALGORITHM FOR THE FORMATION OF QUESTIONS AND VERIFICATION OF THE RESULTS OF TEST IN MATHEMATICS
Kharkov National Automobile and Highway University

The article describes the author’s personal experience of algorithmic processes that accompany the students passing the entrance exams and full-time students of the university at the time credit modules on mathematic and other disciplines.

The algorithm that is presented below, was developed by the author of this article and for many years been used for the automated forming a package of tickets
and for automated checking of works during the written examination in mathematics for entrants of the University, that are entering on the budget form of training.

At present, these developments are successfully used in unit testing of students in the mathematical sciences. Testing can be performed both in writing and on the computer. In any case, the student must solve a series of tasks and write (enter from the keyboard), the responses in certain places of forms of the test (on the sheet or on the computer screen).

If testing is conducted in writing, the teacher will have to enter after the test responses of each student into the database. At the computer testing student’s responses are entered into the database automatically.

Then it is produced the automated verification of test results and appointment of points for each correct answer according to the selected in advance (before testing), the criterion of evaluation.

Each examinee is assigned an identification code. All accumulated points for correct answers are summarized and determined the final result of the test.

The following arrays of information are used in the large-sized chart of algorithm that described above.

1) Relational database (RDB) of all questions of discipline questions.dbf, which is formed in advance, complies with the requirements the curriculum and the work program for the discipline, as well as the requirements for the organization of any RDB [see, eg, 1].

The structure (a set of fields) RDB questions.dbf could be next: № topic; № question in the topic; Question wording (in the form in which the student sees the question in the text of the ticket or on the screen); Reply (the correct answer to this question in numerical format).

The primary key of records of the RBD questions.dbf is determined by concatenation of two fields: № topic + № question in the topic.

2) On the basis of RBD questions.dbf is formed files of examination (test) tickets that can be shown out on printing (as a text) or on a screen (as a form of input) with their subsequent filling by an examinee.
The rules of forming of files of tickets are the following: there are not two identical tickets in a package; every concrete ticket with number \( i \) does not contain identical questions with the tickets with numbers \( i - 1 \) and \( i + 1 \), where \( i = 2, N - 1 \), \( N \) is an amount of tickets in every package. \( N \) is equal to the amount examinees in the most numerous group.

Topics and amount of questions in a ticket are determined by a teacher. Numeration of tickets is through on all packages - from 1st to \( M \times N \). Amount of files (M) is determined by the amount of days of examinations (testing).

3) RBD *etalon.dbf* contains right answers on all questions of all tickets (test screen forms) of all packages.

The structure (set of the fields) of RBD *etalon.dbf* is the following: \( \# \) ticket; Answer 1; Answer 2; ... ; Answer \( N \).

The primary key of records of the RBD *etalon.dbf* is the field \( \# \) ticket.

4) RBD *answers.dbf* contains the answers of every examinee on \( N \) questions of the ticket (test screen form) that was given out to him.

The structure of RBD *answers.dbf* is the following: Code of examinee, \( \# \) ticket, Answer for a question 1, Answer for a question 2, ... , Answer for a question \( N \).

The algorithm of verification of testing results we will consider on an example one group of examinees with number \( i \) (\( i = 1, I \), \( I \) is an amount of testable groups).

The algorithm consists of the following steps.

Step 0. The beginning of the algorithm.

Step 1. It is formed the array \( \text{RESULT}i(n_i, 2N+3) \) of results of realization of test in the \( i \)-th group. There is the information in the every line of array - about one, \( k \)-th, examinee of the group (\( k = 1, n_i \)): identification code; \( \# \) ticket; answer for the question 1; answer for the question 2; ... ; answer for the question \( N \); result 1; result 2; ... ; result \( N \); total result of test. Here - \( n_i \) is a common amount examinees, that are passing a test in this group.
The first $N+2$ columns of the array are filled from the RDB answers.dbf. Last $N+1$ columns at forming of array remain free. In further, they will be filled with information about the correct (1) or incorrect (0) decision of this question of test and the calculated sum of points for correct answers.

Step 2. Organization of cycle on the lines of array $RESULT_i$ from $k=1$ to $n_i$.

Step 3. On the number of ticket (2th field of current line of array $RESULT_i$) we filter the records of RBD etalon.dbf and form the array $ET(N)$ of right (standard) answers on questions of this ticket.

Step 4. Organization of cycle on the numbers of the answers of the examinee from $j=1$ to $N$ (fields answer for the question 1; answer for the question 2; ... ; answer for the question $N$ of array $RESULT_i$).

Step 5. Comparison of values answer for the question 1 and $ET(1)$.
If these values are equal, we save "1" ("right") in the field result 1 of the current line of array $RESULT_i$, otherwise - we save "0" ("error").

Step 6. Accumulation of sum of right answers of this examinee in variable RES.

Step 7. Passing to the next answer of $k$-th examinee: $j := j + 1$. If $j \leq N$ - passing to the step 5. Otherwise – to the step 8.

Step 8. Content of variable of RES (total result of passing of test by $k$-th examinee) is saved in the field total result of test of array $RESULT_i$.

Step 9. Passing to verification of the results of next, $(k+1)$-th, examinee: $k := k + 1$. If $k > n_i$ - passing to the step 10. Otherwise – to the step 3.

Step 10. Output the results of passing of test by examinees of the $i$-th group.

Step 11. End of algorithm.

An algorithm can be realized on any of high-level languages. An author used the language of Visual FoxPro for drafting of the programs.

Universality of this algorithm consists of that he can be used for filling and verification of results of test on any disciplines, such, that on every concrete question of test there can be given unambiguous answer in any of formats - numerical, text, dates, logical.
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CID: J31207-425

Pogodaev V.P., Pogodaev A.V.

INNOVATION SCIENCE AND EDUCATIONAL CENTER
OF MATERIALS RESEARCH

The Far Eastern Federal University

The modernization of Russian industry in innovation based on new demands for professional and personal qualities of graduates of higher technical educational institution. The increasing complexity of modern technical systems and devices require the deepening of existing and acquiring new knowledge in the field of professional activity, the development of creative abilities and skills of scientific work. The level of difficulty and complexity of problems solved by an engineer, especially in knowledge-intensive manufacturing industries.

Keywords: welded structures, plastic deformation, the destruction of the material, analytical equipment.

Improving the efficiency of welding requires the preparation of master's ability to creatively solve problems of optimization of the design and manufacture of welded structures, process control of their production with minimal labor and management materials.

Welding production Sub-Department of Far Eastern Federal University (FEFU) based V.P. Vologdin is the oldest department that carried out the first issue of welding engineers in 1930, currently the department is preparing for the Master's program, "Machinery and Welding Technology" trend 150400.68 "Technological machinery and equipment."

One of the research areas the department is to study the interaction between plastic deformation and fracture of weld material. The fracture of solids is controlled
by its mechanisms and proceeds resulting from the interaction of structural objects with different levels of scale from the atomic to the mesoscopic and the dislocation substructure and. The surface layer undergoes major influence of dynamic loads and exposed to corrosive media. Conventional methods used for determining the properties of bulk materials are not suitable for layers with a thickness of several microns or less. In addition, the rapid development of nanotechnology and nanomaterials in the introduction of science and technology requires the development of new methods of analysis of certified materials and surface coatings.

The sub-department has interdepartmental laboratory instrument with a unique database that allows you to perform complex precision studies of the physical and mechanical properties of the surface of the welded joints. The research objective laboratory studies to identify and analyze the morphology of the structure and mechanical properties of various materials. In order to solve research problems laboratory is equipped with modern equipment with computer control and processing of research results. Laboratory learning task: the formation of students' knowledge and skills in the use of modern methods of studying the structure and mechanical properties of materials. To solve this problem, organized training sessions on subjects' "Physical basis of strength "and Research work of students.

CID: J31207-559
UDC 629.7.054

Kalinina M.F.

SPECIAL CHARACTERISTICS OF AN ELASTIC INTERACTION BETWEEN ACOUSTIC SHOCK AND AIRCRAFT BOARD EQUIPMENT AT OVERCOMING THE SOUND BARRIER

National Technical University of Ukraine "Kyiv Polytechnic Institute"

The distribution mode of highly intensive acoustic radiation at overcoming sound barriers by aircrafts has been analyzed. The phenomenon is considered as an
external disturbing factor that affects the construction of the aircraft, when its surface transforms from a completely solid state into the state of impedance (there is an elastic interaction). There has been established the cause of such internal phenomenon ("slam"), which occurs during the sound barrier; its structure in space and time and the impact of acoustical wave on aeronautical equipment to further advance in finding solution to the problem of reducing errors of inertial navigation equipment.

**Keywords**: penetrating acoustic radiation, sound barrier, shock wave, slam

**Introduction**

The significant issue for the rocket and space technology is the improvement of the accuracy of inertial navigation equipment carriers, which serve for aeronautical purposes.

The penetrating acoustic radiation is one of the external factors (angular fuselage pitching, vibration, thermal torch rocket engines), which affects the accuracy of inertial navigation systems.

The overall level of acoustic field in the vicinity of jet stream can reach 180 dB in the frequency band width of 0 to 10 kHz (it is a well-known fact that sound radiation takes about 1% of the mechanical engine power). Such mode has been considered in detail and observed from the start of launch vehicle (LV) from the Earth surface i.e. from the mines. Usually the acoustic radiation reaches 140-150 dB, which is observed in natural conditions in space RN space rocket that jets blown [1].

When aircraft overcomes the sound barrier the level of acoustic emission for different classes of vehicles may increase by 10 times in comparison to its level at the start. Sound pressure of such intensity will have a significant impact not only on the construction of aircraft, but also on the mechanical systems on-board equipment.

**Presentation of the basic material**

During the flight of the moving objects with low trajectories in the dense atmosphere there can be observed a phenomenon, known as the sound barrier, which accompanies the movement of aircraft (planes, missiles) at speeds fairly close to the speed of sound, or even exceed it.
Let us define a class of carriers, such as the ballistic missiles (BM), which are subject to this phenomenon. The flight time of the vertical launch from submarines BM is about 15 minutes at 2800 km range and with normal trajectory, and 7-8 minutes in flight at low trajectories [2].

The rocket that flies with the supersonic speed creates aerodynamic flow, which leads to the sound strike. The stream is formed mainly by waves of compression and expansion waves, which are located between them. The compression waves overlap with one another with the increasing distance from the aircraft, leading to a sharp increase of pressure at the beginning and at the end of this system of waves. Similar increases in pressure are called consolidation jumps (shock waves) (fig. 1). The system of waves accompanying missile has almost conical form, and usually reaches Earth's surface, where it gets reflected and scattered, depending on its features.

At the edge of the shock wave, which has a very small thickness (small share of mm), almost like jumps the drastic changes in the characteristic of the flow occur - its speed, in relation to the body, decreases and becomes subsonic, the pressure in the flow and gas temperature increases through the jump. Part of the kinetic energy flux converts to internal energy of gas. The higher speed of the supersonic flow, the greater the changes are.

![Fig. 1. Schematic representation of the shock wave rocket – change of overpressure Δp depending from time t](image)

The time from the first strike till the second peak of pressure is called the overall duration Δt (fig. 1). The rise time τ varies usually from 1 to 30 ms (the mean is 10
ms), the time $\Delta t$ – from 100 to 400 ms (increases with increasing length of the rocket and to a lesser degree with increasing altitude) [3]. Measured data of the rise time $\tau$ are more apparent and seem larger than it was expected from the theoretical consideration of a flat jump strengthening, taking into account friction and heat. The reasons for such an outcome may be the increase of the air density during the appearance and distribution of shock waves, the turbulence in the lower layers of the atmosphere, and also focusing effect due to change in temperature and wind speed.

Due to small deviations in the atmospheric pressure, on the diagram of maximum overpressure $\Delta p_{\text{max}}$ minor fluctuations are observed, and pressure curve can be sharp or rounded at its end. During the noise strike, due to the similarity of the diagram overpressure with the Latin letter N, the new appearing is often called perturbation N-shaped wave (fig. 1).

Passing by the aircraft the sound barrier is accompanied by "slam". Slam — is a sound strike of a high level, nearly of 240 N/m$^2$ (180 dB and above) [4].

Acoustic wave transforms into a sound wave, and passes through the body of the device and under Chief Aerodynamic Part (CAP), which is the most vulnerable part of the rocket, similar to the sound bridge, and generates non-linear oscillation (including resonance) in mechanical systems of onboard equipment, which results in stressed-strained state of suspension gyroscope, which is regarded by devices as "useful" incoming signal and consequently leads to errors of inertial navigation equipment.

**Conclusion**

The distribution mode of highly intensive penetrating acoustic radiation at overcoming sound barriers by aircrafts targeted at further reduction of the errors of inertial navigation has been analyzed.

The noise strike (the slam), though the elastic interaction with the construction of a moving object greatly affects the mechanical systems of on-board equipment.

The acoustic strike of high intensity when dealing with aircraft sound barrier makes a significant impact on aeronautical equipment that serves as the appearance of additional errors. As a result, errors of navigation equipment lead to poor tactical
and technical characteristics of the pH and reduce passport characteristics of devices and systems of command and measurement complex flying machines as a whole.

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Pogodaev A.V.

DETERMINATION OF SURFACE PROPERTIES, MICROSTRUCTURE AND MECHANICAL PROPERTIES HARDENING OF COATINGS STRUCTURAL MATERIALS

The Far Eastern Federal University

The reliability of modern diesel vehicles as they are crossing, lower specific gravity and growth of economy is increasingly limited reliability of friction pairs working in complicated stressconditions.
Keywords: microindentation, scanning probe microscopy, rehabilitation, work hardening, coatings, durability, topography.

The efficiency of anti-friction layer depends on the material properties of the antifriction layer design, as well as performance. Theoretical and experimental studies on the issue of reliability of friction pairs of transport diesel engines require further improvement and generalization. One of the promising ways to improve the reliability is currently restoring and strengthening parts coating, as it provides the highest tribological properties of antifriction material compared to the weld. The technological process (TP) and the recovery of hardening parts coating consists of several stages and production operations. The most time consuming step in the development of process technology is to determine the mode parameters that allow you to get the optimal parameters of the surface layer of parts for coating. The problem of optimal control of the formation of the surface layer of parts is very important. Necessary to estimate the parameters of roughness and waviness of the surface profile, the microhardness of the material, the tensile strength of coatings, coating thickness, surface microstructure, etc. [1,2,3].

To study the comparative durability of the new diesel plunger assembly VD 26/20A3 (standard) and the plunger assembly with a plunger, chrome on the optimal mode of composite coatings (chromium electroplating, and organic-mineral + coating) conducted field trials. For e of the technique estimates of the strength of coatings using atomic force microscope and ultramikrotestera for the dynamic tests the hardness of materials. Determination of tribological and mechanical properties, metallographic features and topography of the investigated coatings to select the composition of mineral and organic materials for the modification of chromium plates for maximum durability of steel friction units CVH - durable composite coating.

In the course of the research used optical and atomic force microscopy and nanoindentation. Tests on the microhardness of coatings allow us to determine the hardness of individual structural components and the heterogeneity of the mechanical properties of the surface layer, provide an opportunity to indirectly assess the fragility of the individual components [4]. To determine the nature of the physical and
mechanical properties of coatings in order to study their influence on the tribological properties of virtually the only universal tool is the nanoindentation [5]. The connection between the physical and chemical properties of solids and coatings with nanostructure [5, 6]. To investigate the physical and mechanical properties of coatings at the nanoscale ultramikrotester used for dynamic testing of materials hardness DUH-211S, Shimadzu (Japan). The device is designed to measure the hardness \( H \), elastic modulus \( E \) and elastic recovery of the method \( We \) nanoindentation. The tests correspond to the standard ISO 14577-4. In the process of measurement is removed loading and unloading curve, which is further processed by the method of Oliver-Farr [7]. As the indentor used nanoindentor Berkovich (triangular diamonds pyramid).

Studies were conducted to determine the structure of the structural features of the surface layer of the coating. Evaluation of the structure of the structure and topography of the surface layer of the coating at a high level of resolution available with atomic force microscopy, and in most cases, to characterize their quality, physico-mechanical and tribological properties [8]. Morphology and the local properties of the coatings investigated in the scanning probe (atomic force) microscope SPM-9600 the company Shimadzu (Japan) with high spatial resolution. Diagnosis of the surface and its topography is carried out by a direct method of studying the structure of the surface of the contact atomic force microscopy. To measure the microstructure of the surface layer of a series of measurements of surface topography with high spatial resolution in contact mode atomic force microscopy.

- The results of the primary research layers formed on steel surfaces, friction units CVH - wear-resistant composite coating can be made to the following conclusions:
  - Results of microindentation allow the assessment of mechanical properties of coatings, which is extremely important to monitor the coating process.
  - A study of the morphology and surface topography of the layer formed to evaluate the roughness and the distribution of structural components.
• Implemented techniques with high spatial resolution opens the possibility for systematic studies of friction surfaces in the process of modification, which will allow more efficient use of the unique properties of the coatings to increase the share of machinery while reducing energy consumption.

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INCREASE OF EFFICIENCY OF SNOW-REMOVING ROAD COVERINGS

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The effect of cutting angle of the blade on cutting forces compacted snow formations. The optimum parameters of the cutting angle, cutting force identified depending on the physico-mechanical properties of snow, angles and depth of cut.

Key words: compacted snow, blade model, cutting force, the angle of the angle of cut.

Winter maintenance is a complex work, including: protection of roads from snow drifts; struggle with winter ice and slipperiness. Work on the winter maintenance designed to ensure smooth and safe movement of vehicles.

The system measures for winter maintenance of roads constructed in such a way as to ensure the best conditions for the movement of vehicles as easy as possible and reduce the cost of winter maintenance. To ensure the fulfillment of these tasks, with the winter maintenance is carried out: preventive measures, which aim to prevent or to weaken the influence of snow and ice deposits on the safety, protective measures to help block the access road to prevent the formation of snow and ice action to remove snow sediments and ice from the road and reduce their impact on vehicular traffic.

According to traffic police of the Russian Federation about 21% of accidents occur due to the poor state of roads of which approximately 70% (15% of total accidents) were in the snow-covered road surfaces, 5 - 7% of accidents on snow-covered and partially covered with ice, at the same time slippery surfaces marked by the most severe consequences of an accident.

For each of the road set deadlines removal of snow and eliminate ice formation, determined on the basis of technical and economic calculations, taking into account
the significance level of the road, and the intensity of traffic, weather and climatic characteristics of the area and equipment of the road maintenance service machinery, equipment and supplies for the winter maintenance of roads.

To clean the surfaces of roads and airfields of snow is quite widely used by snow machines, equipped with blade, this is due to their versatility, ease of construction and maintenance, mobility and relatively low cost.

The basis for the establishment of effective and efficient snow plows is the solution to reducing the energy intensity of the cutting process compacted snow formations blade. Of particular interest are the questions the best choice of camera angle and capture angle of cut in the blade, providing reduced power consumption. Realization of this question is constrained insufficient information about the forces of cutting compacted snow formations. Study the cutting process of snow studied by such scholars as A. L.Gorbunov, I. S. Weisberg, G.G. Voskresensky, A. P. Kulashand U. I.Molev.

The main objective of studying the laws of the cutting process compacted snow formations depleted in the blade of the road surface is to find a suitable for practical application of the functional relationships between power characteristics and geometric parameters of the installation of the working body. Experimental studies were carried out at ambient temperature from – 4 to – 13 °C, with samples of snow density of 400 – 500 kg/m3 at a special stand, which was mounted on a track specially made tenzozveno with a fixed blade model made in 1:10 scale. Experiments were carried out at an angle of 90 degrees set model blade, cutting corners 15, 30, 45, 60, 75, 90° and thickness of thin shavings of snow 10, 20, 30 and 40 mm. Before you start cutting the sample was mounted on a stand of snow, the snow carved out of rolling, formed on the pavement. The surface of the sample pre-leveled. The required depth of cut is ensured by raising the snow sample with calibrated plates.
Fig. 1. The dependence of the horizontal component of cutting force on the angle and depth cutting of compacted snow formations blade model: *a* – snow density of 400 – 450 kg/m$^3$; *b* – snow density of 450 – 500 kg/m$^3$, 1, 2, 3, 4 – depth of cut, respectively, 10, 20, 30, 40 mm.

On (Fig. 1) are present obtained dependence of the horizontal component of the effort of cutting on the angle and cutting depth, with the angle of installation model blade 90 degrees. Analyzing the obtained dependence, it is seen that the values of the horizontal component of the effort of cutting with the increase of the angle of cutting change at the polynomial dependence. The smallest effort of cutting are observed in the coal cutting 45 - 50°.

The obtained values of the efforts of the cutting of compacted snow formations and their dependence on the angle and cutting depth can be used for the design of...
blades and the calculation of the energy intensity of the snow cleaning machines. Setting the angle of cutting 45 degrees provides the least effort of cutting compacted snow formations, may be recommended for use of road-operational organizations in carrying out work on the pavement snow cleaning. Installation blade snow machines angled cutting 45 degree will enable to reduce the energy intensity of the process of cutting, improve the productivity of snow-removing machines without increasing the capacity of the base of the machine, to reduce economic expenses on the maintenance of roads in the winter period and ensure the rational use of capacities of the basic machines.

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INFLUENCE TOPPING OUT AT THE OXIDATION OF MOTOR OILS

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The effect of topping on the oxidation of motor oils of different basic principles, viscosity grades and group performance characteristics. Set the parameters of oxidation and increases the potential resource for top-up at a temperature of 180 °C.

Key words: absorption coefficients of luminous flux, the relative viscosity, thermal-oxidative stability, volatility.

One of the important ways of increasing efficiency of use of motor oil is to improve quality and increase the resource. However, during operation of internal combustion engines as a result of wear of the cylinder group increases waste oil, topping the caller, and updates the operational properties of the oil by increasing the concentration of additives. The inconsistency of authors [1-3] dealing with the problem of research in the process of topping oil exploitation DIC indicates a lack of study of this problem, so research in this area become relevant.
Investigation of motor oils were: Lukoil standard 10W-40 SF / CC, Lukoil Super 10W-40 SG / CD, and Lukoil synthetics 5W-40 SL / CF. In the first stage oil sample mass of 100 ± 0.1 g poured into heat-resistant glass and thermostated at 180 °C with stirring a glass stirrer at a constant speed of 300 ± 2 rev / min. After every eight hours of testing with the sample cup was weighed to determine the mass of vaporized oil and the samples were taken for the change of the absorption coefficient of the light flux and viscosity. After measuring these parameters, samples are merged back into the same glass, which is re-weighed. Tests were conducted during the time required to reach the absorption coefficient of luminous flux equal to about 0.7-0.8 units. The second phase of research conducted on the same technology with the difference that after each measurement on the photometer and vizkozimetre oil sample into a glass topped up to 100 g.

The test results of selected oils on thermal-oxidative stability of a hundred-without refilling and topping are shown in Fig. A. It is established that the oxidation processes are slowed down topping. So, time to reach the unit rate. with mineral oil - Lukoil standard (curves 1 and 1 ') for topping up by 9 hours, partially synthetic - Lukoil Super (curves 2 and 2') for 25 hours and synthetic - Lukoil synthetics (curves 3 and 3 ') for 37 hours. Massa topping the time trials, respectively, was 17.7 g, 21 g and 36.9 g, and the speed is determined by the ratio of the mass topping topping the time of testing and were as follows: 0.268, 0.188 and 0.125 g / h, i.e. with mineral oil topping the highest speed, and synthetic - the smallest.
Fig. 1. The dependence of the absorption coefficients of luminous flux on the time of the test motor oils: 1 - Mineral oil Lukoil standard 10W-40 SF / CC; 2 - partially synthetic Lukoil Super 10W-40 SG / CD; 3 - Lukoil synthetics Synthetic 5W-40 SL / CF (figure unprimed - test without refilling, numbers with a prime - test with topping)

The change in viscosity during oxidation was estimated coefficient of relative viscosity, determined by the ratio of viscosity to the viscosity of the oxidized oil trade. Fig. 2 shows the dependence of viscosity on the time of testing. It is established that the viscosity of mineral oil (curves 1 and 1') at the beginning of the oxidation decreases and then increases. The viscosity of partially synthetic oil (curves 2 and 2') tends to increase and the maximum increase of 13% of the viscosity of the oil trade. For synthetic oils (curves 3 and 3') is characterized by an initial decrease in viscosity, and then stabilize and increase reuse. Also topping the reduced viscosity of the oxidation. The maximum reduction in viscosity without refilling, constitute 18% and a topping - 28%.
For mineral and synthetic motor oils, partially refilling slightly affect their viscosity.

The volatility of mineral oil (curves 1 and 1') (Fig. 3) was not significantly changed from the topping, and for partially synthetic oil (curves 2 and 2'), it decreases with topping. Thus, over 80 hours of testing without refilling the volatility of oil was 12.3 grams, and a topping - 9.5 grams.

For a synthetic oil with topping (curve 3') to 130 hours of volatility is less than without the topping, and with increasing test time is increased, which may be caused...
by destruction of the basic framework or viscous additives, as viscosity synthetic oil with topping decreased more rapidly than without refilling (see Fig. 2).

As an indicator of oxidative stability of engine oils offered rate thermo-oxidative stability, defined by the sum of

\[ E_{TOC} = K_\Pi + K_G, \]  

where \( K_\Pi \) – the absorption coefficient of the luminous flux; \( K_G \) – coefficient of volatility:

\[ K_G = \frac{m}{M}, \]  

where \( m \) and \( M \) – respectively, the mass of evaporated oil samples and the remaining mass for a certain period of time of oxidation, g.

Coefficient of thermal-oxidative stability is a complex indicator, because takes into account the tendency of oils to oxidation and evaporation. According to the data presented in Fig. 4, mineral oil (curves 1 and 1') is the least stable to oxidation, and synthetic oil (curves 3 and 3'), the most stable.

![Fig. 4. Coefficient of thermal-oxidative stability of the oxidation time of motor oils (usl. code no. See Fig. 1)](image)

Topping up engine oil increases during their oxidation (resource), so at odds units. oxidation time for mineral oils (curves 1 and 1') has increased from 63 h to 70
h, the partially synthetic (curves 2 and 2') from 82 to 109 h, and synthetic with 273 to 292 h (curves 3 and 3'). In addition, topping synthetic oil does not affect the value of the coefficient for 130 hours of testing. According to Figure 4 have the greatest impact on slowing topping the oxidation of partially synthetic oil and the acceleration of oxidation processes in synthetic oil in the test period from 130 to 270 hours.

The results obtained to quantify the influence of topping on the resource allow you to adjust the resource oil, depending on the actual condition of engine oil.

Literature:


OPTIMIZATION OF A DEVICE FOR MANUFACTURING THE TORSION SUSPENSIONS FOR SENSING ELEMENTS OF THE INSTRUMENTS UISAT-1

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The present report sets a task of optimization of the device for manufacturing the torsion bars with helical anisotropy UISAT-1 designed for production of torsion suspensions for sensing elements of the instruments. With a purpose to achieve the set goal, elements of the theory of machines and mechanisms, methods of analytical
mechanics, as well as the modern computer modelling programs MatLab and Compass have been used.

Keywords: device for manufacturing the torsion bars with helical anisotropy UISAT-1, synthesis of the optimal arrow-like cam profile, cam, optimization

Introduction.

The purpose of this research work is optimization of a device for manufacturing the torsion bars with helical anisotropy UISAT-1 designed for production of torsion suspensions for sensing elements of the instruments.

The device can be classified as equipment for production of braded works, designed mainly for manufacturing the torsion suspensions for sensing elements of the instruments, and can be applied in magnetometry, seismology, geodesics, meteorology, electrical engineering, etc. The device can be used to manufacture torsion bars for sensing elements of highly sensitive magnetometers, accelerometers, seismometers, tiltmeters, microbarographs, galvanometers, as well as in sensors of burglar alarm systems.

With a purpose to improve characteristics of devices of this type, developments of the theory of spiral-anisotropic bodies are applied, and the torsion suspension of a sensing element is manufactured in a form of “braid” woven from kevlar fibers.

The known device makes it possible to manufacture a “braid” with diameter of 0.03-1.5 mm by means of waving three strands, which is used for torsion suspensions of highly sensitive elements of the instruments, with the pre-determined parameters (material, thickness, structure, waving density, torsion modulus, strength, etc.). Torsion suspensions with the pre-determined parameters have a property of elastic anisotropy.

The use of such torsion suspensions in instruments with sensing elements makes it possible to:

• reduce the torsion modulus (increase the response level);
• increase withstandability to the changes of climatic factors, increase stability in time (reduce to zero the temperature drift);
• increase withstandability to dynamic loads.
Specifics and unique character of this device is based on a fact that the special material, i.e. filaments of synthetic high-modulus threads belongig to a class of paraaramid fibers, are used as raw material for brading. Diameter of fibers is 0.01 mm, length 400 mm.

However, the device has the following disadvantages: instability of operation caused by a lack of coordination in movements of the braiding mechanism due to a shape of arrow-like cam (provides the influence onto the uniformity of braiding); some difficulties in operation and adjustments; not sufficiently high speed of operation (not more than 100 mm/hour) caused by design features created in course of the device development. Aforementioned factors provide the influence onto the quality of torsion suspension, comfort of operation/maintanence, and operation speed of the device for manufacturing the torsion bars with helical anisotropy. The elastic torsion suspension is represented with a “braid” of three strands (one thread per each strand). It serves for creation of the torsion axis of the indicator magnet. The density of braiding is 10 knots/mm. The envelope curve of the cross-section of the elastic torsion suspension is represented with the ellipsis, with the bigger axis of 0.04 mm and the smaller axis of 0.03 mm; the total length of the suspension is 100 mm. The specific breaking load is 1.5N.

For the time being, they are used as a suspension of the magnetosensitive element (MSE) in a torsion magnetometer (TM), which is a part of the geophysical complex GI-MTS-1 (SPbF IZMIRAN). The main advantage of TM with this MSE is registration of magnetic fields and their variations in the frequency range of 0…15 Hz, with the meansquare noise level not exceeding $1 \, \mu T/\sqrt{Hz}$. However, the device has low stability for climatic factors (temperature, moisture), and this increases resistance to dynamical load.

Operation concept of the UISAT-1

Physical and kinematic configurations of the device are shown in Fig. 1.
The process of braiding is implemented as follows: the electric motor M through some intermediate transfer mechanism ($d_1$..$d_4$) revolves two disks 5 and 6, in which slots three strands (1..3) of future braid are passed through. By means of gear wheels $z_1$ and $z_2$ rotation of the disks in the mutually-opposite direction is realized. Synchronously with the rotation of the disks, reciprocating motion of arrow-like cam is implemented through the yoke mechanism drive ($z_1$, 7, 8) of cam 4. Thus, the arrow-like cam transfers braid strand from slots of one disk to free slots of another one. Feed gearing ($d_1$..$d_{10}$, IX, 12) provides a uniform lift of braiding block as strands are being interlaced by braiding mechanism. Constant braid strands (1..3) tension is provided by plummets (9..11).

The sketch of executing mechanism of the device, the diagram of working cycle and the structure of produced torsion bar are accordingly shown in Fig.2 [1].
Fig. 2. Actuating mechanism of the UISAT-1 (a), diagram of working cycle (b) and product (braid) (c).

1..3 – braid strands, 4 – arrow-like cam, 5,6 – disks, 7 – connection rod, 8 – yoke, \( z_1..z_3 \) – gear wheels

**Optimization of the device.**

The technical task being solved by the authors consists in development of the device for manufacturing the torsion suspensions, which would be simple and easily operable, providing the increase of the operation speed, without reducing requirements for technical characteristics.

The Fig. 3 shows a kinematic configuration of the device with additions. The collection mechanism is represented with a grip that fixes the threads ends, which can move vertically against the braiding mechanism. The collection mechanism is equipped with a guide rail that has a hole 13 pulling together the strands, the guide rail has two possible positions (by height). This guide rail enables to change the angle of braiding, but it is not sufficient to regulate the braiding density. On the axis of a screw driving the nut (on which the grip fixing the ends of threads is located), a variable-speed gear is installed, that makes it possible to change the speed of the grip movements against the braiding mechanism. The variable-speed gear is represented with a driving three-step pulley \( d_9 \) installed on the output spindle VII of the mechanical gear-box, and with a driven three-step pulley \( d_{10} \) installed on the axis of
the screw IX driving the nut.

Fig. 3. Kinematic configuration of the device.

1..3 – braid strands, 4 – arrow-like cam, 5, 6 – discs, 7 – con-rod, 8 – yoke, 9..11 – plummets, 12 – screw-nut, 13 – guide rail, I..IX – spindles, 
z₁.. z₃ – gear wheels, d₁..d₁₂ – pulleys

Plus to this, the mechanism of the product collection is equipped with the reverse device (direction-reversing switch) that switches the nut movements and is also used to return the collection mechanism into the initial (starting) position. The reverse is represented with a mechanical gear-box consisting of the pulleys d₁₁ and d₁₂. The reverse is turned on through the following procedure: the pulley d₈ installed on the output spindle VIII is turned off, and the reversive mechanical gear-box is turned on (the reverse pulley d₁₂ is connected to the output spindle VIII). The pair of pulleys of the variable-speed gear, that provides the maximal possible speed on the axis of the screw IX is used. In such a mode, the device is running idle, providing for the return of collection mechanism into the initial position.

The critical element of the device is the actuating mechanism that implements turning over of threads. This is why it was suggested to optimize the profile of the arrow-like cam which is the core element of braiding. A shape of the working surface
of the arrow-like cam was generated using the “geometrical” method of generation of cam mechanism profiles. The theory of machines and mechanisms, namely the field of analysis and development of cam mechanisms [2, 3], was a basis that enabled to solve a problem for the synthesis of a cam mechanism under following condition: the theoretical (central) profile is given, which in the system of the cam coordinates, describes the center of the cross-section of the thread working profile while it is moving along the constructional profile of the cam. The external working profile of the cam is understood as the constructional profile. The optimal path of the strands motion is given, it is represented with a closed line of 8-shape, the sizes depend on construction.

The Fig. 4 shows the actuating mechanism of the device UISAT-1 with the improved profile of the arrow-like cam.

Fig. 4. Actuating mechanism of the device UISAT-1 with the improved profile of the arrow-like cam.

1..3 – strands, 4 – arrow-like cam, 5,6 – discs, 7 – connecting rod connecting rod, 8 – yoke, 14 – optimal path of the strands motion, 
z1.. z3 – gear wheels

A method of generation of the optimal arrow-like cam profile is shown in the Fig.5
Fig. 5. Generation of the improved profile of the arrow-like cam

The suggested amendments of the design provide influence onto achievement of the expected result.

Introduction of changes into the shape of working surface of the core element of braiding, the arrow-like cam, enables to avoid problems relating to instability of the actuating mechanism operation, that implements turning over of the threads. These problems were caused by disarrangement in the braiding mechanism motions, and that provides the influence onto the braiding evenness.
Introduction of the variable-speed gear and the guiding rail with a hole pulling together the strands into the configuration of the device provides for a possibility of additional regulation of the braiding density. In its turn, this makes the device adjustments easier, and enables to increase the quality of the torsion suspension. The use of variable-speed gear also enables to raise the speed of operation in the process of braiding, and in the reverse mode.

Introduction of the variable-speed gear, reverse, and changes into characteristics of the mechanical gear-box makes it possible to ease the operation and maintenance of the device thanks to the semi-automated accelerated return of the collection mechanism into the initial (starting) position, and also to increase the overall speed of the device operation.

**Conclusion.**

This work has solved a problem on improvement of the device for manufacturing the torsion bars with helical anisotropy of UISAT-1 designed for production of torsion suspensions for sensing elements of the instruments. Description of UISAT-1 is provided, the optimal profile of the arrow-like cam, which is the core element of braiding, has been developed.

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**UDC 669.13.017:620.18**
Shipelnikov A.A., Rogotovsky A.N.

FEATURES OF MORPHOLOGY OF GRAPHITE IN STRUCTURE ALLOYED CONSTRUCTIONAL CHUGUNOV

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This work about results of researches by methods of scanning zondovy microscopy of morphology of inclusions of graphite in structure constructional alloys, influencing a complex of their properties

Keywords: spherical and lamellar graphite, form, constructional alloys, properties.

Introduction. The form, extent and graphite distribution in a metal matrix define practically all range of mechanical and physical and chemical properties constructional gray alloys in technological tests and stock material. For identification and forecasting of changes of properties alloys (first of all – superficial firmness of preparations) there is a row of «standard microstructures», including on identification of morphology of the lamellar graphite, used in practice in work of laboratories of foundry shops. However there is a set of questions to communication of parameters of morphology of graphite and mechanical properties cast iron (alloys) – hardness and tensile strength which are important acceptance characteristics of made steel products. In structure of high-strength cast iron existence of a quantity of graphite of the wrong spherical form, including, and vermikulyarny graphite is allowed. This situation is systematically observed in real technological process production of stock material from cast iron with spherical graphite (fig. 1).

Respectively even the insignificant deviation of a form of graphite from the correct spherical brings (should lead) to decrease in the relation of hardness, durability, heat resistance and other important properties in relation to unit of mass (volume) of structure. Therefore today in literature and practice of production there are various and at times inconsistent points of view on this perspective [1-3].
Fig. 1. Inclusions of graphite correct spherical and star-shaped form in «nirezist» cast iron structure

From our point of view, similar questions more can be removed only after detailed researches of features of formation of morphology of inclusions on more «the thin plan» the structure organizations, concerning possibilities of a modern optical metallography with practical permission at level of 0,1 microns, - conditionally designated by us as "nanostructure" (is more true – "sublevel" of the organization of structure) at the permission reached at present to 500x500 nanometers (Regional center of collective using equipment than LGTU).

Results of pilot studies and their discussion. To the analysis was exposed part of metal preparation shaped casting from «nirezist» type cast iron with a spherical form of graphite after deep etching of a surface in spirit solution of 4% of $HNO_3$. Also zones part of metal preparation shaped stock material from constructional gray СЧ03Ц01Б cast iron were investigated. The structure alloys at metalgraphic increase is presented on fig. 2.

Further results of research of "nanostructure" part of metal preparation with the nuclear and power techniques on a platform «Solver P47H» (fig. 3-5) are presented.
Fig. 2. Type of a microstructure cast iron, x650: at the left – "nirezist", on the center and on the right – СЧ03Ц01Б

Fig. 3. 3D-model rather "large" to 15 microns of inclusion of spherical graphite (after smoothing in PPK)
It should be noted that near large inclusions of spherical graphite a relief of an austenitny matrix "quieter" - without sharp hollows and peaks.

Fig. 4. 3D – relief model: at the left – graphite, on the right - a metal matrix of cast iron, after program smoothing of a signal of a probe

Thus change of a relief of a surface of a matrix in zones free from inclusions also slightly: the amplitude size on an axis Z concerning basis doesn't exceed 20 nanometers (fig. 5).
Fig. 5. 3D-model of a surface of an austenitny matrix "in the distance" from inclusions

The average relief in a cut on an axis Z in a sink (crater) – before a place of occupied of spherical graphite – is presented on fig. 6. The average relief of a surface of structure near inclusions of lamellar graphite is presented on fig. 7.

Fig. 6. Relie of internal space of a crater: at the left – "large", on the right – "small" of spherical graphite
Fig. 7. Relief of a surface of structure: at the left - with the maximum height ("peak") of inclusions of graphite more than 70 nanometers, on the right - with the minimum height ("hollow") of inclusions of graphite: less than 50 nanometers

According to results of measurement of hardness of structure in a zone with a lamellar perlite makes from 220 HB to 240 HB, in a zone with inclusions iron carbide – from 300 HB to 420 HB, in a zone with dot graphite – from 190 HB to 250 HB. Average hardness on part of metal preparation made 166 HB. Selective results of measurements and comparison of micro hardness and hardness of a surface part of metal preparation and average hardness from СЧ0ЗЦ01Б cast iron with vague structure are presented in table 1.
Comparison of micro hardness, superficial hardness on part of metal preparation and casting in the presence of inclusions by quantity of lamellar graphite 6-10

<table>
<thead>
<tr>
<th>Structural components and phases</th>
<th>Micro hardness</th>
<th>Hardness on part of metal preparation, HB</th>
<th>Average hardness, HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamellar perlite</td>
<td>353-370 HB</td>
<td>209-235</td>
<td>more than 180</td>
</tr>
<tr>
<td>Alloyed Cu a perlite</td>
<td>370-390 HB</td>
<td>229-248</td>
<td>more than 220</td>
</tr>
<tr>
<td>Iron carbide (the zone beat off)</td>
<td>980-1064 HV</td>
<td>more than 450</td>
<td>-</td>
</tr>
<tr>
<td>Trosto-martensit</td>
<td>443-469 HB</td>
<td>-</td>
<td>more than 250</td>
</tr>
</tbody>
</table>

In table 2 results of measurement of hardness, tensile strength and structure alloys in cast samples in diameter of 30 mm are presented.

<table>
<thead>
<tr>
<th>Graphite morphology</th>
<th>Hardness, HB</th>
<th>Tensile strength, MPa</th>
<th>Maintenance of a perlite, %</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>ПГф1, ПГф2; ПГд25-180; ПГр1, 4, 9, ПГ10</td>
<td>201</td>
<td>270</td>
<td>92-96</td>
<td>Insignificant inclusions fosfidny mechanical mix</td>
</tr>
<tr>
<td>ПГф1, ПГф2; ПГд25-180; ПГр4, 9, ПГ10</td>
<td>179</td>
<td>128</td>
<td>70-85</td>
<td>Insignificant inclusions fosfidny mechanical mix with a dendritny segregation</td>
</tr>
</tbody>
</table>
Conclusion. Thus, by the results specified above the following conclusions (demanding, certainly, careful check on wider analytical base) arise:

1. the form of rather large spherical graphite most answers the "sphericity" requirement: the deviation of the sizes of radiuses of craters in the perpendicular direction doesn't exceed 30-40%;

2. on surface unit the prepared sample "nanodefects" of an austenitny matrix in the form of sinks and "raznozernistost" near small spherical graphite much more, than near large (in 2-2,5 times); thus in both cases the relation of depth of "landing" of spherical graphite in a matrix to cross-section diameter of inclusions makes more than 1,2-1,3;

3. other things being equal structure formations not its hardness of a surface (on part of metal preparation) influences, both graphite morphology, and type, and dispersion of a metal basis. The first has more considerable influence among: dot graphite – large inclusions of lamellar graphite (to 180-360 microns) [1];

4. graphite makes a greater impact only in zones with a ferritny (granular) matrix;

5. in measurement zones with a lamellar perlite and rectilinear and zavikhrenny graphite the greatest influence renders dispersion of a perlite;

6. on the increased hardness at low tensile strength the greatest influence is rendered by a dendritny segregation at existence in mezhdendritny space fosfidny mechanical mix.

Literature:


Vdovin K.N., Feoktistov N.A.

Researching of hot cracks formation reasons on the casting «slag chalice» by modeling of potting and crystallization process

FSBEE HPE «Magnitogorsk State Technical University named after G. I. Nosov»

Slag chalice is the one among kinds of metallurgical shops substitute equipments destined for acceptance of liquid slag from smelting unit and transportation it to slag dumps.

In the CJSC «Mechanically-Maintenance Complex» slag chalices are casted for blast-furnace, oxygen-converter, arc-furnace shops of OJSC «Magnitogorsk Iron and Steel Works». In addition chalices are supplied to Nizhny Tagil Metallurgical Combine, Norilsk Combine and some other combines [1].

Cracks having crystallization character are forming on the surface of slag chalice during the casting solidification process. Due to carrying out of topographic researches zone of most often hot cracks defeat was found (fig. 1).

![Fig.1 Slag chalice: a – draft of casting, b - location of hot cracks.](image-url)
Hot cracks locate at an altitude of 715±10 mm (from end of chalice) to 1770±10 mm. Thus size of hot cracks defeat zone can achieve 1055 mm. This size of fracturing has been determined by the survey of 150 slag chalices [2].

Nowadays many researchers use dimensionless criterion of Niyama (Ny). By means of this criterion it can be possible to assess probability of appearance of porosity in a casting. It can be count by expression 1:

\[ Ny = \left| \frac{G}{\sqrt{T}} \right| \leq [Ny]_{kr} \]  

(1)

where \( T \) – speed of cooling;

\( G \) – gradient of temperatures into two-phase zone close to temperatures of solidus;

\([Ny]_{kr}\) – critical value of Niyama number (for most steels \([Ny]_{kr} \approx 1\)).

There are necessary conditions of shrinkage and gas- shrinkage porosity forming in all points of casting body, where the above inequality is right. For speed of cooling and gradient of temperatures computation are used numerical methods and systems of castings solidification modeling [3].

This criterion can be count with the help of program LVMFlow.CV4.2r2, which considers local thermal conditions, properties and conditions of alloy crystallization.

Analysis of metal consecutive solidification process was carried out due to modeling of casting chalice solidification (fig. 2). It was revealed that greatest accumulation of pores took place on region which was found by us owing to topographic researches. It is known that shrinkage porosity is one of the reasons of hot cracks formation. These cracks are called intercrystalline. For the purpose of prevention cracks bound with availability of pores it is necessary to regulate temperature and speed of pouring and also casting supply conditions in order to improve the filling of shrinkage vacancies [4].
Fig. 2 Section of solidified casting «slag chalice» with location of porosity on it

Also color scheme of temperature distribution inside the casting in initial period was got during of modeling process (fig. 3).

Fig. 3 Color scheme of temperature distribution in initial period of slag chalice's solidification
It is obvious that there are three conditional zones of sharp transition from one temperature to another. First zone is near casting income (the hottest zone). Temperature of metal in this zone is about 1506°C. Lower there is zone with the temperature 1391°C. Gradient of temperatures in this zone is 115°C. It must be point that first zone of transfer from temperature 1506°C to temperature 1391°C according scheme of figure 3 doesn't have sharp hollows, line of transition is straight. It means that smooth temperature transition is accomplished inside horizontal section in real conditions. There are almost no cracks in this part of casting, because there is head in the region of chalice. It is enough of head's metal to supply near parts of casting.

Next conditional zone (second) – zone of transition from temperature 1391°C to temperature 1276°C. Gradient of temperatures in this zone is 115°C too. But in this case line of transition from one temperature to another isn't smooth, it has sharply wavy character. This character of temperature distribution on line of transition is conditioned by complex action of following factors:

1) by availability of distance between feeders (fig. 4).
2) by availability of supports for collar of slag cars.

Distance between feeders is designed evenly along diameter of chalice and is equal 890 mm. Hottest zone appears in this region, where feeder is situated.

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Fig. 4 Gating system (view from above)
Consequently, layers of metal located above feeder have higher temperature on the distance equaled the half of chalice's height owing to action of forced convection (during effluence of metal from feeder under operation of hydrostatic pressure of metal in riser).

In the region, where feeders are absent, layers of metal are heated by neighboring layers, which located above feeders. Therefore metal are heated about temperature 1276°C just on one third of chalice's height in this region. Besides, there are supports for slag car's collar in design of chalice (fig. 1). The supports are thermal knots for the casting and influence on temperature distribution in second zone of slag chalice.

In third zone there are gradient of temperatures in a size of 115°C too. Character of conditional line of transition from temperature 1276°C to temperature 1161°C is wavy as well. It is determined by same factors as in the previous case.

Due to analysis of shown temperature zones of slag chalice we can make a conclusion that middle part of the casting is most probable region of crack formation (fig. 2). There are formations of shrinkage porosity and wavy character of temperature distribution in conditional line of transition from one temperature to another in this part (fig. 3). This character of temperature distribution leads to beginning of stretching tensions. It is clean that these two factors (porosity and strains) lead to formation of cracks.

Formation of cracks doesn't realize in the third conditional zone of casting in spite of the same gradient of temperatures as in the second zone. Absent of cracks in this part of casting is conditioned by availability of supports for slag car's collar. Supports solidify quicker than wall of chalice and are ribs of inflexibility for this zone of casting. These ribs prevent the action of stretching tensions, which form due to shrinkage of alloy. Besides shrinkage porosity doesn't form in this region.

As a measure for removal of conditional line of temperature gradient can be offer change some parameters of existing gating system, which is used for pouring of slag chalices in operating shop.
Diameter of feeder in existing gating system is 4 sm. Consequently transverse section square of feeder is \( F_{\text{feeder}} = 12.56 \, \text{sm}^2 \). There are 5 feeders on one Then total square of transverse sections are \( \Sigma F_{\text{feeders}} = 62.8 \, \text{sm}^2 \).

Diameter of gate in this gating system is 9 sm. Square of transverse section accordingly is \( F_{\text{feeder}} = 63.59 \, \text{sm}^2 \). \( \Sigma F_{\text{feeder}} < F_{\text{gate}} \), therefore gating system is closed. Total square proportion of feeders to square of gate is \( \Sigma F_{\text{feeders}} : F_{\text{gate}} = 1.01 : 1.0 \) [1].

Feeder is limited link of consumption of liquid metal if narrowing gating system is used for filling of mould. In this case flow of steel from feeder accomplishes with great speed and that can lead to formation of «fountain» of metal. Result of this is uneven temperature distribution through chalice's height (fig. 3).

We offer to segue from narrowing type of gating system to widening. For this purpose we change sizes of feeder and make them elliptical with broadening to the top (fig. 5).

Square of transverse section of feeders in changed gating system is \( F_{\text{feeders}} = 32 \, \text{sm}^2 \). Total square of feeders accordingly is \( \Sigma F_{\text{mrr}} = 160 \, \text{sm}^2 \). Proportion square of gate to total square of feeders is \( F_{\text{gate}} : \Sigma F_{\text{feeders}} = 1 : 2.5 \).

![Fig. 5 Feeders of changed gating system](image)

Gating system with changed feeders is presented on the figure 6.

Modeling in licence programm LVMFlow_CV4.2r2. of pouring, crystalization and colling processes was carried out for the purpose of confirmation of theoretical assumptions about influence of system parameters on temperature distribution in casting slag chalice. Temperature distribution in the processes of casting crystalization and colling were consired in the same stretch of time as in first case (fig. 3).
Received color scheme of temperature distribution in slag chalice is demonstrated on the figure 7.

![Fig. 6 Gating system with changed feeders](image)

**Fig. 6 Gating system with changed feeders**

![Fig. 7. Color scheme of temperature distribution in initial period of slag chalice’s solidification, which was poured through changed gating system](image)

**Fig. 7. Color scheme of temperature distribution in initial period of slag chalice’s solidification, which was poured through changed gating system**

From shown figure we can see that along chalice's all height temperature gradient is absent due to smoother filling of mould by alloy through widening gating system.
Temperature difference is observed in the third conditional region of the casting (close feeders) and near head. But probability of crack formation in these regions, as noted earlier, isn't significant.

Summing results of full research we can make following conclusions:
• interaction of two technological factors – tension and porosity in casting's body comes before hot cracks' formation in casting «slag chalice»;
• magnitude of nascent tensions depends on the temperature distribution in casting;
• parameters of gating system used for filling of mould make great influence on temperature distribution in casting.

List of literature

CID: J31207-515

Radchenko K.M.

Modern state of metallurgical industry of Ukraine
KNU named by Taras Shevchenko

The modern state of metallurgical industry of Ukraine is analyzed in the article. The location and value of industry are determined in the economy of country. Its problems are considered in the context of post-crisis renewal of home economy.
Metallurgy, steelmaking, products from metal, competitiveness.

General improvement of the economy of Ukraine, that is observed today, certifies that a country went out on the stage of post-crisis renewal. Important direction of public policy on this stage is providing of firmness of positive economic results and creation of pre-conditions for the further economy growing, first of all for the industrial and productive sectors of economy of Ukraine.

A metallurgical complex it the most meaningful sector of the Ukrainian economy. It is the large socio-economic system, that provides the development of others base industries of home economy - mechanical engineering, shipbuilding, motor-car industry and others like that. In addition, large metallurgical complexes plays an important role in the development of regional economies and functioning of theirs social infrastructure, especially in such industrial regions, as Donetsk, Dnepropetrovsk and Zaporizhzhya regions.

Analysis of the state of national economy and his separate industries, in particular metallurgy are carried out in labours of home and foreign scientists: A.K. Golubchenko, S.G. Gryshchenko, D.O. Derkach, A.A. Ivanov, S.F. Ermilov, V.L. Mazur, O.O. Smirnov, V.M. Polishchuk et al. But the questions of the modern state and progress trends need further research taking into account the dynamic of development of economy on the whole and metallurgical complex in particular.

A research aim is a study of the modern state of metallurgical industry of Ukraine and realization of analysis of some ways of overcoming of the crisis state.

A metallurgical complex is base industry of economy of Ukraine, as provides over 25 % of industrial production and 34 % of general export of commodities.

The basic types of products of metallurgical industry is cast-iron, steel, rent of black metals, pipes of steel. From them to the hi-tech products of metallurgical production belongs stainless steel products, alloy steel products, special steel products.

A world economical crisis 2008-2009 brought in substantial changes in loading of production capacities of metallurgical complex and positioning of home producers of metallurgical products in the world market. Thus, a steelmaking in Ukraine grew
short in 2008 on 13,3 % (in comparing to the previous year), in 2009 - on 19,4 %, in 2010 - there was an increase on 12,4 %. In other countries, that are the basic producers of steel, falling of production during a crisis was less, and in China and India, without regard to a crisis, an increase took place. On results work of metallurgical enterprises, Ukraine in 2011 grew a steelmaking on 5,7 % comparing to 2010, taking the eighth place at rating of 64 countries - basic world producers of this products, according to the World association of producers of steel(WSA) [1].

The first ten of countries-producers of steel on results 2010-2011 is driven to the table 1.

Table 1.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>683,265</td>
<td>624,771</td>
<td>an increase is on 9%</td>
</tr>
<tr>
<td>2</td>
<td>Japan</td>
<td>107,595</td>
<td>109,747</td>
<td>falling is on 2%</td>
</tr>
<tr>
<td>3</td>
<td>THE USA</td>
<td>86,247</td>
<td>80,210</td>
<td>an increase is on 7%</td>
</tr>
<tr>
<td>4</td>
<td>India</td>
<td>72,000</td>
<td>67,68</td>
<td>an increase is on 6%</td>
</tr>
<tr>
<td>5</td>
<td>Russia</td>
<td>68,743</td>
<td>66,681</td>
<td>an increase is on 3%</td>
</tr>
<tr>
<td>6</td>
<td>South Korea</td>
<td>68,471</td>
<td>57,516</td>
<td>an increase is on 16%</td>
</tr>
<tr>
<td>7</td>
<td>Germany</td>
<td>44,288</td>
<td>43,845</td>
<td>an increase is on 1%</td>
</tr>
<tr>
<td>8</td>
<td>Ukraine</td>
<td>35,332</td>
<td>33,318</td>
<td>an increase is on 5,7%</td>
</tr>
<tr>
<td>9</td>
<td>Brazil</td>
<td>35,162</td>
<td>32,859</td>
<td>an increase is on 7%</td>
</tr>
<tr>
<td>10</td>
<td>Turkey</td>
<td>34,103</td>
<td>28,305</td>
<td>an increase is on 17%</td>
</tr>
</tbody>
</table>

Today the stake of Ukraine in a world steelmaking presents 2,4%.

Considerable production volumes and metallurgical industry distribution volumes determine meaningfulness of this type of activity for the economy of Ukraine (pict.2.).
A metallurgical complex became the first industry of the Ukrainian economy, that assumed the blow of crisis in 2008. Falling of foreign markets resulted in a volume, that a decline in a production on metallurgical enterprises of country presented in 2009 up to 50% and more. The reason of such deep slump is explained by that industry always was oriented to the export, supplying outside a country to the 80% of its products. For the last two years metallurgy began to recommence, but pre-crisis indexes, as well as before, remain an unattainable dream. If in 2007 the 43,7 million tons of steel were smelted in Ukraine, then in 2011 - only 35,3 million tons, id est, falling presents over 8 million tons. Thus the increase of production in 2011(on 5,6 % or on 1,9 million tons as compared to 2010) was provided exceptionally due to the increase of consumption at the internal market, in particular, due to building projects under Euro-2012. The metallurgical enterprises of Ukraine shortened the branded and size assortment row of products considerably, decreased the production of hi-tech goods and increased the production of semi-manufactured goods (table.2).
Table 2.

A production of metallurgical industry in Ukraine in the period of 2005-2011, millions of tons

<table>
<thead>
<tr>
<th>Products</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Black metals:</td>
<td></td>
</tr>
<tr>
<td>- cast-iron</td>
<td>30,7</td>
</tr>
<tr>
<td>- steel with semi-manufactured products</td>
<td>27,9</td>
</tr>
<tr>
<td>Wares from black metals:</td>
<td></td>
</tr>
<tr>
<td>- rent</td>
<td>22,7</td>
</tr>
<tr>
<td>- steel pipes</td>
<td>2,39</td>
</tr>
</tbody>
</table>

In a metallurgical production and production of metallic finish goods on results 2011p. the increase of products of 8,5% is got, including on enterprises from producing of cast-iron, steel and ferro-alloys - 6,9%, pipes - 21,5%, other types of roughing-out of steel - 4,6%, finished goods - 15,1%.

In the world market Ukraine is presented by such metallurgical combines and plants as: JSC "Mittal Steel Kryvyi Rig", JSC "MMK named by Illich", JSC "MK Azovstal" (Metinvest Holding), JSC "Zaporizhzhya metallurgical Combine "Zaporizhstal", JSC "Alchevsc metallurgical combine" (Industrial Union of Donbas), JSC "Dnipro metallurgical combine named by Dzerzhinskiy" (Industrial Union of Donbas), JSC "Yenakiievo metallurgical plant" and "Metalen" (Metinvest Holding), JSC "Makijivka metallurgical combine", JSC "Dnepropetrovsk metallurgical combine named by Petrovskiy", JSC of "Doneckstal metallurgical plant".
Production, but as consequence and consumption of metallurgical industry production in particular the steel, at the internal market of Ukraine depends on production of industries-consumers volumes. The basic consumers of the production of metallurgical industry are base industries of industry: mechanical engineering, motor industry, building, carriage building and pipe industry.

The internal consumption of metallurgical products limits (table.3) enough in Ukraine, besides there is a tendency of his reduction in a period from 2008 to 2010 in relation to 2007 accordingly on 8,4; 3,9 and 8,4 %. Increase of part of internal consumption in the structure of the realized products in 2009 (from 21,2 oh 25,7%) is explained by reduction of volumes to the export of metallurgical goods considerable in this year (on 32 % comparing to the previous year), [2].

Pict.3. Production volumes of steel of the leading Ukrainian enterprises in 2010-2011, t/ton.
Table 3.

**General volumes of realization and internal consumption of national metallurgical goods**

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volumes of realization of national metallurgical goods, mlrd/hrn</td>
<td>94,7</td>
<td>109,5</td>
<td>141,0</td>
<td>177,1</td>
<td>127,9</td>
<td>167,3</td>
</tr>
<tr>
<td>Including export of national metallurgical goods, mlrd/hrn</td>
<td>68,3</td>
<td>77,8</td>
<td>99,3</td>
<td>139,5</td>
<td>95,0</td>
<td>131,9</td>
</tr>
<tr>
<td>Internal consumption of national metallurgical goods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mlrd/hrn</td>
<td>26,4</td>
<td>31,7</td>
<td>41,7</td>
<td>37,6</td>
<td>32,9</td>
<td>35,4</td>
</tr>
<tr>
<td>volumes of realization %</td>
<td>27,8</td>
<td>28,8</td>
<td>29,6</td>
<td>21,2</td>
<td>25,7</td>
<td>21,2</td>
</tr>
<tr>
<td>Import of metallurgical goods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mlrd/hrn</td>
<td>8,6</td>
<td>11,2</td>
<td>16,5</td>
<td>24,9</td>
<td>13,5</td>
<td>22,2</td>
</tr>
<tr>
<td>Import in general volumes internal consumption</td>
<td>24,6</td>
<td>26,1</td>
<td>28,3</td>
<td>39,8</td>
<td>29,1</td>
<td>38,5</td>
</tr>
</tbody>
</table>

**For reference**

General volumes of realization and internal consumption (national products + import), mlrd/hrn | 35,0 | 42,9 | 58,2 | 62,5 | 46,4 | 57,6 |

The import of metallurgical products in 2010 in comparing to 2009 increased on 64,4 % that entailed the increase of part of import in the pattern of internal consumption of metallurgical goods (in 2010 there is a 38,5 % of import in the general volume of consumption of metallurgical goods).

Part of import of metallurgical goods in 2011 presented 5,2$ mln [3].

For in Ukraine a steelmaking presents 35,3 mln/t the results of 2011. From them on an internal consumption there is 9,4 mln/t against 7 mln/t in 2010, while in to a pre-crisis period the Ukrainian market consumed 10 mln/t.

In 2011 Ukraine exported 25,8 mln/t of steel (by a year before is 25 million tons), or close to the 80% of the production volume, here 10,8 million tons, or an about 40 % export presented semi-manufactured goods. A record was attained in 2006 is 30 million tons. The stake of export of metallurgical goods in 2011 presents 20,7$ million.
For today the integral system of support of export is absent in Ukraine, insufficient is securing of interests of exporters for foreign markets, undeveloped mechanism of the export crediting, substantial problems are kept with the compensation of VAT.

The conducted analysis testifies to the presence of the problems accumulated in metallurgical industry of Ukraine. For reformation of home metallurgical industry it is necessary to create terms for the effective use of scientific potential and increase of role of the state in realization of investment-innovative model of development of industry. Priorities of reforms must be reductions to power-hungryness of production, increase of demand at the internal market on the home products of metallurgical industry, stimulation of export, providing of competitiveness of metallurgical products.

Literature:

1. World Steel in Figures, World Steel Association, 2011.
3. Derzhovnishinform // the Commodity monitor, № 5. - in 2011
USE OF SOLAR POWER FOR POWER SUPPLY OF ECONOMIC OBJECTS OF MARINE AQUACULTURE

Federal state budgetary establishment of a science Institute of marine technology problems FEB RAS

In work ecologically pure technologies of independent power supply of an industrial target (factory) of marine aquaculture in an all-the-year-round mode with use modular of solar power systems are considered.

Keywords: the accumulator, industrial pool, mariculture, of solar power, object, water-preparation, water area, temperature, energy.

On the basis of long-term data of the analysis of climate information and of solar technical modellings calculations the expediency of use of ecologically pure renewed energy sources in maintenance with heat and an electricity hydraulic engineering systems of economic objects of marine aquaculture located in coastal and in island territories of a southern part of Primorsky region of Peter the Great bay sea of Japan [1,2] is revealed.

The innovative project the technological scheme of shop (factory) cultivation the invertebrates of marine aquaculture which includes modular systems warmly and the electro maintenance, using a solar energy is developed. The shop (object) with hydraulic engineering systems of incubation and cultivation of sea (pools) represents an one-storey of building in the size 12х24м on external perimeter (to a total area 290 м2), height of a wall of 6 m without taking into account a roof. Protecting designs (walls and a roof) are executed from a sandwich-panels by thickness of 0,125 m, a floor not warmed, in the form of a concrete coupler on a ground, thickness 0,1м. In a building of shop are located: reserve capacity for the sea water, connected by the pipeline with pools of various volume (for cultivation a sea invertebrates) and a transformer of heating (cooling) of water, modular systems of filtration clearing of a
circulating water stream for each pool, system of heating of shop, auxiliary mechanisms, monitoring systems of water in pools and all modular subsystems of water-preparation, the block of the central management. Total amount of used technological sea water in system 70 м3 (daily replacement of water of all system 10 м3).

Outside of a building of shop devices of a fence and dump of water with mechanical and disinfecting filters, of solar plant with solar vacuum collectors and the soil accumulator, system of accumulation of heat with use of superficial waters of adjoining water area, reserve an and the electro-generator, photo-electric installation for development of the electric power demanded on illumination, work of executive mechanisms, devices of the control and automatics (fig.1) are located.

Modular systems the heat in a transformer due to a system of solar energy, selection of heat or a cold from adjoining sea water area and system of heating are filled by a nonfreezing liquid.

The of earth accumulator is executed in the form of chinks field. Number of vertical chinks for accumulation of heat and a cold equally 5, the size 0,1x60м. In each chink on 2U-figurative heat exchanger, thus joint and separate work heat exchanger of warmth exchange in one chink (heating, cooling) is possible.

The solar power plant can work in a direct mode of heating circulating sea water in pools (contour C) (fig.1.) The temperature of water in pools is adjusted mixing thermal controller after warmed water in a separate contour (contour A) and submission of flowing water from water areas (contour E). The fence of sea water from water area in reserve capacity and pools and its dump from hydraulic engineering system of shop functions continuously. Maintenance of necessary ecological and technological parameters of the sea water used in pools for biotechnologies culture and in reserve capacity, is carried out by means of systems of filtration clearing (contour K, E). At a fence of sea water and dump systems of a mechanical filtration and disinfecting are used.

The system provide warmth waters for pools and heating (cooling) of air of a premise of shop (object) is automated and works in the closed circulating mode.
For an estimation of capacity of a thermal source by the standard technique [3], object necessary for a heat supply, total thermal losses which develop of thermal losses through protecting designs, expenses of thermal energy for heating of ventilating air in shop and on heating of water in pools were defined.

Air exchange in is accepted $0.5 \text{ m}^3 / (\text{m}^2 \cdot \text{hour})$ In an offered variant settlement capacity of thermal losses of object was estimated at a minus 24°C (at average temperature of the coldest five-day week security 0.92 [3]), in view of heating of sea water in pools, has made 14.5 kw. As windows are closed by filters, at calculation it is accepted, that receipts of direct solar radiation and heat in a building through window apertures are not present.

Thermal expenses for heating of water in the pools located in a building of shop culture a aquatic animals, in view of all-the-year-round climatic conditions of area of an arrangement of object and a thermal mode of sea water on depth of 10 m (a fence of sea water) for concrete area of water area of Peter the Great bay, in particular, area of a gulf the East have been calculated.

In figure 2 settlement data теплопотребления object and work of solar thermal installation of seasonal accumulation with the area on an adsorber 84m2 (contour) are presented. In the given calculation security by heat of object in view of heating sea water in pools due to гелиосистемы is accepted 70 % at sufficient solar light and losses in the seasonal soil accumulator. Missing heat for heating air of a premise of shop is selected during the warm periods of an annual season from adjoining water area by means of system of contour $Д$ for accumulation in the earth-accumulator. During the cold seasonal periods of year at lack of heat it is used electro-heater (2) figure 1.
Рис.1. A function chart-technological of independent power supply of object (shop) of marine culture: 1 - recuperator of heating (cooling) of sea water; 2- reserve electro-heater water heater; 3- pump circulating; 4 -adjusting ; 5- U figurative chinks; A- a contour circulating, thermoregulation flowing water in pools and reserve capacity; B-a contour thermoregulation safety an overheat-cooling of a contour And; C-a contour thermoregulation a mode of direct solar heating and night cooling; Д-a contour of selection of heat-cold from superficial waters of sea water area; Е-a contour of a mode of circulation of water in pools with; К-a contour of ecological correction of water parameters in pools.

The system of selection of heat from sea water areas (contour) works during the periods of warming up of superficial layers of water (0-5 meters) above 12°C. The analysis of long-term supervision of a temperature mode of waters in the East bay resulted in work [4], have shown an opportunity of selection of thermal energy during from May till November at mean quantity for last years temperatures of superficial waters 10-21°C and the maximal values of this parameter 25-27°C.
Fig. 2. Quantity of thermal losses of object (a), a share of a solar energy in a heat supply of object (б) and expenses of heat for heating of sea water in pools (в).

Offered technologies of independent power supply of shop (object) of marine culture allow:

- to use ecologically pure power resources of renewed energy sources (sun) for independent power supply of marine aquaculture;
- to accelerate process of cultivation гидробионтов (valuable foodstuff of the sea) due to the control and regulations in ecological parameters of all technological process in an all-the-year-round cycle in not dependences on temperature climatic conditions;
- to exclude the current financial expenses spent for traditional power resources.

The literature:


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RESEARCH OF MACROSCOPIC REGULARITIES OF HEAT AND MASS TRANSFER AT THE IGNITION OF A LIQUID CONDENSED SUBSTANCE BY AN IMMERSED SOURCE WITH A LIMITED ENERGY CAPACITY

O.V. Vysokomornaja, G.V. Kuznetsov, P.A. Strizhak
National Research Tomsk Polytechnic University

We carried out a numerical and experimental investigation of heat and mass transfer at the ignition of a liquid condensed substance by a typical immersed source with a limited energy capacity, being a small, intensely heated metallic particle. We established such terminal conditions for the immersion of a source with limited enthalpy that prevent inflammation of the condensed substance.

Keywords: heat and mass transfer, liquid condensed substance, metallic particle, immersion, submersion, ignition.

The processes of ignition caused in condensed substances (CS) by various sources of heat are interesting, first of all, due to a high risk of fire and explosion [1] and due to special technical applications [2]. Recent years have seen a fairly comprehensive analysis of macroscopic regularities of ignition processes in solid [3] and liquid [4] CS at local heating induced by typical sources with a limited energy capacity (in particular, by intensely heated metallic and non-metallic particles of different physical nature). It is interesting to analyze the conditions of igniting a typical liquid CS by an immersed (submerged) source of heat with limited enthalpy.
The processes of heat and mass transfer in the system “liquid CS – small heat source – oxidant” are studied on a basis of the model outlined on Fig. 1.

As a local heat source with limited enthalpy, we examine an intensely heated metallic (steel) particle of small dimensions. Numerical research is made using the example of a typical liquid combustible with well-known thermophysical and thermochemical characteristics: kerosene.

**Fig. 1. A scheme of the solution domain for the ignition problem at \( \tau=0 \) (a) and \( 0<\tau<\tau_d \) (b): 1 – oxidant (air), 2 – particle, 3 – liquid CS, 4 – vapor gap, 5 – vapor-gas mixture**

It is assumed that a hot particle is slowly (at 0.5 m/sec) deposited on the surface of a liquid CS (Fig. 1, a) and immersed into it (Fig. 1, b). It is taken into account that the liquid warms up as energy is supplied from a local heat source. As a consequence, there emerges a vapor gap between the immersed source and the liquid. The vapor is injected into the oxidant and, due to diffusion and convection, becomes mixed with it. There arises a vapor-gas mixture, including, as its initial components, the oxidant, as well as the vapors of water and combustible, involved in a chemical reaction. As one reaches the terminal conditions for the concentration of combustible and for the temperature of vapor-gas mixture, the process of oxidation accelerates and becomes irreversible, thereby causing ignition.

Numerical modeling is made under the following assumptions, which do not impose any essential restrictions on the generality of the problem statement:
1. As a result of evaporation of the liquid, there emerges one substance with known characteristics. We have assumed a realization of one “effective” reaction, involving only one combustible.

2. No allowance is made for a possible burn-out of the liquid.

3. No allowance is made for convective flows emerging in the liquid due to the warming of its near-surface layer.

In our numerical modeling, we have used two criteria of ignition, reflecting in the most complete manner the macroscopic regularities of the processes of heat and mass transfer in the system under consideration (Fig. 1):

1. The heat emerging due to the chemical reaction of oxidation of combustible vapors in the air is greater than the heat transferred from the heat source to the liquid CS and vapor-gas mixture.

2. The temperature of the mixture of the CS vapors and the oxidant is higher than the initial temperature of the heat source.

The numerical modeling of ignition of the liquid CS in the system under consideration (Fig. 1) at $0<\tau<\tau_d$ reduces to the solution of a set of non-linear non-stationary differential equations with partial derivatives, presented in accordance with [4]. The initial conditions (Fig. 1, a) and the boundary conditions (Fig. 1, b) also presented in accordance with [4].

In order to make a passage to dimensionless variables, we use the following scale quantities: $z_L$ is the characteristic size of the solution domain ($z_L=0.02$ m); $V_m$ is the scale of convection velocity of the combustible vapors near the surface of the liquid, m/s; $t_m$ is the time scale ($t_m=1$ s); $T_m$ is the temperature scale ($T_m=1000$ K).

The set of equations is solved by the method of finite differences [5]. At the same time, we solve difference analogues of the differential equations by the locally one-dimensional method and the method of alternating directions [5]. In order to solve one-dimensional difference equations, we use the sweep method with an implicit four-point scheme [5]. Non-linear equations are solved by the iteration method [6].
The reliability of the obtained results has been verified by the test of conservatism of the utilized difference schemes, whose algorithm is given by [4], as well as by comparison with the experimental data, carried out by the method [7].

Our research of the processes of heat and mass transfer in the conditions of physicochemical transmutations has been carried out for the following values of parameters [8-11]: the initial temperature of the liquid CS and oxidant being $\Theta_0=0.3$, that of the metallic particle being $\Theta_p=0.8\pm2$; the thermal effect of oxidation of the combustible vapors in the air being $Q_o=42$ MJ/kg; the thermal effect of evaporation of the liquid being $Q_e=25$ kJ/kg; the activation energy and pre-exponent of the oxidation reaction being $E=193$ kJ/mol, $k_0=9\cdot10^8$ s$^{-1}$; the melting temperature of the particle's material being $\Theta_c=1.4$; the thermal effect of crystallization being $Q_c=205$ kJ/kg; the blackness degree of a steel particle being $\varepsilon=0.6$; the particle size being $Z_p=0.15$, $R_p=0.05\pm0.3$; the thickness of the layer of liquid CS being $Z_{liq}=0.5$; the sizes of the solution domain being $R_L=0.5$, $Z_L=1$. Thermophysical characteristics of the interacting substances are given by [10–11].

As a result of numerical and experimental (using the method [7]) research, it has been established that, in the system “liquid CS – local source with a limited energy capacity – oxidant”, depending on the enthalpy of the source, it is possible to realize several regimes of ignition that differ by the location of the zone of leading oxidation, as well as by the ranges of variation of the basic integral characteristic, being the ignition time delay $\tau_d$. It has been revealed that the zone of leading oxidation can be located in the gas region above the source with limited enthalpy, being a submerging particle near the lateral facet of the heat source partially immersed into the CS, in the vapor gap between the particle and liquid near the lateral facet of the source. It has been established that under no circumstances does ignition occur in the vapor gap below the particle (Fig. 1). The discovered regularity is accounted for by the deficit of oxidant in this region, as well as by a substantial absorption of energy during the evaporation of the liquid combustible CS and by a considerable cooling down of the source with a limited energy capacity near the separation border “particle – liquid”.
It has been established that, as the temperature of the particle $\Theta_p$ increases, the size of the vapor gap between its facets and the liquid also increases due to a large supply of energy, and therefore, due to a more intense evaporation of the combustible. As $\Theta_p$ increases, the depth of immersion of the particle into the combustible also increases. Under these conditions, the most part of the source energy is expended for the warming and evaporation of the liquid, and the probability of inflammation also decreases. For instance, it has been established that in the case of $\Theta_p<0.9$, with the remaining conditions of the process being adequate, hot particles of metal become entirely submerged in a liquid CS without reaching the inflammation conditions (Fig. 2).

![Figure 2: Isotherms ($\Theta$) of the system “liquid CS – metallic particle – air” at the complete submersion of the source ($\tau=3$, $\Theta_p=0.85$, $R_p=0.15$, $Z_p=0.15$).](image)

We have shown both experimentally and numerically that inflammation of a liquid CS is impossible in the case of a complete submersion into it of a typical source with a limited energy capacity, being an intensely heated metallic particle.

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Antsiferova I. V., Esaulova I. A., Zenkov A. I.
ecological risks control and management in production of the nano-powders and their oxides.

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In the article the methods of the analysis and measurement, to carry out an optimum control over particles behavior, are considered. It will allow to define standards for labor safety and quality control of end-products. The actions to allow operating risks of use of nano-powders and their oxides were proposed.

Keywords: nano-powders, risks, personnel, working zone air, ecological aspects, identification, pure premises.

The greatest success in nano-technology development was reached in production of nano-sized powders (nano-powders), it attracts more and more attention as a perspective object to use them in industry.

Since the nano-particles possess absolutely specific physical-chemical and biological properties compared to conventional materials, there is a need for a stringent control over nano-particles production technology.

The aim of this work was to develop a risk control program, which is considered as an integral part of the global program of labor safety on workplace, where nano-materials or products containing nano-particles, are produced or used. A critical element of the program is a possibility to foresee emerging risks and to find their relation to changes in production process, use of a new equipment or material. This evaluation should be a continuous cyclical process, which provides detection of the sources with potential exposure and determination of possible solutions of the problems emerged [1].

Chemical and dispersive compositions of nano-powders, their concentration in working zone air and in the outlet, were determined. The chemical composition was determined by XRD-phase analysis. The concentration of nano-particles was determined using a criterion «dust concentration», based on analytical control of the suspended materials concentration on the housing place of the technological line.
equipment. Relating to the nano-dispersive substances, the release is defined by a number of particles in purifiers.

The forecasting of potential hazard of nano-powders was carried out using a prognostic-analytical procedure of potentially adverse biological effects, based on the existing data analysis including physical, physical-chemical, molecular-biological, cytological, toxicological and ecological properties of nano-particles.

In sanitary (or hygiene) investigations the quantitative functions of harmful factors impact on human organism were studied depending on their level and regimes of influence. Interactions “doze-effect” are investigated on the basis of observation of a certain group of people according to the medical statistics or to the results of the investigations specially carried out.[2]

In order to control particle safe impact a technology of clean premises can be used.

An operating premise is proposed to be created, which operates in accordance with the specified requirements and a certain number of employees, which work on a strictly regimented documentation, with the Good Manufacturing Practices of EU, as well as with a group of Russian requirements postulated in a group of State Standards Р ISO 14644. The class of clean premises is defined by a MAC of particles of a certain size according to the formula

\[ C_n = 10^9 \times \left( \frac{0.1}{D} \right)^{2.08} \]

according to the formula (equation 1)

- \( C_n \) – MAC (particles/m\(^3\)),
- \( N \) – classification number,
- \( D \) – low limit value of particle size, mcm.

Indoor air exchange can be significantly reduced, if harmful substances are caught in the places of their exhaust. For this purpose the technological equipment, which is the source of harmful substances emission, is supplied with special devices, from which the polluted air is drawn off.[3]
In order to manage risks, which recently affect the health of employees, a safe occupational behavior is used, which is of great importance. Some studies have been conducted in this area, in which certain aspects of psychological contact, concerning health and safety, were defined. These studies suggest alternative solutions and explanation of certain risks and safety. Participants showed, that the employer should provide them with training on working risks. The working hazards are often associated with the stress. The employer is suggested to take care of health and safety. We also suggest the following employer obligations: training on working risks, participation in development of rules and procedures in the field of health and safety, a clean tidy workplace, taking into account a fulfillment of requirements to health and safety during the carrier progression, reporting of accidents, audit of safety system, estimation of safety risks [4].

Thus, risk management is a step-wise procedure based on a logical sequence, which allows to continuously increase efficiency of decision-making, simultaneously, continuously making work quality to be better. The companies, which effectively manage their risks, are more likely to achieve their goals, at a lower cost, though.

Therapeutic and preventive measures, aimed at preserve the health of employees, have been also developed.

The use of anti-oxidative drugs in a specific ratio (official drug) leads to the significant normalization and stability throughout the hemostatic system as a whole. The use of an antioxidant combination (vitamins C, E, and A), against this background, leads to the significant changes in the system of such regulators. The patients with hypertonia and vegetative-endocrinal dystonia also completed a protracted treatment by an alternating magnetic field (AMF).

AMF was found to cause a pronounced positive dynamics of subjective symptoms.[5]

The same tendencies were also found in relation to a very important indicator of peripheral artery tone – SPR (specific peripheral resistance). In the group of patients exposed to AMF there has been found a reducing trend of this indicator (before treatment – 46,0±3,9; after treatment – 41,0±2,5 at р 0,1). But in the control group
with «» this tendency was not observed (before «exposure» SPR was 43.1±3.9, after «exposure» – 41.6±3.9 p 0,5).

The local effects of AMF on BAP zones (biologically active point) are thus an effective treatment method of patients with hypertonia and hypertonic form of vegetative-endocrinal dystonia. In the mechanism of AMF hypotensive action a some decrease of cardiac stroke output and peripheral resistance is of importance.

Risk management and safety control in powder production of metals and their oxides is therefore possible. The economic effect is expected to be in the reduction of morbidity rate of the employees, occupied in production of nano-powders and products, as well as in the reduction of work incapacity, and this is a direct way to improve productivity and decrease economic costs in this industry. This work was supported by RFBR «Evaluation of the potential risks of nano-dispersed powders and non-metallic compounds for the environment and personnel» (project №11-08-00374)

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Gorshenin A.S., Krivosheev V.E.

THE CHOICE OF TARGET FUNCTIONS FOR THE OPTIMIZATION OF THE STRUCTURAL AND OPERATIONAL FACTORS MODEL OF HEAT EXCHANGE OF ALUMINIUM INGOTS IN THE COOLING CHAMBER

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This work of receipt of the objective function for optimization of heat transfer in the cooling chamber aluminum ingots. Considered the target function, the optimization criteria, and constraints.

Keywords: target function, optimization, mathematical model.

Investigation of heat transfer with constant and variable structural factors, made by the authors show that the main factor influencing on the process of heat transfer in the cooling chamber, is the width of the channel between the rows of aluminium ingots $\delta$. To determine the best width of the channel is necessary to optimize the design parameters in [1, 2]. For the optimization of the structural factors it is necessary to make the target function, the set of permissible solutions for the target function and optimization criteria.

For the compilation of the objective function we use the method of multiplicative convolution [3]. He is to replace the common criteria $K_i$ one general criterion $\kappa$

$$K(x) = \prod_{i=1}^{n} K_i^{a_i}(x),$$

where $K(x)$ - the General criterion of, $K_i^{a_i}(x)$ - a set of private criteria, $n$ - the number of private criteria, $a_i$ - the relative weight (importance) of the private criterion $K_i(x)$.

Consider the criteria that needs to be optimized in our case. Based on the analysis of studies of mathematical models, it can be concluded that the main factor influencing on the process of cooling is the width of the channel $\delta$. The width of the
channel defines the overall size setting the height of the cooler. Increase the width of the channel has a positive impact on the process of cooling of ingots, leads to a lower discharge temperature of the ingots, but at the same time reduces the total mass of the charge, that reduces productivity.

Decrease in the width of the channel leads to an increase in the final temperature of the ingots, but increases the mass of charge. This allows you to handle a greater number of bars, an increase in productivity. Decrease in the width of the channel will lead to the fact that the load of the height will be reduced, and not take the entire height of the cooler. This will lead to the emergence in the upper part of the chamber of empty space.

The cooling air from the lack of resistance will go into this space, cooling SADC just on the edge. To overcome this limitation, it is necessary to increase the hydraulic resistance of this space. This can be done installing metal boxes.

Thus, the width of the channel $\delta$ directly affects the mass of charge $M_{al}$. Batch weight $M_{al}$ is the first optimization criterion $M_{al} = K_1(x)$. It is necessary aspires to increase it so that the width of the channel $\delta$ was the greatest and is not required the installation of metal boxes.

Define the first optimization criterion $K_1(x)$. Batch weight is determined by the expression

$$M_{al} = m_1 \cdot n \cdot z,$$

where $m_1 = \frac{\pi \cdot d^2}{4} \cdot l \cdot \rho_{al}$ - weight of one ingot, $n = \frac{A}{d}$ - the number of bars in a row, $A$ - width setting, $z = \frac{h}{\delta} + 1$ - the number of rows in height, $h$ - the height of the ponds.

Thus,

$$M_{al} = \frac{\pi \cdot d^2}{4} \cdot l \cdot \rho_{al} \cdot A \left(\frac{h}{\delta} + 1\right) = \frac{\pi}{4} \cdot l \cdot \rho_{al} \cdot A \cdot d \left(\frac{h}{\delta} + 1\right) = K_1(\delta) \quad (1)$$

From the analysis of the expression (1), it follows that for an ingot of the same diameter changing parameters affecting an optimization criterion, is the only channel width $\delta$.  

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The second optimization criterion is the total time of cooling of ingot $\tau_{\text{об}}$, i.e. $\tau_{\text{об}} = K_2(x)$. The total time of cooling ingot $\tau_{\text{об}}$ does not affect the width of the channel $\delta$ and is determined only by the diameter of an ingot and necessary final temperature of the ingot. The lower the temperature of the ingots requires a long period of time cooling and leads to higher energy costs. In addition, the cooling time in any case should not exceed the time cook in the oven homogenization.

Define the second optimization criterion $K_2(x)$. We use the mathematical model of the cooling bar [1] to determine the cooling time

$$\frac{(T_e - T_\text{n})}{(T_0 - T_\text{n})} = \exp(-Bi \cdot Fo \cdot 4)$$

Прологарифмировав and converting (2), we obtain

$$\tau_{\text{об}} = -0.25 \cdot c_{\text{шл}} \cdot \rho_{\text{шл}} \cdot d \cdot \frac{1}{\alpha} \frac{(T_e - T_\text{n})}{(T_0 - T_\text{n})} = K_2(\delta)$$

After the determination of the optimization criteria it is necessary to determine the relative weight (importance) $a_i$ each partial criterion. In our case both private criterion are important to the same extent, because it is important to have the minimum amount of time cooling and greater productivity, i.e., mass. Therefore $a_1 = a_2 = 0.5$

Write down the goal function

$$K(\delta) = \left( K^{a_1}_{\text{об}}(\delta) \right)^{\frac{1}{a_1}} \div \left( K^{a_2}_{\text{об}}(\delta) \right)^{\frac{1}{a_2}}$$

Substitute optimization criteria

$$K(\delta) = -\frac{\left( \frac{\pi \cdot l \cdot \rho_{\text{шл}} \cdot A \cdot d \left( \frac{h}{\delta} + 1 \right) }{4} \right)^{0.5}}{0.25 \cdot c_{\text{шл}} \cdot \rho_{\text{шл}} \cdot d \cdot \frac{1}{\alpha} \frac{(T_e - T_\text{n})}{(T_0 - T_\text{n})}^{0.5}}$$

The expression (3) is the target function of zero order, with the set of permissible solutions in the following limitations:

- the speed of the cooling air must not exceed $15 \frac{M}{c}$. 

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- weight of charge, which shall not exceed 20 tons \( M_{\text{ax}} \leq 20m \), not to exceed the carrying capacity of a loading machine.

Thus, the objective function can be written with the restrictions in the following form

\[
\begin{align*}
K(\delta) &= -\frac{\pi \cdot l \cdot A \cdot \left( \frac{h}{\delta} + 1 \right)}{c_{pax} \cdot \frac{1}{\alpha} \ln \left( \frac{T_c - t_R}{T_0 - t_R} \right)} \rightarrow \max \\
0 < W < 15m/s \\
M_{\text{ax}} \leq 20m
\end{align*}
\]

(4)

The system of equations (4) can be used for study of the optimization of structural and operational factors mathematical model of heat exchange of aluminium ingots in the cooling chamber.

Literature:


NEW TECHNOLOGIES IN PRODUCTION OF SPORTS SHOES

South Russian state university of economy and service

In this article there is a speech about need of increase of a competitiveness of sports shoes of a domestic production, in connection with a universal tendency of development of physical culture and sport. For ensuring steady demand for domestic sports shoes improvement of technology of its production, in particular compounding of moulding compositions is necessary.

Keywords: competitiveness, moulding compositions, environmental friendliness, decrease in labor input, flexibility, elasticity.

In our country it is necessary to take measures to improve the health status of the population, the formation of new values of young people, high level of civicism and patriotism.

The world experience shows that the means of physical culture and sports have a universal ability to complex to solve the problem of raising the level of health of the population and formation of a healthy moral and psychological climate in the collective and in society as a whole.

In accordance with the global trend and in our country, the issues of development of physical culture and sports are becoming a key goal of the social policy.

Beautiful and comfortable sports clothes and footwear adds to the attractiveness of the sports way of life.

According to statistical data, half of the sales on the Russian market of the sports goods takes clothing and footwear, the sports shoes occupies 20-25% of the total sales. Sales volume increase contributes to the constant renewal of the assortment, as well as the high demand, because in Russia, 80% of sports footwear sold not only for sports, but also for everyday wear.
In the premium and mid-price segment of sports Shoe on the market is dominated by well-known Western manufacturers. The share of high-quality goods of the Russian manufacture not great. When this is the main problem of the market remains shadow imports, which is 60-85% of the total imports of footwear. The uncontrolled import of cheap and low-quality sports shoes, which abound in clothes markets of Russia, is one of the most significant barriers for the development of domestic production. In addition, the sports shoes, which are produced in Russia is, in General, shoes from imported component parts and materials, or in case of domestic components, they cannot compete with import.

Providing sports footwear of domestic production of strong demand and increase the level of its competitiveness is impossible without perfection of the technology of its production.

On the one hand, this is connected with the improvement of the quality of the shoes. It is known that the main cause of the return of shoes is detachment soles, as the existing technology of fastening the bottom of shoes can not always guarantee a reliable connection. On the other hand, improvement of the technology of the production of footwear is connected with improvement of the level of its environmental safety, improvement of working conditions of the industrial personnel, the state of the environment as a whole.

Technology of production of sports shoes implemented using injection moulding compositions for the bottom of a Shoe, the basis of which are polyurethanes, thermoelastoplastics and polyvinyl chloride imported production. In addition to the high cost of molding mixtures, they are not environmentally safe, due to the presence in their structure of toxic components, such as izocionate, belonging to the fourth class of danger. In addition, sports shoes with soles of these materials does not have the necessary complex of properties, requirements to Shine subjected to multiple dynamic loads, due to insufficient flexibility of the materials.

Shoe moulding method of fastening the determining factor properties of the products is a recipe moulding composition. The available data on specific adhesion
while gluing materials cannot unequivocally characterize the molding compounds.

Forecasting the strength of molding compounds is impossible without the mathematical models describing the adhesive connection of the main parameters of the process of direct casting and properties of connected materials. A comprehensive analysis of the formulations of injection moulding compositions depending on the package top-of-shoes - important and not yet implemented provision of optimization of the properties of components of footwear and improve the adhesion ability of a surface of products.

Introduction of new materials will contribute to the increase of volumes production of domestic sports footwear and improvement of demand for it, both on the Russian and foreign markets, as it will meet the requirements of the buyers, requirements to its price, quality and safety.

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DESIGN AUTOMATION OF TECHNOLOGICAL ASSEMBLY PROCESS
SHOE MOULDING METHOD OF FASTENING
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In article scientifically well-founded technological workings out in the field of automation of technological preparation of manufacture of footwear are stated. Their introduction will provide technologists with the accessible tool for designing of technological processes of assemblage of footwear that will promote increase of efficiency of shoe manufacture.

Keywords: technological process of manufacture of footwear, automation, the system analysis, information support, methods of fastening of a bottom of footwear.

The main trends of world production are the creation of new and expansion of the assortment of well-known chemical materials for footwear, introduction and
development of advanced technologies, including injection molding method of fastening the bottom of the Shoe. Today it is the most advanced, reliable of all known modern footwear production methods of mounting. The lack of therefore, the holes or glue joints, makes the shoes are extremely resistant to moisture and aggressive environments and reduces the delamination of the soles and percolation on the line connecting to almost zero. Absence of rigid main insole provides greater flexibility, and special cushion the soles makes shoes unusually light.

The specificity of the Shoe companies dictates the need to have a functionally complete operational, legal and information support of design and technological preparation of production. The weakest point of the enterprises at the present time is the low level of information support of technological preparation of production, while automated only certain stages of the KCCI Shine. In the works [1,2,3,4] shows the result of the work on design automation of technological Assembly process shoes adhesive and mechanical methods of mounting. True continuation of the work in this direction for injection molding and-moulding methods of fastening with the aim of reducing complexity and increasing efficiency of works at the stage of the chamber of Commerce. In accordance with the purpose identified the following principal objectives of the study:

- systemic-structural analysis of technological Assembly process Shoe moulding and-moulding methods of fastening;
- definition of predicates, affecting the structure of the technological process;
- development of the structural-logical models of Assembly footwear;
- formation of a universal database;
- development of software for the automated designing of the technological process.

Theoretical and methodological basis of research: theory of simulation of complex systems theory, operations research, the method of system analysis, the method of classification and coding methodology for development of information systems, theory of object-oriented programming, theory of algorithmic.
Information-theoretical base of the study served as the works of domestic and foreign researchers on the study and related problem, national and industry standards, technological documentation, normative, scientific and reference literature.

It is established, that the use of the footwear manufacture the earlier developed algorithms for drafting process of the production of any other product cannot be. The need for new algorithms for solution of some tasks is due to the fact that with the help of a common program of study of the problem you cannot solve specific tasks. Solving a particular problem has specific features, which requires special forms of analysis and synthesis, their logical methods. It is the presence of specific programs and causes the need to prepare for the solution of different problems of new algorithms. The task of simulation heuristic design elements of the technological process of manufacturing of footwear is the original, and for finding the ways of its implementation should develop a specific program of its decision - mathematical model and an algorithm.

To achieve this goal completed the formalization of the initial information, necessary for creation of automated system of designing of technological processes of Assembly Shoe moulding method of fastening of a zone of all possible options to obtain a Shine with all the predicates design. For objective justification for the procedure of drawing up the scheme of technological process and an algorithm of its choice of matrix composed of coincidences of technological operations depending on the materials, design and machining of parts and units. The process of designing of the technological process it is proposed to divide into several levels, and at each level to identify the most common subtasks with further mutual optimization of their decisions. Designed by the classifier, in which the information about the properties of footwear (predicates) are presented in the form of full list (nomenclature), and block diagram of the model coding Shine for automated design of technological process.

In a formal record of the consolidated workflow and nomenclature of predicates contains all of the data that is necessary for construction of structural-logical models of designing of technological Assembly process Shine and programmed selection of the technological process.
On the basis of structural and logical models of the Assembly of shoes designed database, consisting of more than twenty-connected and subordinate to the tables, and other necessary objects of application: queries, forms, reports. On the basis of the designed database is being developed software for the automated selection of the technological process of Assembly Shine. In accordance developed algorithm are formed precise regulations that define the computing process, leading from varying the initial data to the final result - issuance of a print-ready version of a workflow process for this model Shine with the calculation of labour input. The task of the engineer for the design of the technological process is reduced to the choice of meaningful signs of the model and the basic restrictions, the analysis of the results, the adjustment of the selected conditions (if necessary) and the choice of optimal variant.

Literature:


This report is devoted to the problem of long-term storage of meat products. Storage of cooked meat products is accompanied by microbiological, chemical and physical changes that influence their quality and value. Plant extractions may improve the storage time and quality of meat products.

Keywords: meat products, cooked sausages, quality, conservation effect, plant oils.

The problem of long-term conservation of cooked meat products is still important nowadays, while their storage is accompanied by microbiological, chemical and physical changes that influence their quality and value.

Among physical factors that have a negative influence on quality of such products is water evaporation.

The storage of cooked meat products is associated with changes in quality resulting from microbial activity. Residual microbial population after cooking of meat products comprises mostly of spore-forming saprophyte microorganisms and small number of spore bacteria. The number of non-spore-forming microorganisms is less than 10-12% of general microbial population, survived after cooking. Spore-forming saprophyte bacteria are mostly presented by Bacillus spp. Psychrophilic bacteria proliferate at 3°C, optimal temperature for proliferation of mesophilic bacteria is 25-37°C, but many of them can proliferate at 4-8°C. The temperature of extensive proliferation of micrococcus is near 20-25°C, but some species can proliferate fast at 5-8°C. Few species may survive after short-term pasteurization [1].

Meat products, stored in common aerobic conditions are contaminated with aerobic bacteria of Pseudomonas spp. Optimum temperature for their proliferation
comprises 25-35°C, but most of the species proliferate well above and below 4°C. Being exclusively aerobic, psychrophilic bacteria of Pseudomonas spp. do not proliferate in meat products if stored in nitrogen, carbon dioxide atmosphere or vacuumized [2].

There is data, proving the presence and proliferation of bacteria of Aeromonas spp. in protein rich products if stored at low temperatures, especially in anaerobic conditions. Most of Aeromonas spp. (non-spore-forming) proliferate at 1°C, and some species at -1.5°C [3].

Meat products in impermeable packages filled with noble gases almost do not show any growth of aerobic microorganisms. Nevertheless, proliferation of facultative anaerobic bacteria of Aeromonas spp. and non-spore-forming bacteria of Lactobacillus spp., Microbacterium spp. is detected in the mentioned above conditions [2].

Proliferation of Lactobacillus spp. in vacuum at 1-7°C is slower than proliferation of Pseudomonas in aerobic conditions. Lactobacilli may be one of the main reasons of bacterial spoilage of food. Proliferation of lactobacilli on the surface of meat products is visualized as mucous coating [2].

Proliferation of lactobacilli in meat products in aerobic conditions is inhibited by aerobic psychrophyllic bacteria, particularly of Pseudomonas spp. [4].

Only few groups of bacteria can grow in mixed culture of different microorganisms and not all of them are able to proliferate at low temperatures. Not only low temperature, but also other external factors and interaction between them may influence food products. In such conditions proliferation and inhibition of different groups of microorganism may occur simultaneously. Interaction between microorganisms capable to proliferate in such conditions determines the dominant group of bacteria. Its proliferation influences considerably the quality of meat products and determines the type of spoilage in case of its improper storage [1].

Some fat oils possess antibacterial activity, thus, the fat oil from Salvia sclarea has bacteriostatic activity against S.enteritidis, Ech.freundi; Pr.vulgans, Sh.newcastle;
fat oils from Echinacea purpurea are bacteriostatic against gram-positive and gram-negative microorganisms [5].

Conservation additives of plant origin may improve the shelf life of meat products similarly to synthetic preservation agents, but natural additives consist of complex substances in natural proportions, which influence the human organism in physiological way.

Combination of protein-containing raw materials of animal and plant origin, iodine-containing additives and bacteriostatic (antimicrobial) plant compounds is recommended for improvement of quality and microbiological safety of cooked meat products (sausages).

References:
APPLICATION SUPPORT MATERIALS AS A VOLATILE COMPONENT
SORBENTS WINE

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Agricultural (SSI SKZNIISiV RAAS)

This report deals with the formation of sulfur-containing compounds in grape wines, and their role in the flavor of wine, as well as ways to eliminate extraneous tones of grape, caused by the presence in their study of chemical substances.

Keywords: wine organoleptic evaluation by GC-MS, bentonite, gelatin, tannin, copper-containing drugs, sulfur-containing compounds.

1. Relevance.

Organic compounds containing sulfur, play an important role in shaping the quality of food products such as cheese or beer. These foods are important in human life. They are formed by the activity of different types of micro-organisms - yeast and bacteria. In addition, the sulfur compounds found in fresh foods - fruits and vegetables, where they act as an antioxidant [1].

It is known [2], thiols, sulfides, thioethers are part of different varieties of cheese and can be indicators of the quality of identification and beers. Some sulfur-containing components, such as dimethyl sulfide and dimethyl trisulphide are unique to certain beers. It is known [3] that some thiols adversely affect the organoleptic properties of wine, a product of fermentation. Methanethiol (methyl mercaptan) and hydrogen sulphide are formed by the degradation of the elements sulfur and carbon of the amino acids methionine and cysteine. The formation of hydrogen sulfide during fermentation depends primarily on the race of yeast, as well as on the concentration of sulfur derivatives in the fermentation medium. The formation of hydrogen sulfide and methanethiol, adversely affecting the organoleptic properties of wine, very complex and is determined by a complex of factors, including the paramount
importance of raw materials and features of the enzymatic activity of yeast, and therefore, the development of methods for removing sulfur components from the wine, increase the organoleptic properties the final product, are relevant and reasonable.

2. Objects and methods of research.

As objects of research was selected dry white wine stock table grape varieties Chardonnay harvest of 2011. and ancillary products: Gelbenton (bentonite), Enotanin (tannin), Enozhelatin (gelatin), Kuprotek.

The concentration of volatile aromatic compounds were determined by gas-liquid chromatography chromatograph "Crystall-2000M," and by gas chromatography-mass spectrometry on the instrument Perkin Elmer Clarus 600 T.

3. Results and discussion.

In order to support selection of products that contribute to the elimination identified by organoleptic evaluation of foreign tones (Table 1) wine stock of grapes "Chardonnay" has been processed:

Sample 1 - Gelbenton (bentonite),
Sample 2 - Enotanin (tannin)
Sample 3 - Enozhelatin (gelatin)
Sample 4 - Kuprotek.

Following the processing of wine organoleptic evaluation (Table 1) showed that compared with the control to add Kuproteka reduces oxidation in the color shades and eliminates extraneous tone in taste and flavor. Adding other ancillary products reduces the intensity of extraneous tone (Enotanin), increases the acidity (Enozhelatin).

| Sample number 1 - Table dry white wine stock "Chardonnay" (Control) | The sample is transparent, no sediment and loose straw liquid with a golden tint. In the foreign flavor (hydrogen sulfide) tone complex composition. Taste is moderately fresh, outsider voice. |
| Sample number 2 - Table dry | The sample is transparent, no sediment and loose straw liquid with |
| Sample number 3 - Table dry white wine stock | The sample is transparent, no sediment and loose straw-colored fluid. Varietal aroma, with a slight tone of an outsider. Taste is moderately fresh. |
| Sample number 4 - Table dry white wine stock | The sample is transparent, no sediment and loose straw liquid with a slight golden tint. In the light flavor outsider tone. Fresh, with prominent acidity. |
| Sample number 5 - Table dry white wine stock | The sample is transparent, no sediment and foreign matter liquid light straw color. Varietal aroma, with light floral and fruit tones. Taste is moderately fresh, with a light bitterness. |

It is known that the formation of foreign tones, identified as hydrogen sulfide, garlic, responsible compound dihydro-2-methyl-3 (2H)-tiofenon (Dihydro-2-methyl-3 (2H)-thiophenone, Number CAS 13679-85-1) ethyl-3-metiltiopropanoat (Ethyl 3 - (methylthio)-propanoate, Number CAS 13327-56-5), 3-metiltiopropilatsetat (3 - (Methylthio)-propyl acetate, Number CAS 16630-55-0), 3-metiltiopropanol (3 - (Methylthio)-1-propanol, Number CAS 505-10-2). The second and third compounds are esters, volatile components, which, after the collapse can lead to the formation of 3-metiltiopropanol.

These results chromatography-mass spectrometric studies supporting drug-treated wine (Fig. 1, 2,3,4) indicate that the use of ancillary drugs, reduces the amount of ethyl-3-metiltiopropanoata - ether, forming a nasty tone foreign to the minimum concentration.

Making Gelbentona, bentonite nature of the drug, reduces by 30% dihydro-2-methyl-3 (2H)-tiofenona, 71% 3-metiltiopropilatsetata and increased to 20% concentration of 3-metiltiopropanola.
Processing of wine Enotaninom reduces by 50% the concentration of dihydro-2-methyl-3 (2H)-thiophenone, a 40% concentration of 3-methylpropanol and to the lowest concentrations of 3-methylpropylacetate.

Adding to the wine stocks and Enozhelatina Kuproteka reduces to the minimum concentration of 3-methylpropylacetate content. However, only Kuprotek reduced to the lowest concentrations of dihydro-2-methyl-3 (2H)-3-thiophenon methylpropanol.

The results of organoleptic evaluation and chromatographic-mass spectrometric analysis can be recommended for the treatment of dry white wine copper-containing drugs, such as Kuprotek, in order to eliminate extraneous colors.
To eliminate extraneous colors in the aroma and taste tablespoons dry white wine, identified by organoleptic evaluation of the hydrogen sulphide, it is advisable to use the auxiliary preparations containing copper.

Literature.


CID: J31207-402

Vasyliv V.P.

PRINCIPLES OF THE DETERMINATION OF ELECTRIC CAPACITY IN DISCHARGE GAP UNDER ELECTRIC DISCHARGE IN LIQUIDS

National university of life and environmental sciences of Ukraine

General methodical principles of calculation of capacity of the electric blast portioned on front of the shock wave, thermodynamic parameters of the ambience under high-tension pulsed electric discharge in liquids, founded on decision of the automodel problem about strong blast in ambience which is compressed have offered in the article.

Key words: capacity, discharge gap, high-tension pulsed electric discharge, energy of the plasma, transmission.

In studying the effect of electric spark discharges to change the properties of vegetable raw materials necessary to determine the magnitude of various parameters of the discharge in order to establish rational modes of spark processing of a medium. Of considerable interest is the elucidation of the change in power, which is released
in the discharge gap with the development of the discharge. Since a significant portion of the discharge energy is released in the form of heat, power variation during the discharge reflects a number of specific events occurring in the discharge gap: the formation of the channel, the degree of ionization of the discharge gap, the erosion of the electrodes, the transfer of material and other phenomena. As a result of the measurement voltage across the discharge gap and the discharge current dependence of the discharge were calculated as a function of time [1, 2]. Analysis of these relationships leads to the conclusion that the maximum capacity is allocated at the initial stage of discharge development.

The study of power, which is released in the discharge gap, leads to the consideration of the equation of energy balance, the composition of which can be written as:

\[ N = \sum_{i=1}^{6} N_i . \]  

(1)

The solution of the equation, taking into account all components of \( N_i \) does not exist if not to introduce a simplified assumption.

The terms of \( N_i \) (1) have the following meanings:

- \( N \) - total power, which is released in the discharge gap;
- \( N_1 \) - power that is removed from the discharge channel due to thermal conductivity, which is defined (for a unit volume of plasma):
  \[ N_1 = -\text{div} \lambda \text{grad} T , \]  
  (2)
  where \( \lambda \) - the thermal conductivity of the plasma;
- \( N_2 \) - power that is removed from the discharge channel due to convective heat transfer, which is determined from the expression:
  \[ N_2 = \rho C_p v \text{grad} T , \]  
  (3)
  where \( \rho, C_p, v \) - density, respectively, the maximum heat and velocity of the plasma;
- \( N_3 \) - the power that is spent on improving the internal energy of the plasma.

For the internal energy per unit volume of plasma is equal to:

\[ W = \frac{3}{2} KTn + n_1 U u + \frac{1}{3} (n + n_0) D + x , \]  

(4)
where $n$ - number of units;

$n_i$ - number of charged particles;

$n_0$ - number of neutral particles;

$U_u$ - ionization potential;

$D$ - coefficient of dissociation;

$K$ - Boltzmann constant;

$x$ - the energy of chemical reactions;

$N_4$ - radiated power, which is determined by the law of Stefan – Boltzmann:

$$N_4 = \varepsilon KST^4,$$  \hspace{1cm} (5)

where $\varepsilon$ - the integral over the spectrum of emissivity;

$S$ - surface of the channel;

$K$ - is the Stefan - Boltzmann constant;

$N_5$ - power, which is used for compression and displacement of the medium which surrounds the discharge channel;

$N_6$ - power that is given to the body and the electrodes used in the erosion of the electrodes.

Determining the values of various moments of $N_i$ - used in the discharge, which are considered [2]. Calculation of the heat from the discharge channel ($N_i$) requires knowledge of the thermal conductivity. At very short interelectrode spacing and at a much higher thermal conductivity of the electrode material, its role is insignificant. During the time of discharge (approximately 1mks) because of the inertia of the convection $N_2$ is almost irrelevant. Losses ($N_4$) do not exceed 7% of the total power. Component $N_5$ average discharge time is less than 5% of the total power.

Various authors in the consideration of (1) have to resort to a choice of different models to meet compliance idealization which real processes, depending on specific conditions. For example, at a time when we can neglect all components except the $N_3$, equation (1) reduces to equation Rompuy-Vantselya made up to describe the processes in the short spark discharges. In that case you need to consider an additional component of the $N_3$, using an equation derived S. Braginskii.
Thus, the analysis of thermal processes at the electrodes can take the values of power, which they passed as the sum of $N_3$ and $N_6$ components in the time of discharge 1 microsecond, which is approximately 0.9 total power, which is implemented in the discharge gap.

References:

CID: J31207-520
UDC 664.9.03

Korotkiy I.A., Fedorov D.E., Maltseva O.M.

CRYOCONCENTRATING TECHNOLOGIES IN THE FOOD INDUSTRY

FBPEI HE Kemerovo technological institute of the food industry

This report is devoted to the question of concentrating by freezing in the food industry. The alternative ways of concentrating of products are briefly described: evaporation and membranous methods, advantages of a cryoconcentrating in comparison with these methods are proved.

Keywords: cryoconcentrating, freezing, foodstuff

The problem of preservation of food during the long-lived time term arose at a dawn of development of mankind and to this day remains to one of the most actual problems of the food industry. With a view of extension of shelf life, or for separation of fixed components fluid products quite often are exposed to concentrating at which there is a removal of a part of moisture from solution to strengthening of dry matters. Thus it is possible to slow down undesirable biochemical and microbiological processes with increase of shelf life, and also to reduce liquid volume for storage that allows to lower economic costs of transportation and storage.
Evaporation, membranous methods of division belong to the main ways of removal of moisture from foodstuff (a hyper filtration and an electrodialysis) and a cryoconcentrating.

Evaporation is the most widespread way of receiving dry concentrates. This process is carried out in special vacuum evaporation device in the conditions of diminished pressure, thus the temperature of concentrated substance makes about 50-80 °C that allows to reduce undesirable changes in a product somewhat. Despite apparent advantages of such method of concentrating, evaporation is rather power-intensive technology as a large amount of energy is spent for vacuum maintaining, and also on a warmth supply to object of drying. Besides, elevated temperature nevertheless affects quality indicators of a finished stock.

The substance of such membranous method of concentrating as a hyper filtration is that the fluid product is under pressure passed through express semipermeable membranes with diameter of a pores, commensurable with molecules of solution of components. Depending on porosity a hyper filtration divide into an ultrafiltration (diameter of a pores – 0,5 microns) and a revertive osmosis (diameter of a pores – 1-3 nanometers) [1]. Such methods allow to carry out rather efficient separation of components of solution with economic expenses twice less than at evaporation. However in the food industry they didn't find a wide spread occurance because of difficulties in continuous cleaning of membranes, and also low quality of received concentrates.

At an electrodialysis ions of permeate pass through a membrane under the influence of an electric field. In the food industry such way is efficient only at a demineralization of fluid products, for example, whey.

The method of cryoconcentrating based on freezing of moisture in a product with the subsequent removal of ice and increasing concentration of the solution to 30-40 % shows larger prospects. The main advantage of this method is high degree of safety of quality indicators of products as all process flows past at the negative temperatures. Especially it concerns preservation of aromatic substances and vitamins [2]. Besides, the cryoconcentrating is economically more efficient in comparison with
Evaporation as warmth of a formation of ice of water approximately in 7 times is less than warmth of its evaporation, and losses of dry matter make less than 1 %.

In the food industry concentrating by freezing is applied to a concentration of milk and milk products (serum, a buttermilk), for receiving concentrated fruit juice, beer, coffee extracts etc. In addition this way is used in the medical industry at plasma and blood serum concentrating with increase of the content of dry matters in 2-6-fold, and also different medicinal preparations [3].

Concentrating by freezing gains special value in the countries with a strongly pronounced frigid climate where there is a possibility of use of natural cold that allows to cut electric power expenses.

Thus, the cryoconcentrating is the most perspective method of a concentration in the food industry, allowing at low energy consumption to receive concentrates with most kept properties of an initial product.

Literature:


Despite high sugar content in confectionary products, sweets may contain the abundant population of microorganisms whose behavior is not researched well enough yet. To research this issue, we have run a series of tests studying the changes in microflora, which took place in different timeframes in course of storage, with short intervals for inoculation with term of experiment up to 78 days.

Regular experiments revealed fluctuations in the quantity of microorganisms throughout the all storage period. Results of the tests are presented in Fig. 1 where you can see the curves indicating the quantity of microorganisms detected during the storage.

![Fig. 1 – Variation of Microorganisms’ number in Ptichie Moloko sweets during the Storage.](image)

The curves (Fig. 1) indicate wave-like variation in the quantity of microorganisms’ cells in the sweets, which can only be detected through short inoculation intervals. The total viable count curve has maximum peaks in three points: day 21, day 44 and day 69; and three minimum indexes on day 29, day 50 and day 68.
Microorganisms remain viable throughout the entire storage period, although their quantities tend to vary. In all probability, these variations are indicative of apoptosis – pre-programmed ability of microorganisms to control the number of cells in a population. Under certain conditions, some of the cells may die so as to enable the remaining cells to survive.

Therefore, testing has detected a wave-like behavior of microorganisms’ quantity in the sweets during the storage. Most likely, it is due to the phenomenon of apoptosis in the studied groups of microorganisms.

**CID: J31207-697**

V. Volchenko, O. Nesvyaschenko, S. Nesvyaschenko

**The Possibility of The Fish Oil Usage as an Improving Agent in Baking**

*The Murmansk State Technical University*

This article observes a possibility of fish oil usage as an oxidative improving agent in baking.

*Keywords: cod liver oil, improving agents, disulfide bonds, omega-3 polyunsaturated fatty acids*

Baking production is one of the main branches of the food industry. Bakery products take one of the leading places in the nutrition of our country population. Baking production is a socially important branch of the economics which is currently flourishes actively. There are about 7000 large bakeries and more than 10500 small enterprises in Russia.

The question of the improving baking technology is especially actual during food deficit. So, the producing the high-quality baking products from the lower-grade flour, which is more available on the market even in less plenteous years, is an actual task. The different improving agents are used for solving this task. These improving agents includes different food additives for making possible to make a dough and, consequently, a bakery product with the required characteristics. The most widespread improving agents are reductive and oxidative agents.
For the flour with weak gluten it is reasonable to use oxidative agents in most cases. These agents are the different substances which oxidize –SH-groups (in cysteine) to disulfide bonds (–S–S–) which act like stapling two nearest polypeptide chains of the gluten proteins. This makes the gluten more stiff and strong and makes easier to form a net carcass, so improving the strength of the finished product. But it is no doubt that very strong gluten is a fault yet.

One of the widespread oxidative agents is a vegetable oil. Such oils are able to the peroxide oxidation when sulfhydryl groups are the type II antioxidants (antioxidants containing sulfur). Despite the more effectiveness, fish oils have not considered as improving agents yet because of their smell.

The flour with very strong gluten is not very suitable for making bakery products too. It is reasonable to use reductive agents with it such as sodium thiosulfate. They reduce disulfide bonds to sulfhydryl groups making gluten chains more mobile over each other.

It is reasonable to use a combination of oxidative and reductive agents in some cases. At the beginning of dough kneading an reductive agent is active, so the speed of the process and the structure forming increases while at next stages of the production oxidative agent become active making the gluten stronger.

The aim of this research is the studying of the possibility of using the oil separated during cod liver microwave treatment as an oxidative agent, and studying the possibility to use this oil with a combination with a sodium thiosulfate as a reductive agent. The preliminary experiments showed that including the cod liver oil in dough with the proportion about 1 part of fish oil to 100 parts of flour makes it possible to improve dough characteristics without decreasing the flavor. Moreover, the specific flavor of the bakery product is considered as a positive comparing with a control specimen without fish oil. Higher quantities of the fish oil seriously decrease the flavor.

An experiment of sodium thiosulfate usage at the beginning of dough kneading and fish oil at the end of dough kneading was carried. The wheat flour of the 1st grade was observed at first. The gluten quality was evaluated for estimating its baking
characteristics. The estimations were carried on a clean flour and on flour with the addition of the improving agents (cod liver oil in 1 % to the flour mass and 0.1 N sodium thiosulfate solution in 1 % to the flour mass).

**Table 1**

<table>
<thead>
<tr>
<th>Baking characteristics of the raw material (flour of the 1st grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour specimen characteristics</td>
</tr>
<tr>
<td>Control (clean flour)</td>
</tr>
<tr>
<td>With the sodium thiosulfate</td>
</tr>
<tr>
<td>With cod liver oil</td>
</tr>
</tbody>
</table>

The results of the table 1 show that cod liver oil works as an oxidative agent.

**Table 2**

<table>
<thead>
<tr>
<th>Amount of the component in a specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nº</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

The results of an sensory estimations are shown in the table 3.
Table 3

The results of sensory estimation of the bread (5-ball scale on each criterion).

<table>
<thead>
<tr>
<th>Criterion name</th>
<th>Average estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Appearance</td>
<td>4.35</td>
</tr>
<tr>
<td>Cut appearance</td>
<td>4.8</td>
</tr>
<tr>
<td>Taste</td>
<td>4.55</td>
</tr>
<tr>
<td>Aroma</td>
<td>4.7</td>
</tr>
<tr>
<td>Texture</td>
<td>4.7</td>
</tr>
</tbody>
</table>

It is reasonable to make the following conclusions:

1. It is found that cod liver oil can be used in bakery products compounding without serious decreasing its flavor.

2. It is found that cod liver oil is effective as an oxidative improving agent of the flour.

3. The possibility of using the combination of the cod liver oil and the sodium thiosulfate is proved.

Literature (in Russian):


E. Belikova, I. Drach

Features of intellectual property use in innovative projects of metallurgical enterprise

National Metallurgical Academy of Ukraine

Abstract

This report discusses the use of intellectual property as a component of the innovation project of metallurgical enterprises.

Keywords: project management, innovation, intellectual property, metallurgical enterprise.

Introduction

The implementation of innovative projects as a mechanism to stimulate the development of science and technology can guarantee the economic stability of Ukraine in the global market. Today, the intellectual potential of metallurgical enterprises can provide Ukrainian integration into the world market.

No metallurgical enterprise is not able always be ahead of its technological support processes. And the bigger it is, the harder to maintain the proper level of its production [1]. In addition its maintenance requires huge investments. Therefore, businesses need to have their own human capital. But the reality is that many employees in the company, who look at their problems from a practical point of view, and in direct contact with the production process, do not take part in research and development of new processes, equipment modernization and improvement of the final product. By the creative abilities of employees, rather than their efforts to carry out routine operations and support new solutions it is possible to increase profits and competitiveness. It is necessary for them to create such working conditions to have them opportunity to engage not only the routine work, but also to carry "breakthrough" ideas, since no one better than these employees do not know different
enterprise features. Therefore, the leaders should motivate to creativity and innovative activity in the enterprise.

Innovation and intellectual property are also the main component of any steel plant.

The concept of "innovation project" is used in several ways:
1) case, activity, event, suggesting implementation of a set of actions that achieve certain goals;
2) the system of organizational, legal, settlement and financial documents necessary for the implementation of any action;
3) the process of innovation.

In general, the innovative project is a complex system of interdependent and interconnected resource, time, and implementing measures aimed at achieving specific goals (objectives) in the priority areas of science and technology.

The variety of goals and objectives of innovation development determines many varieties of innovative projects [2].

The innovative project implementation is the process of creation and the removal of an innovative product to market. The innovative project purpose is the creation of a new or changes existing technical, technological, informational, social, economic, institutional and enterprise systems and achievement by reducing the resource costs (industrial, financial, human) better final product quality [3].

The innovative project includes the following stages:
1) planning;
2) development;
3) project implementation;
4) project completion – delivery of project results to the customer and closing contracts.

The introduction of intellectual property objects in innovation projects occurs at the development stage. At this stage, to improve the quality characteristics of the final product, new technology solutions, designs, technical solutions and inventions are create that are directly the objects of intellectual property rights.
The companies need for intellectual property

Metallurgical industry of Ukraine is in need of industry modernization on the basis of innovation to increase production, reduce production costs and adapt to the available resources. Implementation of intellectual property in metallurgical enterprises provides the required level of renewal and modernization of metallurgical units and equipment. It enhances the competitiveness of the enterprises, allows increasing their production, improving profitability and competitiveness of the enterprises. Such processes accelerate the emergence of the market of a new product, materials, equipment, methods of production (technologies) and organizational structures [4].

Realization of innovative capacity of any metallurgical enterprise is not possible without effective management of intellectual property, which is performed at all stages of the live cycle of the objects of the intellectual property law, such as ideas, expertise, development, creation, registering the rights, and their protection commercialization and recycling [5].

At the metallurgical plant production of the final product innovation is a continuous cyclical process. That is why the use of intellectual property rights alters the course of the entire production process as well as its financial and economic parameters.

Using of intellectual property in innovative projects

Any innovative project is directly related to the intellectual property law, since it considers new developments, solutions, inventions, know-hows, and others which are used in the development of innovative products [4].

The peculiarity of the objects of intellectual property law is that they can be created in the process of project implementation and outside the project. An example of the creation of such intellectual property can serve as the activities of research institutes. Under the direct result of the receipt should be understood as an object of intellectual property law as a product of the project that is the result, which was planned in the project initiated [6].
If we consider intellectual property as an end product of the project, its life cycle begins when an idea is born, to be implemented within the project. The final product of the project, taking into account the use of objects of intellectual property rights, may lead to the acquisition or raising already existing intellectual property or creating a new one.

At each stage of the project it is very important to take effective solution on the legal protection of research and development rights which serve as a basis of product innovation. To develop an innovative project for metallurgical plant it is advisable to start with portfolio of existing intellectual property. Market research is carried out at the initial stage of the project. It helps to conclude:

1) if there is enough intellectual property of their own located at the plant that can be used to produce the final product;
2) if it is necessary to create new intellectual property and to protect it;
3) if it is more beneficial to buy such property from another company.

The patent briefcase strategy presupposes the formation of intellectual property for an innovative project and involves the development of more than one invention or a package of inventions. Among them there are those that improve the production technology [4].

The successful forming of the innovative sphere is a result of foremost, political and social terms which are folded in the society. That is why the role of the Government is solving such problems is of outmost importance and includes:

- the formation of an effective innovation policy;
- the correct definition of its priorities, strategies and mechanisms to implement that should be focused on technological upgrading and improve the technological capacities of metallurgical enterprises as well as upgrade manufacturing technology products, personnel training to meet the needs of the market in the production of high scientific and technical level items [7].

**Conclusions**

One of the main ways to overcome the many economic problems is government support for innovation activities of enterprises.
It should be noted that now all the companies regardless of ownership should develop a strategy for effective management of intellectual property within the corporate planning and business development policy in this area, which consists of the following items:

- establishing a system of intellectual property portfolio management;
- implementation of a comprehensive and reliable protection of intellectual property rights;
- development of an integrated intellectual property marketing to prevent violations of intellectual property rights of others and find ways to commercialize an innovative product.

References


Features of temperature measurements in a tubular reactor of aniline synthesis

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Temperature measurement in reactor tubes is a difficult process and requires a great attention as an industrial project control and management is performed based on sensors indications. Aniline synthesis process was investigated as the separate case of highly exothermal processes. Research tool was the mathematical model developed by authors.

Key words: tubular catalytic reactor, temperature control, aniline synthesis, catalyst porosity, reactor modeling.

Reducing reaction of nitrobenzene by hydrogen in a gas phase has a highly thermal effect. Process behavior in a tubular catalytic reactor gives the considerable temperature jump along the tube length in the reaction zone in spite of minor reactor tubes diameter. This leads to heavy resins formation and frequent catalyst regenerations.

To control temperature, thermocouples are installed in several tubes in reaction zone (fig. 1). There may be some of such tubes to ensure temperature control by height. To control temperature in aniline synthesis reactor, 20 tubes are applied and
equipped by thermocouples installed on various depth of catalyst bed. Thermocouple is placed into a metal tube – jacket for protection against environment exposure. Thermocouple placement in a tube with catalyst changes considerably the process behavior conditions in comparison with the catalytic tube without a thermocouple. First, this affects the catalyst bed porosity. It’s necessary to take this fact into consideration for reactors construction and their control in operational process.

![Diagram](image)

**Fig.1. Temperature measurement in tubular reactor**

Using the mathematical model, it was assumed to compare the process features in tubes with or without a thermocouple. For the specific mathematical reactor modeling, experiments were carried out to determine the average porosity value in a tube with circular and ring cross-section on industrial catalysts of aniline synthesis (cylindrical grains with an equivalent diameter ≈ 6.33 mm and 5.14 mm). Experiments were performed with tubes of different internal diameter 18…36 mm [1]. Thermocouple availability was imitated by a metal rod placement of 8 and 10 mm in-line inside of tube. Upon experiments results, functional dependences of the average porosity of the catalyst bed for tubes with or without a thermocouple were proposed. Such equations were used to construct the mathematical model of processes occurring in the tubular reactor of nitrobenzene reduction.

In the result of conducted researches the influence of jacket availability for a thermocouple on catalyst porosity in reactor tube was confirmed. Functional dependences of catalyst porosity from equivalent catalyst diameter and reactor tube were determined for two catalysts types:
Based on literary data, results of experimental researches of authors and computing experiments [2], kinetic process patterns of aniline synthesis were established and kinetic coefficients of chemical reactions were determined:

\[ \omega_{N,k}(T) = k_{0N} \cdot e^{-\frac{-53600}{R \cdot T}} \cdot C_{nb}, \text{ mole/(s \cdot m}^3) \]  
\[ \omega_{N,d}(T) = \sqrt{k_{0N}} \cdot \frac{4 \cdot \sqrt{D_{ef}}}{d_{eq}} \cdot e^{-\frac{-26800}{R \cdot T}} \cdot C_{nb} \cdot C_h^{0.5}, \text{ mole/(s \cdot m}^3) \]  
\[ \omega_{L,k}(T) = k_{0L} \cdot e^{-\frac{-50242}{R \cdot T}} \cdot C_{nb}^{0.2} \cdot C_h^{0.6}, \text{ mole/(s \cdot m}^3) \]  
\[ \omega_{L,d}(T) = \sqrt{k_{0L}} \cdot \frac{4 \cdot \sqrt{D_{ef}}}{d_{eq}} \cdot e^{-\frac{-25121}{R \cdot T}} \cdot C_{nb}^{0.6} \cdot C_h^{0.3}, \text{ mole/(s \cdot m}^3). \]

As not less than 97% of nitrobenzene is used for aniline formation, then this reaction specifies heat releases in course of the process:

\[ \frac{dC_{nb}}{d\tau} = -\omega(T), \quad \frac{dC_h}{d\tau} = -3 \cdot \omega(T), \quad \frac{dC_{an}}{d\tau} = \omega(T). \]  

In the mathematical model, it was assumed that process behavior is similar in all reactor tubes. Catalyst loading is made in such manner that bed resistance in all tubes are equal, a distribution device is installed on reactor inlet to distribute uniformly gas mixture along the tubes.
Quasi-ideal displacement model is accepted for inter-tubular space. Heat carrier temperature is changed not more than by 15 °C owing to high heat carrier consumption and multiple flow direction change stipulated by partitions availability. Possibility to apply such simplification was confirmed in previous works [3, 4]. To calculate an average heat transfer on cross flow of tube packages the following equations are used [5]:

\[
\alpha_T = \frac{0.426 \cdot \text{Re}^{0.5} \cdot \text{Pr}^{0.36} \cdot \lambda T}{d_{T,eq}}, \quad 40 < \text{Re} \leq 300.
\]  
(10)

\[
\alpha_T = \frac{0.21 \cdot \text{Re}^{0.6} \cdot \text{Pr}^{0.36} \cdot \lambda T}{d_{T,eq}}, \quad 300 < \text{Re} \leq 2 \cdot 10^5.
\]  
(11)

In the above equations the coefficient of attack angle influence is already taken into consideration and is equal 0.6 for shell-and-tube heat exchangers with cross partitions.

Stationary operation mode of the reactor was examined. Components temperature and concentration change of reaction mixture along reactor tube and on its radius was taken into consideration as thermal reaction effect is too great. Catalyst bed was considered as a quasi-homogeneous medium with effective diffusion and heat conductivity coefficients. Based on the above mentioned and differential equations of material and thermal balance [6], the following two-dimensional mathematical model of synthesis process in cylindrical coordinate system was adopted:

\[
\frac{\partial C}{\partial l} = \frac{1}{\nu(T)} \left( 2 \cdot D_{ef} \frac{\partial}{\partial r} \left( \frac{d_{tube}}{2} \frac{\partial C}{\partial r} \right) + \omega'(\bar{C},T) \right),
\]  
(12)

\[
\frac{\partial T}{\partial l} = \frac{1}{\rho_{mix}(T) \cdot c_p(T) \cdot \nu(T)} \left[ 2 \cdot \lambda_{ef} \frac{\partial}{\partial r} \left( \frac{d_{tube}}{2} \frac{\partial T}{\partial r} \right) - \Delta H(T) \cdot \omega'(\bar{C},T) \right],
\]  
(13)

\[
\frac{\partial T_r}{\partial l} = -\frac{1}{\rho_r \cdot c_{p,T} \cdot \nu_T} \frac{4 K(T_{av})}{d_{tube}} (T_{av} - T_r),
\]  
(14)
Modern scientific research and their practical application.

\[
\omega'(\bar{C}, T) = \omega(\bar{C}, T) \cdot (1 - \varepsilon), \quad \text{(15)}
\]

\[
K(T) = \frac{1}{\alpha(T)} + \frac{\delta}{\lambda_w} + \frac{1}{\alpha_T}. \quad \text{(16)}
\]

Boundary conditions:

\[
l = 0: \quad C = C_f, \quad T = T_f, \quad \text{(17)}
\]

\[
r = 0: \quad \frac{dC}{dr} = 0, \quad \frac{dT}{dr} = 0, \quad \text{(18)}
\]

\[
r = \frac{d_{\text{tube}}}{2}: \quad \frac{\partial C}{\partial r} = 0, \quad \frac{\partial T}{\partial r} = -\frac{K_T}{\lambda_{ef}} \cdot (T - T_f), \quad K_T = \frac{1}{\alpha_T}, \quad \frac{\delta}{\lambda_w} + \frac{1}{\alpha_T}. \quad \text{(19)}
\]

Medium motion velocity in tube space was determined taking into consideration the equality conditions of hydraulic bed resistance. Average reaction velocity was accepted for every reactor section.

Differential equations system (12-14) was added by equations system to calculate thermal and physical media properties depending on composition and temperature, as well as by data on properties of separate components and object geometry. Also equations (12, 13) were included for tubes in which thermocouples were installed and used to define the longitudinal temperatures profile of reaction mixture. The present mathematical model allows to calculate the temperatures profile for tubes of any diameter with or without a thermocouple.

For calculations, equations (12-14) were replaced by the finite-difference double-layer implicit scheme of the second order accuracy.

Reliability of this model and velocities constants values are checked by control experiments carried out on a laboratory facility and an industrial reactor as well as by research results from literary sources. Comparison of calculation data and experimental values showed a good compliance. Taking into consideration a high process exothermicity, the model adequacy is also confirmed by the coincidence of thermal peak position along reactor tubes (fig. 2). Heat quantity expended for vapour formation in heat recuperator was also evaluated.

Calculations showed the heat compliance transferred for a heat carrier to the value calculated by the formula:
\[ Q_I = \int_F K(T) \cdot (T - T_T) \, dF. \]  

(20)

Fig. 2. Longitudinal temperatures profile

1, 4 – in tube with a thermocouple, design and experimental; 2 – in standard tube; 3, 5 – in inter-tubular space, design and experimental

Computing experiment results showed the good compliance of design data to data obtained from thermocouples. At the same time, design temperature value is higher in standard tubes than in tubes with a thermocouple.

Fig. 3. Radial temperatures profile in hot point

From the diagram (fig. 3) one can see that the difference between maximum temperatures values for tubes with or without a thermocouple used in production is about 20 °C.

Computing experiments were carried out for ratio determination of diameter between standard tube and tube for a thermocouple [7]. Reactor tubes diameter varied
in the range of 20..28 mm, at that tubes number and catalyst porosity change was taken into consideration. Tubes number was calculated according to requirements prescribed for tubular reactors manufacture. All experiments were performed with aniline yield \(\approx 97..98\%\). Table 1 shows tubes diameters for a thermocouple which allow to demonstrate actual temperatures in a standard tube of indicated size.

**Table 1**

<table>
<thead>
<tr>
<th>(d_{\text{tube standard, mm}})</th>
<th>20</th>
<th>24</th>
<th>26</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d_{\text{tube for a thermocouple, mm}})</td>
<td>24</td>
<td>28</td>
<td>30</td>
<td>31</td>
</tr>
</tbody>
</table>

Temperature measurement in reaction zone is a main problem for catalytic processes as temperature sensors, being under other conditions, can give lower readings. This may cause the catalyst usage in temperatures zone higher than according to technical regulations. Thus, catalyst life time may be considerably decreased. Many of chemical processes have a complicated conversions mechanism. As reactions passing velocity depends on temperature, temperature increase may cause by-products formation. For some chemical processes there are critical points that cannot be exceeded. Control loss for an object can provoke a thermal explosion. All reactors possess a great mass, i.e. they are very inert. In case of ignition, fire extinguishing measures are vain.

Other means of temperature measurements, omitting the direct thermocouple contact with reaction mixture through a pocket, are impossible as all space (tube and inter-tubular) of shell-and-tube reactor has temperatures profile non-uniformity in longitudinal and cross-section. Using the mathematical model, we have possibility to determine tubes size for temperature measurement in reaction zone.

**Notations:**

\(C\) – concentration, mole/m³; \(c_p, c_{p,T}\) – specific heat capacity of reaction mixture and heat carrier accordingly, J/(kg·K); \(D_{ef}\) – effective diffusion coefficient,
m²/s; \( d_{eq} \) – size of catalyst grains, m; \( d_{eq} \) – external diameter of reactor tube, m; \( d_{tube} \) – internal diameter of reactor tube, m; \( F \) – calculated area of heat transfer surface, m²; \( \Delta H \) – thermal reaction effect, J/mole; \( K \) – heat transfer coefficient, W/(m²·K); \( k_0 \) – pre-exponential factor in reaction rate equation; \( l \) – coordinate along reactor tube, m; \( Q_i \) – heat reactor power, J; \( r \) – radius coordinate of reactor tube, m; \( R \) – universal gas constant, J/(K·mole); \( T, T_T \) – temperature of gas mixture and heat carrier, K; \( T_{av} \) – average layer temperature, K; \( \alpha, \alpha_T \) – heat transfer coefficient of mixture in tube space, of heat carrier in inter-tubular space accordingly, W/(m²·K); \( \delta \) – thickness of reactor tube wall, m; \( \varepsilon \) – catalyst porosity; \( \varepsilon_{therm} \) – catalyst porosity in tube with a thermocouple; \( \lambda_{ef} \) – effective coefficient of heat conductivity, W/(m·K); \( \lambda_w, \lambda_{\phi} \) – heat conductivity of reactor tube, W/(m·K); \( \rho_{mix}, \rho_T \) – reaction mixture and heat carrier density accordingly, kg/m³; \( \tau \) – time, s; \( \nu, \nu_T \) – gas mixture and heat carrier velocity, m/s; \( \nu_{v, nb} \) – volume of gaseous nitrobenzene passed through catalyst per time unit, m³nb/(s·m³cat); \( \omega_k, \omega_d \) – reaction velocity kinetic and intra-diffusion regions, mol/(m³·s).  

Indexes: L – high temperature synthesis; N – low temperature synthesis; nb – nitrobenzene; an – aniline; h – hydrogen; f – initial parameter value.

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PRODUCTION OF GRANULES WITH SPECIAL PROPERTIES IN SMALL-SIZED VORTEX DEVICES

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Article is devoted to a feasibility study of the special properties of granules in a small-sized vortex device. A new way to create granules of porous structure was
proposed. The experimental investigations of porous layer creation conditions on the surface of granules were conducted. The efficiency of the technological scheme and equipment in its structure were proved.

Keywords: porous structure, vortex streams, granules

INTRODUCTION

The most simple in manufacture and using of industrial explosive agent is porous ammonium nitrate (PAN). PAN is also a basic for production of other explosives.

The most common way of PAN production is based on mixing ammonium nitrate melt with porosity generation and gas generation impurities, followed by granulation. Gas generation and porosity generation impurities promote the formation of porous structure of PAN granules, which increases of absorbing and granule keeping ability. While the tower method of production has significant defects: cumbersome equipment, the significant costs of its service and repair, impossibility to create intensive hydrodynamic within the tower [1]. Creation of new PAN industries based on tower method requires considerable material and labor costs. Also Gas generation and porosity generation impurities that are part of PAN, reduce environmental PAN indicators.

Today for blasting is used standard ammonium nitrate, which was established for the needs of the agricultural sector. This nitrate is less expensive than PAN, but relatively less effective.

Currently, the leading overseas companies with produce nitrogen fertilizer granules and porous structure granules have mastered granular product release, which has increased quality indicators, and therefore granulated products produced in Ukraine may lose the market. For high quality products should be used new technological principles that create the structure of granules in the forming process, which can not provide the tower method of ammonium nitrate production [2, 3].

AIMS OF THE STUDY

The purpose of the work is a feasibility study for the establishment in Ukraine of modern highly efficient and economical production of porous ammonium nitrate
(PAN), which is currently absent. Development of new production will allow for mining and processing plants, quarries and other companies where conduct blasting operations with low-cost industrial explosives (PAN produced by Russia is used in 80% of industrial explosives). This issue becomes even more pressing due to the fact that the international community plans to shift production to lime ammonium nitrate, which is not explosive.

**RESEARCH METHOD**

The formation of porous structure of PAN granules conducts on the granulation of ammonium nitrate stage. For porous surface layer getting there is applied a compact vortex type granulator with a variable height cross section of the working space (Figure 1).

The granulator work is based on new way, which was put to get granules of porous structure [4]. It was based on improving the flow dynamics of granules, which provides the increasing of monodispersion granules, which are grow in the vortex layer and uniformity of size distribution of the finished product. Thus, granules with causing solution are free from surface sealing layer, the conditions of freed moisture out on the surface of granules are created out, there is a porous structure of granules. The granules receive extra weight through the mud that settles on their surface.

The process of granulated ammonium nitrate getting in the vortex apparatus of combined type is endothermic and takes place during deposition on solids drops of solution with concurrent crystallization.

![Figure 1. Constructions of small-sized vortex granulators:](a) (b) (c)
The porous structure of granules production by wetting granules with given quantity of moisture before entering the working volume into the balanced layer and the beginning of contact with high-temperature heat transfer medium provides simultaneity of drying process and porosity generation, to reduce the residence time in a fluidized layer of granules to the minimum necessary, and consequently, the strength of granules saving without destroying the internal crystal structure. The uniform layer of liquid material on the granules surface getting with its previous moistening allows to do the principle of uniformity the main point of which is during the implementation process of porosity generation there is a need to achieve uniform forces that arise in the interaction of damp granules and axisymmetrical eddy of heat transfer medium on each granule.

It is necessary to achieve minimum impact of hydrodynamic regime of the granulator working on initial core granules strength and enhance on the keeping granules ability regarding liquid fuels (for example, solar oil), as this indicator is the main quality characteristic of PAN [5-8].

The proposed method and compact granulator for its implementation to improve the effective of heat and mass transfer processes and porosity generation on the granules surface, the uniformity of their growth and increase the rate of granules formation with a uniform porous layer of dried liquid material in a range of sizes and masses, which provides the increasing of grain size material monodispersion and improve the quality of the final product.

A designed method to obtain layer of porous structure of any liquid material that becomes a prerequisite for bilateral and multi-grains in the volume of one device, on the granules surface.

**RESEARCH RESULTS**

Experiment results define the beginning of monotonous decrease of strength granules with increasing the residence time in the apparatus of its starting value of 7-
10 minutes in dependence on the characteristics of raw materials. Thus, there is a need to reduce the granule’s residence time in the work area of vortex granulator at least by a certain date. This is achieved by using the active turbulent vortex gas flow in granulators, which enables to increase the removing of moisture intensity from the granule and complete the process of porous surface layer creating to the core granules destruction. The creating of vortex fluidized bed with small intensity leads to the increasing time necessary for drying granules to given moisture; granules due to long-term collision between themselves and the walls of apparatus lose their strength or completely destroyed. The research results are shown in Figure 2 and Figure 3.

Figure 2. The dependence of the granule’s strength and residence time in the vortex fluidized layer

The experimental data (Figure 4) also demonstrate the increasing of the granule keeping ability with time, but the mechanism of this increase in time change. At the initial stage (10 minutes) the increasing of the granule keeping ability occurs through the creation of its porous surface layer and pore volume increase. Granule has an integral structure with a clearly expressed form (Figure 3, zone I). After a specified time the specific surface area of granules increases due to its destruction. There is cracks and chips on the surface of granules (Figure 4, zone II). When the residence time of granules in the vortex fluidized layer is 35-37 minutes there is monotonous
decreasing of the granule keeping ability due to the total destruction of its core. The granule has incorrect form, significant cracks and chips (Figure 4, zone III).

![Graph showing the dependence of relative granule's strength on vortex gas flow velocity](image)

**Figure 3. The dependence of the relative granule’s strength on the vortex gas flow velocity**

The analysis of PAN samples, which are received from domestic raw materials and Russian analogue (Figure 6-8) have showed the following.

All samples of porous surface layer have almost similar structure (the received samples in the vortex granulator with an identical strength and keeping ability are investigated) with the Russian analogue, which confirms the high quality of granules. (Figure 9). Analysis of elementary chemical composition of samples by atomic absorption method in graphite electrothermal and flame atomizers has showed the presence aluminum and manganese atoms in the Russian sample, which are part of gas generation and porosity generation impurities. The absence of these elements in received PAN by no-tower method while maintaining the basic parameters demonstrates the applicability of such technology in production.
Figure 4 – Dependence of the granule keeping ability from its residence time in the vortex fluidized bed

Figure 5 – The samples of granules (according to data of Figure 4):
   a) zone I; b) zone II; c) zone III

Figure 6 – The analysis results of PAN, which received by no-tower method (as recycled granules of ammonium nitrate by "Exactly Nitrogen", Rivne production).
Figure 7 - The analysis results of PAN, which received by no-tower method (as recycled granules of ammonium nitrate by “Dnipro Azot”, Severodonetsk production).

Figure 8 - The analysis results of the Russian analogue PAN

Figure 9 - Section of granules which are obtained in the vortex granulator: 
a) according to Figure 6, b) according to Figure 7; 1 - the granule core, 2 - porous surface layer
CONCLUSIONS

During heat treatment nitrate granules are less strong than before heat treatment. Reducing the mechanical strength of granules is directly dependent on the number of cycles of heat treatment of which they were subjected. In addition, great importance is the presence these or other impurities in nitrate, most likely ammonium nitrate granules lose strength that contain no extraneous impurities [9].

The propose way of obtaining the structure of porous granules by heat treatment in combination with moistening granules allows, by varying temperature heating and cooling and cyclical wetting granules, receive the product with desired quality characteristics.

As a result, the comparative study of consumer properties of the product received by no-tower method with the Russian analogue is shown that the keeping ability of PAN on solar oil ranges from 9-17% at the strength of granules to 500 g/granule, and the keeping ability of Russian analogue - 6.8% at average strength of granules 300 g / granule. Experiment results are applied to the development of technological parameters of a porous structure of granules. The proposed technology of PAN (Figure 10), which based on studies, provides the keeping ability, strength and grain size of granules according to the regulations.

The resulting product due to comparatively low temperature of process in the vortex granulator (at 30-50 °C in comparison with the method of manufacturing tower) and no modification transformations provides the presence of air bubbles in granules core, which promote explosive properties of product with preserving mechanical strength and decreasing the number of heat treatment cycles.

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NEW METHODS OF NON-INVASIVE MEASURING OF VIBRATIONS AND DISPLACEMENTS FOR THE MONITORING OF THE STATE OF COMPLEX ENGINEERING STRUCTURES AT THE DISTANCES ABOUT 1 KM

The paper gives the estimate of the main difficulties and outlooks of the development of precision measuring of displacements and vibrations with the goal of constant monitoring of the state of complex engineering structures such as: hydroelectric power plant, dams, bridges and so on.

Key words: radio techniques, displacements measuring, vibration meters.

Precision non-invasive measuring of small vibrations and displacements are necessary, particularly, for monitoring of the state of bridges and dams. This task is resolving with radio technical or with optical methods, which are based at the constant velocity of the electromagnetic emitting, including light [1–3]. Optical devices are more precise, but they demand straight visibility of the object, absence of optical disturbances, and constant value of the light velocity in the atmosphere. These conditions as a rule are not achievable in the open atmosphere. Radio frequency measurers has smaller accuracy and bigger distance, and they also has sufficient dependence of the measuring results on the reflecting features of the object and its shape, on the electro conductivity and the presence of the around subjects. For the realization of this advantage it is necessary to increase abruptly the accuracy of the measuring with radio technical method.

We discovered the following disadvantages of the best from the radiofrequency measurers [1].

1. Insufficient accuracy can be explained with different contribution of the different receiving channel of the receivers.
2. Time indications containing in the signal modulation does not provide effective and precise algorithms and methods of their determination.

The elimination of the different delays of the receiving channels is possible in the case of using of the same leading frequency. However in this case it is difficult to segregate the signals from the two transmitters. Therefore we propose executing of such modulation which preserves its individual time indicators even after the adding of the different signals.

The structure of the proposed measurer is shown at Figure 1. The possibility of the segregating of the received signals is provided with the using of unique modulation functions in each transmitter.

The transmitters radiate radiofrequency signals at the same leading frequency but with the individual modulating function. Each from the two modulation functions contains periodically incipient time indications from the inner generator. These generators act to the inputs of the transmitters and create different and good distinguishable modulation of the transmitted signals of the same leading frequency. The transmitted signals can be received by the receiver in the form of the sum with the coefficients and with delays depending on the distance between the transmitters and receivers. In the received mixture of these signals it is necessary to distinguish their specific time indications from each other. For this porpoise special methods realized in the devices contained in each processing channel are used.

We propose for the effective measuring of the time parameters the following decisions: a) using of the correlation method of the automatic phase tuning of the identical generators at the receiving side to the phase of the according component of the received signals; b) using of the specific method of modulation.

The choice of the modulation method has influence to the effectiveness of action of the mean of optimal tuning. The signal envelope function can contain the time indication. The difficultness of the precise determination of this time indication is in the following. If the dependence of the correlation function on the coincidence of the phases is sharp, then it is, as a rule, non-monotone. If it is monotone, then it is not sharp. With non-monotone dependence it is difficult to provide the stable working
of mean of the automatic optimization. With not sharp dependence it is difficult to provide high accuracy of this mean. The truth of this statement has been proved with the modelling.

The sum of the pseudo-random signal and harmonic one is applied to the input of the correlator. The same sum with some delay is supplied to the second input. If the delay or forestalling of the second signal relatively to the first one inside a quarter of period of harmonic function, then the output signal of the correlator changes from 0 to 0.5. The derivative of this signal on phase can be used for the determination of the value and sign of the tuning error. It provides the possibility of the automatic optimization. Owing to the contained signal of pseudo-random modulation the additional component of the output signal of the correlator changes from 0 to 0.5 with sharp increasing of the result to the maximal value under the conditions of the most accurate tuning. Even with small error of the tuning this component is close to zero. Taking into account the two proposed modifications, the measurer consists of the two complexes, and on of them is shown at Figure 2. At the side of each transmitter we propose the using of the two individual kinds of amplitude modulation, for example, one is providing the smooth modulation with sine low with unique frequency, and the other one is unique pseudo-random set with unique discrete step of changing. The both of these modulations are reproduced at each receiving side, both at the first and at the second receiver. Each receiver analyses the mixture of the received signals and accomplishes the tuning of the two couples of the connected generators to the couple of the components of the received signals.
The proposed method effectively provides safe and precise working of the mean of the extreme tuning, because it provides simultaneously smooth dependence of the
output signal of correlator from the error and sharp increasing of this signal when the tuning with the high accuracy. The realized modulation with the pseudo-random signal must be in such frequency band so as it would can pass all the transmitting and receiving channel without disturbances.

The distinctive features of the development are the following:

1. The straight visibility of the sources and receivers is not necessary.
2. The reflectance or dispersion of the signals is not used.
3. The dependence of the accuracy on the weather changing of the atmosphere characteristics is decreased in comparison with optical measurers.

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OUTLOOK OF THE DEVELOPMENT OF ROBOTIC TRAINING STANDS FOR THE HIGHER PROFESSIONAL EDUCATION IN THE FIELD OF ROBOTICS, AUTOMATION AND MECHATRONICS

The paper gives the estimate of the main prospects of the development of
training stands for the higher education of the students in the field of the automation, robotics and mechatronics. The paper gives the results of the researches of the standard hardware and the aspects of the broadening of the possibilities with the use of meccano Lego Mindstorms NXT 2.0 for the researching and training goals. The paper discusses the approaches to the assembling and programming in this base.

**Key words:** robotics, mechatronics, automation, control in engineering systems, automatic machinery

At the initial stage of the robotic development the industrial manufacturing was the main field of their application [1–4]. Robots are also usable in the conditions where human working is restricted or not desirable, i.e. in space [5, 6], aviation [7, 8], submarine [9, 10] and army [11–13]. Now robotics elements become propagate in the everyday life [14]. Impressive results are achieved in the field of the creating of androids (human-like robots) [15]. These robots often accomplish amusing, demonstrational and training functions. In the nearest future different assistant robots with human appearance will appear. They will essentially lighten human life and professional working. They will help in work of invalids and workers of dangerous and hard professions, and also of professions demanding especially precise manipulations, таких, such as surgeons, collectors of microcircuits and integral optics and so on.

From all the spectrum of the existing robotic means we can separate special class of means for the education goals. It is various moving platforms, assortments of mechanical and (or) electronic components, designing set of robot elements [16]. All these means eliminates from the robot creating process labor-intensive stages, which demands a lot of knowledge. For example, there is no necessity in developing and producing of mechanical assemblies and creating of electronic units from the beginning. Nevertheless, the wide range of the interesting tasks remains and their decision leads at the end to the creation of the robot.

Robotics as a science connected with the development and creating of robots is based on such disciplines as mechatronics, electronics and programming. Specialist developing robots even in the area of the collection them from assortment of the
details inevitably meets various problems from these fields. The successful overcoming of them increases the knowledge which is relevant in the modern world with its electronic and digital technologies. In dependence on the complexity of the resolving tasks the obtained knowledge can to correspond to the user level (the possibility of the controlling of electronic devices), and to the initial level of the developing engineer.

The accomplished analysis of the review of the various platforms and assemblies of the details allows us to distinguish the designer’s assembly Lego Mindstorms NXT 2.0 [17]. That is because it has most significant training possibilities in the range main directions of the robotics: mechanics, electronics (in the smaller limits) and programming. Researcher using simple visual programming media (standard software) can animate self-made robot even without extreme high professional skill (for example, schoolboy). At the same time, the using of the additional means of the development of robot controlling algorithms gives the possibility of essential increasing of the complexity of the resolving tasks and to address them to the schoolboys and students.

The confirmation of the big education possibility of the assembly Lego Mindstorms NXT 2.0 is in its wide using in schools, institutes and universities.

Bellow we sequentially discuss the architecture of the assembly Lego Mindstorms NXT 2.0 and necessary instrumentation for robot creation on this base.

The researching of the basic possibilities of the robot assembly Lego Mindstorms NXT 2.0.

In accordance with the three main basic disciplines of the robotics the assembly Lego Mindstorms NXT2.0 can be divided into following parts: 1) mechanical; 2) electronic; 3) programming.

As the manufacturer of Lego announced it is destined for children more then 10 years old. In accordance with this goal, the standard approach of the using of this assembly is characterized with big attention to the resolving of the mechanical and programming tasks.
It is necessary to point that the proposed possibilities assume redistribution of the key points which can be accomplished in accordance with education goals. For example, standard and (or) slightly modified robots created with the assembly can be demonstration mean for the developing and tuning of algorithms for the programming training. For these purposes non-standard developments can be more proper [18] (which are not discussed in this paper) in compare with the standard visual programming media NXT-G.

The proposed electronic means of the assembly support the realization of rather complex algorithms for graduate classes’ schoolboys and for students. But these possibilities are not the limit. The electronic part of the assembly can be broadened with the additional sensors complex [19] and driving mechanisms. The development and creating of such devices can be itself training task in the field of electronics.

**Mechanical part** of the assembly consists of the following elements: different length beams, corners, various fixings, pinions, axes, tractions, wheels, caterpillar tracks, picturesque elements and others. The total number of the elements is 916. The presence in the assembly of various pinions and transfer mechanisms together with three servomotors (see below) provides the realization of many interesting animated robots. Robots can move with various ways, move objects and accomplish some other work. In the case of the creation of large robots which is possible with the assembly, the designer should care about the stability and harshness of the mechanical construction. It is necessary to predict the construction conduct during the accomplishing of the different actions. For example, during the movement of the robot or while overcoming the obstacles, robot must not turn over or destroy. In such tasks it is important the correct choice of the chassis type (wheel, caterpillar), and correct suspension bracket. Unavoidable wrecks and the next action for their removal with the construction changing swiftly teach the students to use successful decisions. Walking robots are especial case for which the accuracy of the workup of the mechanical construction is necessary. Cases of microcontroller, servomotors and sensors are accomplished by such way that they allow building them into the unit robot construction with the using of standard fixings. The using of the sensors
demands of the workup of the way and place of their fixing, providing the best conditions of the information collection. For example, fixing of the color sensor must be accomplished at the distance about 1 cm, under the right angle to the object, which color is determined.

The main destination of the **electronic part** of the assembly is to allow the possibility of the robot controlling, support the realization of various algorithms of actions by means of servomotors on the base of the collecting information.

The electronic part includes the following elements: microcomputer NXT; two touch sensors; ultrasonic sensor; color sensor; three servo motors; seven cables for the connecting of sensors and servomotors; USB-cable for the connecting with the microcomputer NXT to personal computer.

**Microcomputer NXT 2.0** is the main intellectual element of the assembly allowing to animate the robot and accomplish various programmed actions. The structure similarity of the controlling unit NXT with microcomputer allows treating this device as microcontroller. It has processor (two microcontrollers), display, keyboard (consisting of four buttons), input-output ports for connecting of peripheral devices (sensors, servomotors), communication interfaces (USB and Bluetooth).

Hardware of microcomputer NXT 2.0:

- Main controller – ARM7, 32 bits, 256 KB FLASH, 64 KB RAM;
- Subsidiary controller – AVR, 8 bits, 4 KB FLASH, 512 B RAM;
- USB-port (12 Mbit / s);
- Wireless channel Bluetooth (Bluetooth Class II v2.0);
- 4 input ports for sensors;
- 3 output ports for driving motors (servo motors);
- LC-display (100x64 pixels);
- Keyboard (4 buttons for menu access);
- Loud-speaker;
- Standard feedings – 6 elements AA (LR6).

**Touch sensor** allows determine current position: touch sensor is closed or it is open, and also the fact of touching or release can be distinguished.
Touch sensor can be used in such task resolving as determine the moment of the meeting the obstacle, counting of the number of interaction with some objects. The sensor can be used as additional interface between human being and robot, for example, it can be used as a button activating some robot function.

**Ultrasonic sensor of the distance** allows robot to “see” outward things. The sensor is working according the principle of ultrasonic location, i.e. it calculates the distance to the object from the time delay of the ultrasonic pulse spreading. The sensor can measure the distance in the range from 0 to 255 cm with the accuracy ±3 cm.

It is necessary to consider that small objects has small reflecting surface, and objects made of soft material essentially absorbs ultrasonic pulse. It leads to sufficient decrease of accuracy of the distance determination and even to invisibility of such objects. Two of more ultrasonic sensors working closely to each other can prevent their normal functioning.

Searching of the objects, fixing of the movement, overcoming of obstacles, orientation – these are the examples of the large circle of the tasks, for which resolving the ultrasonic sensor is necessary.

**Color sensor** combines the two functions: color detector and measurer of the light. Besides, this sensor can be used as a light source. With it six colors can be measured, the intensity of the surrounding light can be determined or the intensity of the reflected light which is emitted by own radiator of red, green or blue color.

The sensor is good approach to the task including to the program of many competitions of robots: speed following of the black line [20]. Naturally that the using of the sensor is not restricted with only this application.

**Servomotor** is executive mechanism, allowing robot moving. Velocity of moving can be tuned by means of assignment, by software of various power.

Each servomotor contains sensor of rotation. The presence of such sensor allows assign the value of pivotal displacement with the accuracy of 1 grade and by this mean to control the movement precisely. Another advantage of the built sensor of rotation is supporting of the automatic synchronization of the two servomotors which
provides the precise movement of the robot along the straight line.

Some sufficient difficulties while operating with the electronic elements of the assembly must not occur. The designer should only accomplish the following simple rules for the connecting of sensors and servomotors to microcomputer NXT: 1) servomotors are connecting to the ports A, B and C; 2) sensors are connected to the ports 1–4. It is the recommended way of the connecting to of the periphery devices to the microcomputer NXT 2.0.

The main tasks of the **programming stage** of the robot creation are the development of the algorithm of its conduct, its realization by means of the programming media, loading of the program of robot into the microcomputer NXT and start to its accomplishing.

All these tasks are resolving by means of programming part of assembly consisting of built microcomputer NXT, software, program developing media and the programs themselves.

Built into microcontroller NXT software can be treated as operational system of the robot, which realizes the following functions:

- Organizing of the file system (supporting files are executed ones *.rxe, voice and image files);
- Accordance of the users interface by means pf display and keyboard giving the access to many functions with the aids of menu;
- Accordance of the communication interfaces USB (with PC) and Bluetooth (with PC, mobile phones with the support of Java-application, other microcomputers NXT);
- Execution of the robots programs created in the developer medium and loaded by means of communication interfaces or prescribed with menu, etc.

The standard medium of the development NXT-G (Lego) realizes the approach of visual programming based on the forming of the sequence of actions from the ready units and setting of their parameters. More detailed the programming medium NXT-G will be discussed in the next paper.

In the conclusion it is necessary to point out that the discussed assembly can
make up the hardware base for the student education to robotics, and also present necessary minimal (and not most effective) software for the further working, which must consist in the development of software.

Thus for students the broad field of actions is open, which contains development of assembly of sensors and drivers of robots, the development of its action algorithms, developing of programs and their tuning.

We observed several software kinds for the controlling of said kinds of robots and at the base of the first analysis of the experiments we recommend the using of free software SciLab for Linux.

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Gorbunov, A.A., Fedorenko A.S., Malkov M.A., Ashryatov A.A.

THE ANALYSIS OF PHYSICAL PROCESSES IN DISCHARGE PLASMA OF DIRECT CURRENT FLUORESCENT LAMPS AT CHANGES OF TEMPERATURE CONDITIONS

Mordovian State University named after N.P.Ogarev

The article deals with the analysis of physical processes in discharge plasma of direct current fluorescent lamps, operating at changes in temperature conditions, the main ones are: the formation of ions in the positive column plasma; leaving of the ions from the plasma volume of unit length as a result of the movement of mercury
ions to the tube side; the diffusion of mercury ions to the cathode through the longitudinal potential gradient; the diffusion of neutral atoms of mercury in Hg + Ar mixture from the hot zone into the cold one; mercury evaporation from the surface of the envelope in the lamp volume, the rate of which depends on the temperature of a part of the envelope surface.

Key words: the analysis, mathematical model, physical processes, fluorescent lamp, mercury quantity, mercury transport, temperature condition.

To create a mathematical model (MM) of the method for determining mercury amount in fluorescent lamps (FL) [1], based on the use of longitudinal cataphoresis processes (movement of mercury ions to the cathode during FL operation from the direct current circuit) and the transport of mercury neutral atoms for the formation of gradient of their concentration in the positive column (the formation of the cold zone with the temperature $t_{cz}$ in the cathode side of the FL positive column (PC) and the hot zone with the temperature $t_{hz}$ in the PC anode side), an intensive analysis of physical processes in the discharge plasma of FL is required in order to choose the most important ones for consideration in MM.

The formation of ions in the PC plasma of FL is mainly the result of the stepwise ionization of mercury atoms through $6^3P_0$ and $6^3P_2$ long-lived metastable levels and of the associative ionization at collisions of excited atoms at $6^3P_{0,1,2}$ levels. The distribution of the concentration of mercury ions on the tube radius with the regard for the quasineutrality of the plasma is close to the radial distributions of electron densities and concentrations of excited atoms.

The average number $v_i$ of formed ion-electron pairs (during one second per electron), under the assumption of its independence from radial position, in accordance with the theory given by Schottky is determined with the formula [2]:

$$v_i = \left( \frac{2.4}{R} \right)^2 \mu_i \left( \frac{kT_e}{e} \right)^2,$$

where $\mu_i$ – the mobility of mercury ions in the gas, m$^2$/V s;

$T_e$ – the electron temperature, K;

$R$ – the inner radius of a tube, m.
To determine \( n_e \approx n_i \) and \( T_e \) it is possible to use the approximations of the results of our probe measurements of \( n_e \) and \( T_e \) in the function of \( P_{Ar}, P_{Hg} (t_{hz}), I_l, r/R \) (\( n_e \) – the electron density, \( n_i \) – ion concentration, \( P_{Ar} \) – argon pressure, \( P_{Hg} \) – mercury vapor pressure, \( t_{hz} \) – the hot zone temperature, \( I_l \) – lamp current, \( r \) – the distances of the considered volume of plasma from the tube axis) [3]. The replacement of \( t_{cz} \) for \( t_{hz} \) in approximation formulas is caused with the peculiarities of the developed method for determining the amount of mercury in FL.

To determine the concentration of excited atoms of mercury at \( 6^3P_{0,1,2} \) levels the accurate approximations of excitation cross-sections of these levels in \( T_e \) function obtained experimentally should be applied, as well as calculated transition probabilities (per an electron and an atom) to these levels from the ground state \( 6^1S_0 \) of mercury in \( T_e \) function, they are available in the form of tabular data [3].

Leaving of the ions from the plasma volume of unit length is caused with two processes: the movement of mercury ions to the tube side due to ambipolar diffusion of ions and electrons (radial electric field for standard FL of 40 W with a tube diameter of 38 mm is equal to 8 W [2], and the potential gradient is about 4 V/cm) and the diffusion of mercury ions to the cathode due to the longitudinal potential gradient (about 1 V/cm for FL of 40 W).

The main parameters affecting the mobility of mercury ions in FL, others than the potential gradient, are \( P_{Ar} \) and \( P_{Hg} \) pressures or \( Ar (n_{Ar}) \) and \( Hg (n_{Hg}) \) concentrations.

The ions mobility in other gas is considered in [4], in this case the function of velocity (energy) distribution of the ions is characterized mainly with elastic ion scattering on atoms (in our case, of \( Hg \) ions on atoms of \( Ar \)). Simultaneous allowance for polarization capture and small-angle scattering gives the formula for ion mobility \( \mu_i \), divided by the density of atoms \( N = 2.69 \times 10^{19} \text{ cm}^3 \):

\[
\mu_i = \frac{35.9}{\left( \frac{\beta}{m_{np}} \right)^{1/2}},
\]

(2)

where \( \beta \) – the atom polarizability in atomic units;
\( m_{np} \) – the ion and atom reduced mass in proton mass units;

dimension \( \mu_i \) – \( \text{cm}^2/(\text{V} \cdot \text{s}) \).

Taking into consideration that \( n_{Ar} \) is 200 ÷ 300 times (depending on the temperature of the envelope) as many as \( n_{Hg} \), the influence of \( Hg \) atoms on the mobility of \( Hg \) ions can be neglected.

The mobility of mercury ions in \( Ar \) (at \( P_{Ar} = 133 \text{ Pa} \) and the temperature of 300 K) is equal to 0.140 \( \text{m}^2/(\text{V} \cdot \text{s}) \) [2,5].

The distribution \( n_{Hg} \) along the tube radius under the influence of the radial distribution of gas temperature (argon) \( T_r \) and \( Hg \) ions transport to the side during the joint action of ambipolar diffusion and diffusion of neutral \( Hg \) atoms from the side to the axis is determined by the formula [3]:

\[
n_{Hg}(r) = 9.66 \cdot 10^{18} \frac{P_{Hg}}{T_r} - 0.445 \left( 1 - \frac{T_{Hg}}{T_r} \right) n_{Hg} \frac{T_r}{T_R},
\]

where the index «\( r \)» determines the value of quantities at a point, which is distant from the tube axis at a distance \( r \) (the current radius), and the index «\( R \)» indicates the temperature at the inner surface of the lamp.

Longitudinal potential gradient can be calculated by the formula [3]:

\[
E = \sqrt[\mu_e]{\frac{W_e}{\mu_e}} = 2.5 \cdot 10^7 \sqrt[\mu_e]{\frac{W_e}{\mu_e}},
\]

where \( W_e \) – overall energy loss of electrons, \( W \);

\( \mu_e \) – the electron mobility, \( \text{m}^2/(\text{V} \cdot \text{s}) \).

When calculating \( W_e \) the energy loss of electrons are taken into consideration: for the formation of radiation (\( W_{rad} \)), elastic collisions with \( Ar \) atoms (\( W_{eAr} \)) and \( Hg \) atoms (\( W_{eHg} \)), as well as for ionization, including associative one. Collisions of electrons with both \( Ar \) atoms and mercury atoms are taken into consideration when calculating \( \mu_{er} \). The formulas for calculation of these and the above mentioned values are given in [3].

The calculation of the diffusion of neutral mercury atoms through a mixture of \( Ar + Hg \) with temperature gradient is a great challenge because of significant difference of \( n_{Ar} \) and \( n_{Hg} \) and a large difference in atomic masses (\( m_{Hg} \approx 5m_{Ar} \)).
probability of $Hg$ ions loss as a result of collision with $Hg$ atoms is very low and such losses can be neglected.

The diffusion of neutral $Hg$ atoms through an inert gas ($Ar$) can be also effected with thermal diffusion [6], which consists in the fact that during the formation of a temperature gradient in a mixture of two gases the heavier and larger gases ($Hg$) show a tendency to move in the direction of decreasing temperature. Quantitatively, this effect depends on $Hg$ and $Ar$ mass ratios, their diameters and volume parts of heavy and light gas. The necessity to account of this effect is subject to further consideration.

To determine the rate of mercury evaporation ($\nu_{Hg}^eV$), using data from [7], we found a formula:

$$\nu_{Hg}^eV = 7 \cdot 10^{-8} e^{0.0632T}$$

where $T$ – the temperature of mercury in the liquid phase, K.

The described analysis with use of modern mathematical instruments will make it possible to create a theoretical MM for the calculation of mercury amount in FL of different types and sizes.

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WAYS OF IMPROVE THE EFFECTIVENESS OF OPERATIONAL ANTI-ELECTROSTATIC CONTROL IN PROTECTIVE CLOTHING

South-Russian State University of Economics and Service

Paper is devoted to the problem of electrostatic safety on spark intense objects. Presented one of the solutions for monitoring the parameters of the electrostatic field.

Keywords: electrostatic safety, electrification of materials, static electricity, monitoring of parameters electrostatic field.

The analysis of statistics of the reasons of fires and explosions as a result of a detonation of steam-air mixes, in oil and gas industry as most intensively progressing, showed that the reason in 27% of cases was the static electricity [1]. Electrization of clothes is inevitable and is a consequence of constant interaction of materials with external subjects, with each other and an integument [6, 7]. Consequently, for protection of the person against emergence of emergency situations, owing to formation of an electric discharge, it is necessary to know rate of these electrostatic charges in places of their highest concentration. This requires operative devices of monitoring of parameters of the electrostatic field, built in constructive elements of special protective clothes, and globally signaling (not only for 1 person) about excess of the set maximum permissible values are required.

An analysis of domestic and foreign literary sources shows that the industry produces devices for measurement of static electricity (for example, CT-01, ETS-216, ИЭСП-01 and others) [1], and also monitoring (EM Aware family devices)
electrostatic discharges [2, 3], having the function of the light and sound alarm system at excess of the set threshold. Also, these devices have an interface for optional connection to a centralized computer system of data collection [2, 4, 5].

All above-stated devices have one serious shortcoming their size and weight characteristics don't allow to build in them constructive elements of special protective clothes. And also don't possess possibility of a remote signal transmission about excess of parameters of an electrostatic field of the certain moving object (person) being in a dangerous zone, on the device signaling about electrostatic danger. The system which simplified scheme is presented on figure 1 can be one of possible versions of the solution of this problem. The system consists of two devices – the analyzer transmitter (at the left) and the receiver signaling device (at the right). The analyzer transmitter which is built in constructive elements of special protective clothes, contains the independent power supply, the sensor of an electrostatic field, the analyzer, the block of remote data transmission. The receiver signaling device established on spark stressful objects, includes the power supply, the block of remote receiving of data, a signaling device of electrostatic danger.

**Fig. 1 – the simplified scheme of system of remote control and the alarm system of electrostatic danger**

Here:

1 – sensitive element (sensor of an electrostatic field);
2 – the analyzer – compares the current value of controllable parameter to the set critical;

3 – the control block, in case of excess of the current value of the set critical – turns on the block of remote data transmission;

4 – the block of remote data transmission – in case of activating, transfers data on excess of critical value of controllable parameter to the receiver signaling device;

5 – stand-alone power supply;

6 – device case;

7 – the block of remote receiving of data – accepts data from all devices transmitters in a network;

8 – the alarm system block – at data acquisition about excess of the set critical values from any device, activating the local alarm system;

9 – a power supply;

10 – device case.

Such principle based on the offered device, will allow to react operatively to emergence on spark stressful object of potential electrostatic danger, warning the person about possibility of an emergency situation, owing to formation of an electric discharge.

References


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Abdullin A.A., Churagulov D.G., Samorodov A.V.

SOFTWARE AND HARDWARE CENTER FOR EVALUATION OF PUMPING UNITS WITH ELECTRIC DRIVE

«Ufa State Petroleum Technological University» Salavat branch

The work is dedicated to the development of hardware and software to evaluate the efficiency and the current technical condition of pump units with electrically driven.

Keywords: energy efficiency, neural network, hardware and software system, the spectral method.

Energy efficiency and conservation - a key sector for economic growth of any enterprise. In the technological cycles of oil and gas companies for moving fluids, usually used pump-compressor units with electric drive. They consume about 20% of all electricity generated in Russia. In connection with this increase in production
efficiency is directly related to the effective use of pumping equipment. Particularly acute problem for equipment that is morally and physically obsolete.

To evaluate the energy efficiency of equipment we offer hardware and software system, which on the basis of power consumption of the electric network and the net power expended in pumping the fluid will give the conclusion about energy efficiency equipment. If the evaluation of efficiency does not correspond to the normalized value, then further diagnosis is carried out pumping equipment with electric drive, in order to detect defects and the specific causes of low efficiency values.

On the basis of the sensor currents, voltages, pressures, and cost values will be computed consumption and the utility power.

Hardware and software system allows you to: monitor the efficiency of the equipment, as well as to evaluate the technical condition of the pump unit with electric drive and detect faults at an early stage of their development, without taking the unit out of operation.
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