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PROSPECTS OF NANOTECHNOOGIES IN AEROENGINE CONTRUCTION

Here are considered the main aspects of the nanotechnology application in the production of aircraft gas turbine engines. Here are presented possibilities of synthesis technology of the thermal barrier coating on cooled turbine blades of next generation GTE, technology of nanostructured multilayer coatings for metal cutting tools. Here is made actual the issue of industrial production of leucosapphire single crystals. In conclusion, here are presented competence-based personnel training educational programs for nanoindustry companies.

Keywords: nanotechnology, aeroengine manufacturing, nanoindustry, gas turbine engine, turbine blade, leucosapphire single crystal, personnel, educational program.

Aeroengine construction is the industry which includes the results of research and development of scientists and engineers from many high-tech areas, herewith almost all the technical solutions are based on the essential basic research in the sphere of engines, gas dynamics, combustion and heat transfer, structural integrity theories, and the theory of integral and intelligent control and diagnostics. The work for creation of innovative products in the aeroengine construction sphere can not be performed without the use of a high-level computer multi-disciplinary simulation and a physical modeling test and field testing of components and engines as a whole using of a unique simulating test benches.

The development of gas turbine engines for aircrafts and for ground applications marks tendency to increase the temperature in the combustion chambers of gas turbines from 1300 ° C to 1700 ° C, and the prospective gas turbines to ultrahigh temperatures of 2000 ° C, providing an increase of efficiency and performance factor of gas turbine engines. The increase of operating temperatures of gas turbines makes it especially urgent to introduce new high-performance thermal barrier coatings for thermo-loaded gas turbine components - flame tubes of the combustion chamber and cooled blades of the first stages of the turbine.

University scientists developed the synthesis technology of thermal barrier coatings on cooled turbine blades of a new generation GTE, which includes the steps of applying a heat-resistant metal layer Al2O3, with α - a modified crystal lattice by ion-plasma method and heat-resistant ceramic layer by vapor deposition on the vacuum electron beam unit. Directions of workflow optimization and an optimization criterion – ply rating, the essence of which is to model the synthesis of nanostructured coatings Al2O3, allowing to eliminate the phase instability and low adhesion of its components (Figure 1) are proposed.

Continuous improvement of aircraft engine design, extensive use of hard materials for critical parts with high accuracy of working surfaces led to a large scale implementation of machine tools with CNC, machining centers, transfer lines and other expensive equipment that requires a considerable intensification of the cutting parameters that causes an increased tool consumption as a result. One of the effective ways to reduce a tool consumption while achieving a high level of processing is the use of metal tools with a wear-resistant coatings. Wear-resistant coatings allow to get working surface of a tool with a desired service characteristics, usually without changing

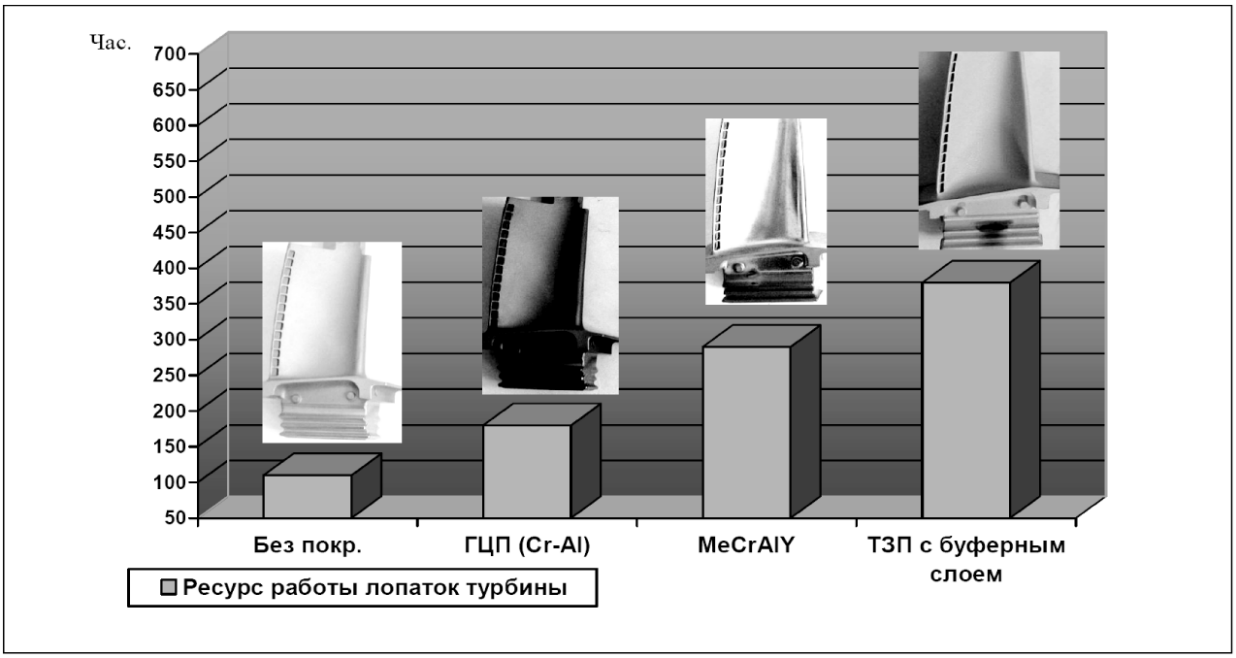

Figure 1. Operational life of thermal barrier coatings of cooled turbine blades at the temperature 1100 °C.

the properties of the main tool. Therefore, nowadays tool manufacturers, like Sandvik Coromant, Iscar, Dormer, Walter, JSC "NIR", Kirovograd carbide factory, etc., are being developed in the following areas: improving the geometry and the material of the cutting end, the development of wear-resistant coating technologies.

Nanostructured multilayer coatings consisting of several layers separated by thin intermediate are becoming more common nowadays. The coating technology allows to give them the characteristics needed for specific processing conditions, and to ensure that the coating effectively complements the physical and mechanical properties of the substrate of the carbide. In a multi-layer coating each wear layer performs its function, improving the performance of the cutting edge. By varying the composition and thickness of the layers, you can create cutting edge of hard alloys, designed for processing a certain group of materials for specific operations or for universal application for different workpiece materials and working operations.

RGATU by P.A. Solovyov has conducted researches to improve the performance of carbide cutting tools with wear-resistant coatings, used for GTE machining. The mechanism of influence of a multi-layered coating architecture on its structural parameters, mechanical properties, wear and breakdown (Figure 2) is developed. It is established that the effective resistance of a delamination spread of a wear layer can be raised or lowered by thermal stresses, that are realized by a sudden temperature change of the coating layer.

The study found that the use of a damping multilayer coating AlTiN-TiN-Ti (with variable thickness of AlTiN), prepared by high-speed magnetron sputtering, significantly increases the efficiency of carbide end mills. This allows to expand their use in machining, where there are loads that often cause the destruction of conventional coatings at the very beginning of work, especially when milling carbide workpieces with large cutting thickness. The developed in the University technology of optimization of the coating process of wear resistant nanostructured coatings of solid carbide end mills by the boundary delamination complex includes an extensive set of factors that determine the resistance of the coating, including the physical and mechanical properties of the treated and tool material, cutting conditions, the geometric parameters of the cutter, that allows to predict the structure of the multilayer coating on the stage of productions tooling of end mills.

In the field of aviation instrument making RGATU by P.A. Solovjov together with JSC "RIMP" run an innovative project for the technology development and industrial production in an industrial scale of single-crystal leucosapphire weighing up to 30 kg for electronics, optoelectronics, optics, precision mechanics, instrument making and laser technology.

Leucosapphires are used to create high-brightness LEDs, for the development and production of pastes for the metallization of solar cells, which are one of the most

Figure 2. Mills with nanocomposite wear-resistant coatings and results of thickness monitoring of tool coatings using caliper «Calotest»

promising segments of the renewable energy market. In the future - the development of technologies for producing shaped crystals of ruby refractory compounds, aluminum yttrium garnet, etc. Work is underway to transition to a more efficient technological equipment for leucosapphire crystal growth by Kyropoulos method, that allows to obtain leucosapphire single-crystal boules weighing up to 60 kg, used in the construction of space ships and aircrafts.

It should be noted that it is of great importance in the development of any field of science and technology not only high-end engineering technologies, but also educational.

Analysis of the situation with qualified personnel for high-tech companies, as well as the situation in the regional segment of the labor market has shown that there is not a quantitative deficit, when there are experts, but their number is not sufficient, and the qualitative and structural shortage. In fact, the profession reproduction in many important areas has stopped, and the educational system in institutions of vocational education behind the changes in the field of practices. The situation with staffing science intensive plants hampered by the lack of effective forms of interaction between the system of training and professional sphere of consumption. The labor market is stripped from mechanisms for the influx of new staff and young professionals in the industry.

Thus, nowadays there are no most critical elements of infrastructure of staffing, as well as the reproduction of human resources for aeroengine industry, rocket, ship, instrumentation and other high-tech industries.

The task of forming an efficient infrastructure of staffing of high-tech sectors of industry can not be solved within an enterprise, it requires the participation and the consolidation of the efforts of many parties: public authorities, associations of producers, institutions, corporate training centers, information centers and specialized agents of the labor market. Therefore, it is taken to consider the regional training systems and attracting engineering and management staff to the company as the basis of stuffing the high-tech industry sectors.

In a shortage of highly skilled stuff on the labor market aviation, aerospace industries and other high-tech industries have to develop and apply new technologies for training and attracting staff.

On behalf of RSATU and with a support of "Rosnano" technical training center for specialists in the field of nanomaterials and nanotechnology (UTC PS ERIP) was created in 2010. The specialization of the centre was based on the requests of employers. In particular, the training of qualified personnel for industries, using axial tools with nanostructured coating - on behalf of JSC "New instrumental solutions." Training according to the program "Technologies of leucosapphire single crystal and other refractory crystals growth for electronics and instrumentation" is held under contract with JSC "Rybinsk instrument making plant." Training and retraining of personnel in the sphere of synthesis of termobarrier nanostructured coatings of GTE hot parts – on behalf of JSC "NPO Saturn" and JSC "Saturn-Gas Turbines."

The educational programs of technical training center are based on a modular approach, which provides the ability to create optional specializations to enhance training in a specific direction.

Education of the specialists, as well as improving of their skill level is based on the competency curriculum, which is the main document. A feature of this curriculum is to focus not on the training set of topics and subjects taught in a certain volume, but on the received practical knowledge and skills that enable professionals to successfully meet the challenges related to the development and production of modern high tech machines.

There is an opportunity to create specializations as part of specialties and areas of training and retraining. Specializations are part of the specialty in which they are created, and expect to obtain deeper professional knowledge in a particular specialty profile. Number of hours (laboriousness) for disciplines of the specialization should be based on the discipline specificity.

One of the problems that require joint decision by educational institutions and enterprises is to define the requirements for the competence of engineers involved in the production process, and the definition of the competences required to perform specific functions in the process, the implementation of their goals (objectives) and the achievement of the planned results according to the quality requirements. Joint development of for company specialists allows to design educational programs coordinated with the strategy of the enterprise.

The competence models design for the company specialists is performed under the analysis of two interrelated systems: a complete system of business objectives, defining the area of final results that are achieved by total implementation of all activities of the company management; complete system of enterprise processes and functions required for the operational management under the formed task system. The advantage of this approach is that the process of defining the required competencies of staff and their subsequent development are related to the processes of development, coordination and implementation of organizational tasks. It is provided the ability to change the requirements for the staff competence in the case of new enterprise development goals and, therefore, the new features of employees work in order to prevent the emergence of inconsistencies in the manufacturing process due to timely raise of the requirements to the personnel competences.

The main assessment tools for increase of the personnel competences during the education and after it are the following technologies: the use of automated information system, measuring the competencies using a test, unification of the results into groups of competencies, drawing of a radar chart of student competences and overlay of it on the radar chart of required competencies; self-appraisal of the competencies change for the implementation of which each student is provided with the available in the educational complex tasks for self-control and control questions. It is also expected to modify the automated information system of competencies measurement to enable on-line access for the students involved in the training program.

In general, the developed two-level system for training specialists provides the implementation of an optimal training paths for each student and allows to form the necessary competencies for the program. The proposed studying program can be used to develop a competence-oriented program of advanced training of personnel for nanotechnology companies. Test scores after the subjects studying, and the results of graduation thesis are evident of the acquired competences that will be used in the further production activity of the specialists at the nanoidustry and aeroengine production enterprises.