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INFORMATIONAL SUPPORT OF CARRYING OUT EXPERIMENTS ON PRODUCING NANO-COVERINGS

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Abstract: *The given article considers the process of arranging informational support in carrying out experiments on putting nano-coverings on different materials. For putting nano-coverings, there is used special plant, which is given different modes of performance. For accounting all parameters and for accumulating the data, which characterize the results of the experiments, there is suggested an informational system which employs the data base designed for these purposes. The suggested informational system also allows processing the results of the experiments with the use of statistical methods. The article suggests an approach to defining the main requirements and functions of an informational system on the basis of functional simulation and considers the issues of its realization.*
KEYWORDS: FUNCTIONAL MODEL, DATA BASE, PARAMETERS OF COVERINGS, MODE OF PERFORMANCE

1. Introduction

Financing of the investigations and design in the area of nano technologies in different countries has recently been increased by several times, and the national programs of their development have been adopted in more than 30 countries all over the world. The progress in various spheres of industrial branch, including the aerospace industry, military, mechanical engineering, metal processing industries is connected with the discoveries in this scientific area. According to the preliminary experts' forecast the volume of production in the branch of nano-technologies will exceed one trillion of dollars after 10-15 years period [1]. Furthermore, the expected development of the world nano industry will be based on the fundamental of creating the efficient and competitive technologies of obtaining the nano-sized materials (powders, fibers, and pipes), nano-covering and nano-structural three-dimensional materials. The nano-technologies designed in the latest decades comprise such technology as the process of vacuum plasma deposition of nano-covering. The nano-materials conventionally involve disperse and massive materials with some content of structural elements (grains, crystals, blocks, clusters), if their geometrical sizes do not exceed 100 nm at least in one dimension and possessing the brand new properties, and functional and operational features.

An increase in the vehicles mechanical components durability is one of the primary tasks for aerospace mechanical engineering. This area is characterized with operation conditions of the highest dynamic loads, as well as possibility of erosion abrasive particles ingress in the friction knots [2]. The deeper investigation of tribotechnical processes taking place inside the vehicles limiting components as well as their controlling are the great reserves for the resource increase and upturn of the efficiency of machinery employment. The structure and the properties of durable covering depend in a great extent on the technique and technology of its employment. The methods of employment by the means of deposition are divided into two big groups: physical (PVD – physical vapor deposition) and chemical ones (CVD – chemical vapor deposition). There are a lot of varieties within these two groups.

All these processes are divided into two big groups: the processes utilizing the evaporation procedure, and the processes utilizing the sputtering procedure.

Among all facilities dealing with the sputtering procedure, the most widely used ones are the plants on the basis of magnetrons (MSIP — Magnetron Sputtering Ion Plating). In the process of implementing the high voltage in the atmosphere of inert gas (it is argon as a rule) the glow-discharge occurs. The inert gas ions from plasma usually possess the high energy and impact the target, inserted as a cathode. At the expense of impact impulse the release of the material takes place, and then it is sputtered escaping the intermediate liquid stage.

The magnetron method is the sub-kind of the cathode sputtering method, which assumes that the layer of plasma is formed at the surface of the sputtering cathode (the target) employing the crossed magnetic and electrical fields. The density of this plasma is significantly bigger compared to the common (non-magnetic) systems of cathode sputtering. Accordingly, there is a sufficient growth of the density of ion current on cathode and the velocity of cathode sputtering. The magnetron method allows applying the wide spectrum of covering of various metals and their compounds with the high uniformity of properties including the highly rigid durable coatings. The sputtered particles contain the neutral atoms on 75-95%, that is why the bottom layer (a detail, an item, a tool…) is heated faintly, and this permits to deposit the coatings on the detail having the low fusion temperature (low-melting-point metals and alloys, plastics, organic substances). The magnetron sputtering is supposed to be the prospective method and at the same time it is a method which has been well-tried and developed in the laboratory of vacuum technologies in the Institute of Transport Machinery Technologies in Riga Technical University.

2. Prerequisites and Means of Problem Solution

2.1. Experimental Plant for Applying the Coating

The research group of the Institute of Transport Vehicles Technology of Riga Technical University is dealing with the issues of applying thin layers (nano coatings) on different surfaces for long period of time. The experimental plant employed for applying coating presents the modified vacuum plant NNV-6,6-I1 implementing the technology CIB – condensation of the substance from the steam phase with employing the effect of ion bombing.

Two arc evaporators and one magnetron dispenser are used as the sources of evaporation material. The refined details subjected to evaporation are inserted into the plant camera. The plant is extracted into high vacuum, then final refining and heating the details up to the temperature of deposition takes place with the employment of the ion bombing effect. Then the plant is transferred into the mode of evaporation in accordance with the preset program, the required composition and properties of coating are determined by the materials of vapor source, magnetron target and gas, injected into the operating camera. The coating thickness is regulated with the help of power of vapor source and the length of evaporation process.

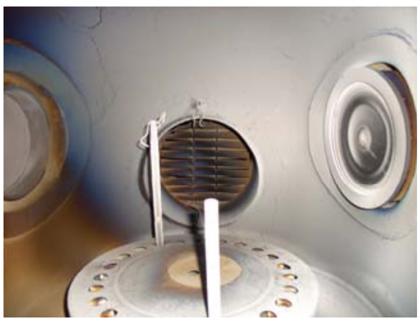

Fig. 1 Plant for applying the coating

The employment of different materials and injected gases in the process of evaporation allows obtaining the multi-component and multi-layer coatings, possessing the preset properties on section. So it is possible to obtain durable and corrosion-resistant, as well as ornamental coatings, and reestablish the geometrical sizes.

Fig.2. Stator blade of the gas-turbine engine after applying the coating

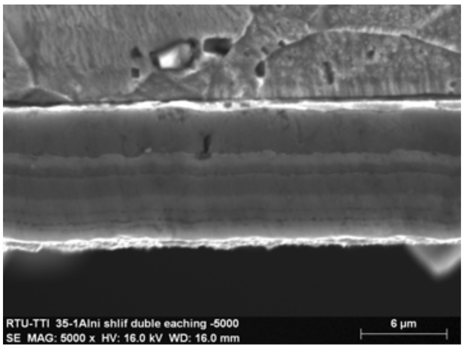

Fig.3. Structure of the multi-component multi-layer coating of the system

The diffractometer ADP-1 is used for evaluating the phase composition of obtained nano-coatings. Nevertheless the output analog signal was directed to the computer M-6000 and data plotter. The investigated detail of this diffractometer can be irradiated and rotated on the operating table for 60^0 at a pitch of $0{,}001^0$. Consequently, under investigation of one sample only, the massive of 60 000 signals, describing the deposition uniformity and coating structure is obtained. It is necessary to compare the amplitudes of output signals with the base (reference) values for determining the quality of coating with preset properties. The diffraction patterns and special tables are employed on this purpose.
The measurement of the following parameters is necessary for evaluating the quality of precipitated coating:

- coating thickness;
- microhardness of coating or composition of coating-backing, GPa;
- power of coating and backing adhesion;
- roughness of the surface with coating;
- coefficient of friction.

The below listed parameters can be shown for comparative characteristics of the sample parameter values before and after applying the layer:

- hardness;
- surface roughness;
- friction coefficient.

The measurement of values of the above listed parameters is done by the measuring devices (complexes) and the values are registered in the logbooks.

3. Information System Development

3.1. Analysis of Requirements to the System

The necessity of information support for implementing the experiments is determined by the whole range of reasons. Information on the results of the conducted experiments is kept separately; part of it exists in electronic form, and part in the hardcopies. It takes a lot of time to process the results and to determine the coating thickness according to the tables, and that is why the device, capable of transforming the analog signals from the diffractometer into the digital ones has been designed, and the data are registered in the special database; it is done on the purpose of computerizing the results processing.
The presented business requirement has been formulated for the system: the specialists of the research group need the information system capable of providing the registration and accumulating information on the conducted experiments, processing data, received from the measuring devices and the complex statistical processing of the obtained results.
This system allows increasing the quality of measurements processing, to register and store centrally the information on investigated samples, to take the statistical analysis of the obtained results.

3.2. Functional Model of the Coating Applying Process

The functional model of the coating applying process has been developed for finding out the full set of functions and tasks of the projected information system. The functional model in the framework of formalization allows gathering the information on the coating applying process in so called “information pile”. The functional model has been constructed on the basis of the system structural analysis with implementation of the method IDEF0 (Integration Definition for Function Modeling) [3].

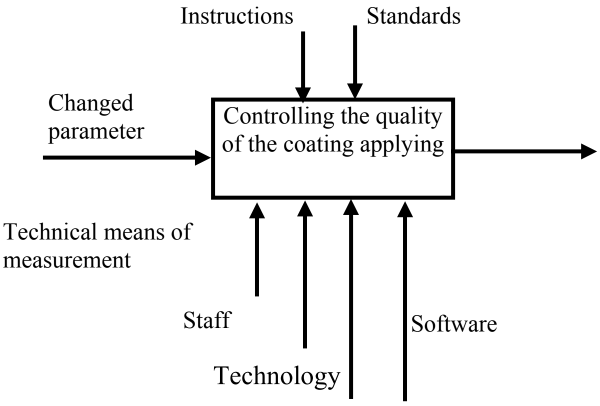

Fig.4. Functional model of the coating applying process

The received model is put into details in accordance with the tasks and it is possible to sort out the following functional blocks:
1 – *prepare the sample*; the sample is prepared for experiment, the measurements of parameters are found out and entered into the database.
2 – *apply the nano-coating*; the sample is put into the plant, the necessary values of parameters for coating applying are preset and fixed in the database.
3- *measure the parameters after the coating application*; the measurement of the coating application uniformity, hardness, friction coefficient and strength of its adhesion with its backing is done with implementing the measuring devices.
4 – *enter the results into the database*; this functional block gathers all the data in the experiment process into the “information pile” for consecutive processing and analyzing.
5 – *to process the results*; the accumulated information is processed with statistical methods employment, then the analysis is done, and moreover, the user has possibility to receive the interesting information from the database in the form of output papers on the basis of the created query.

3.3. Database Implementation

The database has been implemented on the basis of functional model. MS Access 2007 is used as DBSM [4]. This DBSM quite corresponds to the solved tasks on saving, storage and processing the information, under the condition of conducting experiments. The model is presented below.

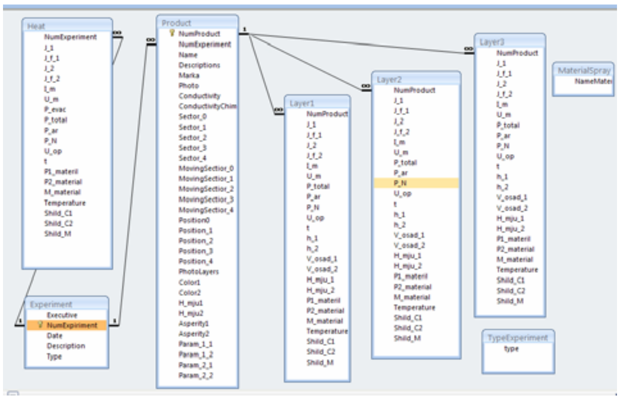

Fig.5. Model of the Information System Data

The special application interface for operating the database has been developed and implemented. After DBMS (Database Management System**)** launching the user receives the basic form, allowing starting the work with the database. The parameters for the experiment data registration are in the upper part of the basic form.

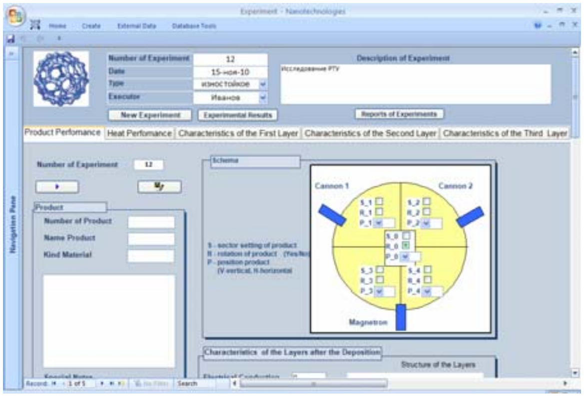

Fig.6. Application Interface

There is a form for obtaining the necessary information on the conducted experiments; employing this form, the user can look through the experiments results for the certain time period, select the experiments according to the type, look through the results of the experiments with any material of deposition, receive information on the experiments, when the certain hardness has been obtained.

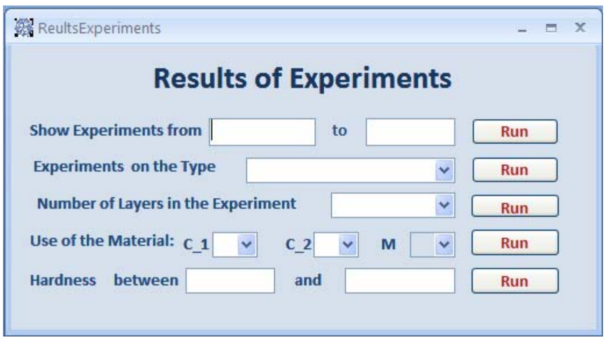

Fig.7. Form for data sample on experiment

There is a form for formation of experiment protocol according to the preset standard; it is possible to choose the number of experiment, and then observe it on the screen or print it.

Fig.8. Form for Formation of the experiment report

4. Conclusion

The paper demonstrates the approach towards the development of the information software in the process of conducting the experiments on applying nano-coatings. This information system permits to accumulate the information on the conducted experiments in centralized form and to process it. In the process of developing the information system, the system functional model implementing the IDEF0 method was designed. Conjugation of the database and diffractometer via the coordinating device allows registration of the measurement directly into the database.

5. Literature

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