The automated system of scientific researches of high and critical technologies in engine-building manufacture

S.G. Selivanov
Department of Aviation Technological Systems
Ufa State Aviation Technical University
Ufa, Russia
e-mail: S.G.Selivanov@mail.ru

S.N. Poezjalova
Department of Aviation Technological Systems
Ufa State Aviation Technical University
Ufa, Russia
e-mail: Poezjalova@mail.ru

Abstract [1]

The functional model of The automated system of scientific researches of high and critical technologies (ASSR-HCT) for existing systems of research and development is adapted and different is constructed by that allows to develop methods of the system analysis, mathematical modelling and optimization of design-technological decisions for their use in applied problems of The automated system of technical training of manufacture (ASTTM) for realization of technological maintenance.

1. Introduce

The innovative policy of the state, formation in the country of modern innovative economy provides now mobilization of budgets of all levels on development of innovative activity. A kernel of innovative economy and innovative activity are technologies. Innovative technologies, innovative designing and innovative activity provide competitiveness of new production and manufacture. It should raise rates and provide stability of economic growth, but also provide a gain of the advanced positions in segments of the world markets of aviation technics, manufacture and export of a hi-tech industrial output for achievement of technological leadership of the country. Modern competitive manufacture should be based on application of new, so-called "critical" and "high" technologies. The specified technologies matter for development not only innovative economy, defense of the country or safety of the state, but also for increase of competitiveness, quality and production technological level (grocery innovations). For this reason the List of the major "critical" technologies is defined not only at Federal level (it is confirmed by the order of the Government of the Russian Federation from August, 25th, 2008 №1243-r and rules of formation, updating and realization of priority directions of development of a science, technologies and technics in the Russian Federation and the list of critical technologies of the Russian Federation), but also on regional levels of management of the industry and in various branches of machine-building manufacture.

The state-of-the-art review of the scientific and technological literature shows that the basic problem of well-founded working out of such "critical" and "high" technologies is insufficient scientifically-methodical maintenance of their designing for application in innovative activity.

In this work it is offered to use modern methods of a science for System engineering designing "high" and "critical technologies" [1]. The automated system of scientific researches is developed for the decision of the given problem in research by means of functional modelling, application of the artificial intelligence means and other means of system engineering ASSR-HCT in aircraft engineering is designed.

ASSR-HCT allows to automate researches on working out of innovative projects and to optimize on the basis of mathematical modelling uniform, central, design, perspective and directive technological processes which develop during performance developmental (PD) and skilled-technological works (STW). This and other innovative technologies are necessary as for technological maintenance of new generation aviation engines creation, and for working out of projects of modernization engine-building manufacture with a view of statement on new technics manufacture.

For this reason the problem of system engineering of workings out ASSR of the high and critical technologies which are base for technological maintenance of works on designing and creation of new generation aviation engines is actual. Research objective is working out of the automated system of scientific researches which provides the system analysis, mathematical modelling and optimization of high and critical technologies in engine-building manufacture on the basis of research of laws of alternation of aviation technics generations.

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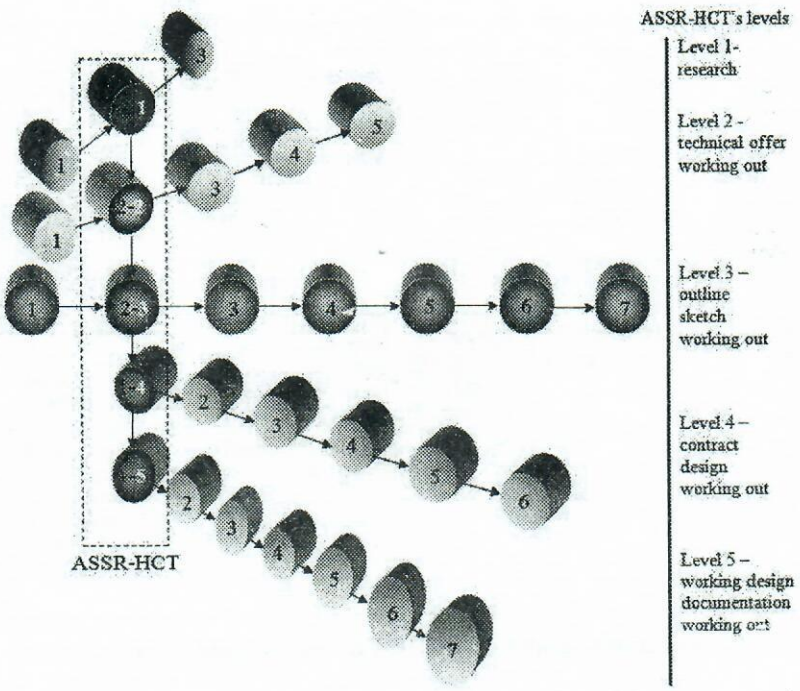


Fig. 1. The count of construction of structure ASSR-HCT in research and development 1, 2, 3...– Functional blocks of research and development stages 2-1; 2-2; 2-3; 1-4; 1-5 – Functional blocks of ASSR -HCT is adapted to USDD and Uniform system of the technological documentation (USTD)

2. The methods of construction of the ASSR in The automated system of technical training of manufacture (ASTTM)

The method of structural modelling of ASSR in ASTTM is developed which is integrated (in the form of a multilevel multigraph) (fig. 1) with functional modules of ASTPP for engine working out agree Uniform system of the design documentation (USDD).

The mathematical models received by means of ASSR-HCT, new knowledge of the scientific laws established by means of ASSR-HCT are necessary for working out not separate technological operations as it follows from others considered of ASSR technological appointment, and serve for creation of innovative technologies, for technological maintenance of creation of new generation aviation engines at working out stages of "preliminary projects of the technological documentation» and preparation of "complete sets of the documentation of directive technological processes» with a view of statement on manufacture of new technics.

Let's consider in more details blocks of ASSR-HCT problems (fig. 2):

1 block of problems – the analysis of a technological level of aviation engines. The result of functioning of the given block is definition of requirements on technological maintenance of new products competitiveness at performance researches and technical project formation on designing of a new product;

2 block of problems – the ordering of the patent and scientific and technical information. The result of functioning of the given block are electronic databases on domestic and foreign research and development in engine-building manufacture, the systematized patents on the industrial samples useful to models and inventions of ways, devices and materials who can be used by working out of innovative projects during research and development of aviation engines;

3 block of problems – a choice of high and critical technologies by results of research, generalizations of scientific and technical reserves, inventive and patent-license Business, including with use of possibilities of a transfer of high technologies, formation of conclusions and substantiations by possibilities of application of high and critical technologies during the further researches and development of new generation aviation engines;

4 block of problems – the formation of uniform technologies of new generation aviation engines for system engineering of workings out of innovative projects. The result of work on this function is the decision of problems on cession of rights on uniform technologies, definition of structure of innovative projects;

5 block of problems – the working out of complete sets of the design and directive technological documentation for practical realization of innovative technologies: directive technological processes for maintenance of statement of new production on manufacture and technological processes design.

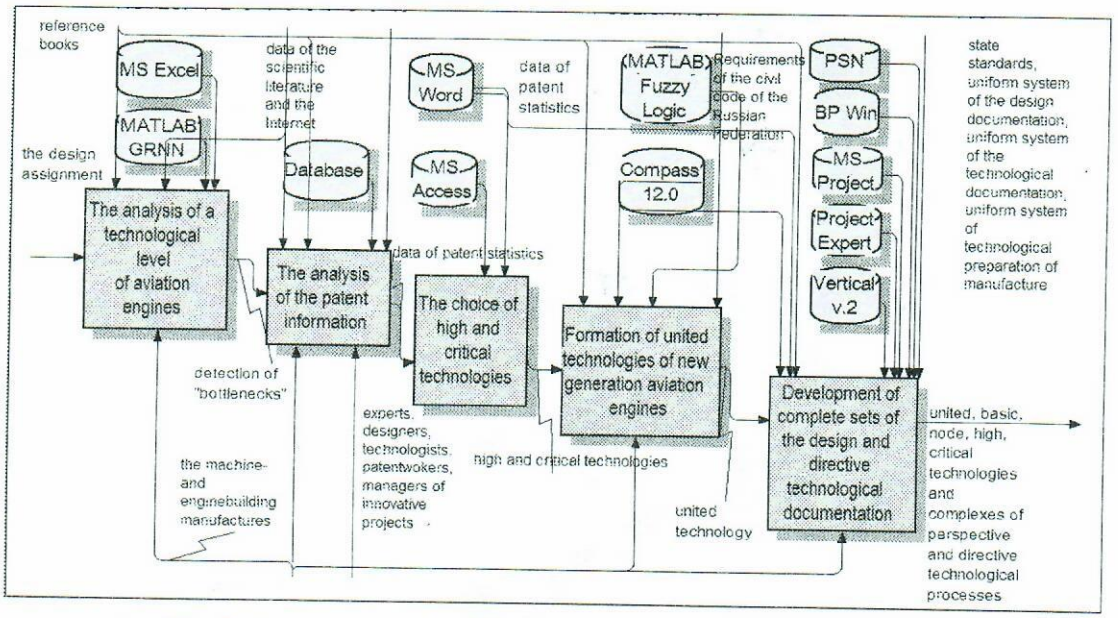


Fig. 2. Functional model ASSR-HCT in engine-building manufacture

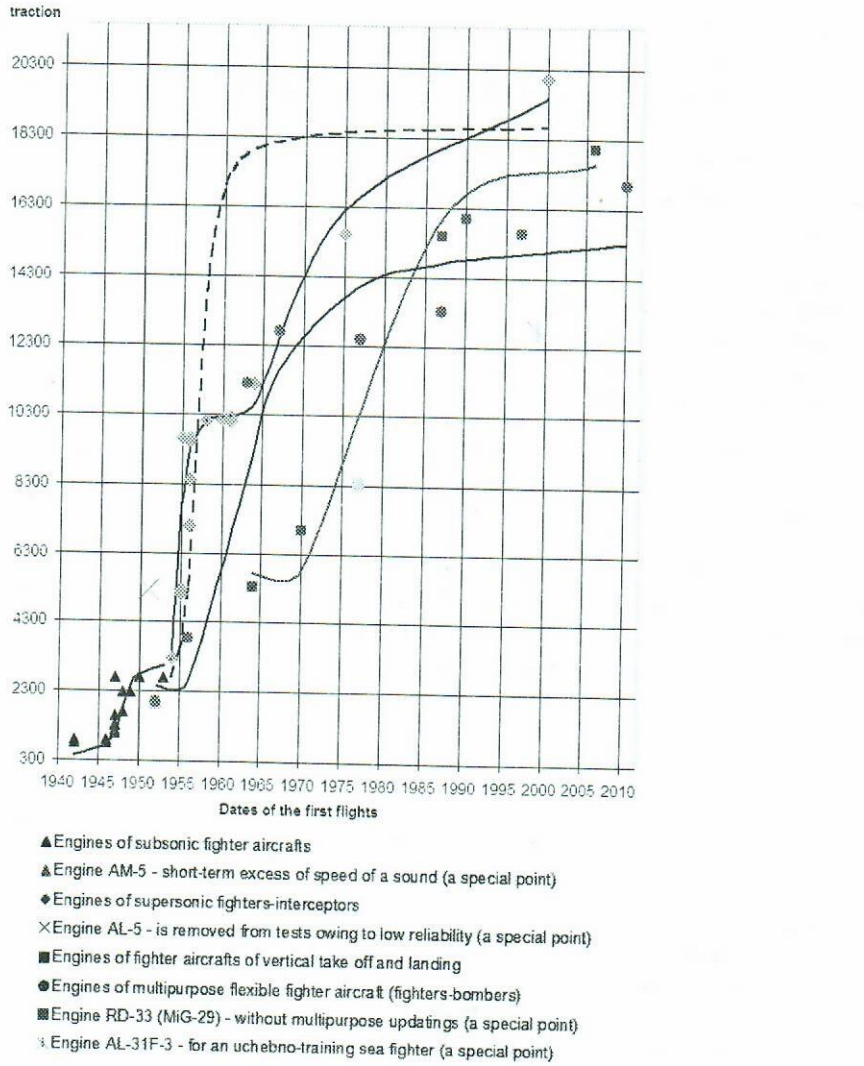


Fig. 3. Generalized sigmoid laws of development aviation engines of domestic destructive aircraft

3. The research of laws of alternation of generations of aviation technics in ASSR–HCT

The developed methods of the system analysis of development of aviation technics and technologies in ASSR-HCT allow in an analytical kind with use of artificial intelligence techniques to develop mathematical models of development of such technologies and to explain laws of alternation of generations of aviation technics. Mathematical modeling by means of ASSR-HCT developments of planes and aviation engines for the decision of problems of performance research and innovative designing with a view of alternation of generations of technics and technologies and maintenance of competitiveness of analyzed aviation technics is carried out. The research within the limits of ASSR-HCT is carried out as for a stage of development subsonic and the supersonic aviation technics on an example of fighter aircrafts and their engines.

As the main criterion for the analysis of a technological level of flying machines of the given type the maximum speed of the fighter aircraft was considered. On the basis of the spent mathematical modeling the conclusion is drawn that in a point of an excess of S-shaped law at transition from a stage of intensive development in a stage developments of the given type of technics it is desirable to start the beginning of research works on transition to the new S-shaped curve of development based on application in analyzed technical system of a new principle of action. The given decision allows to carry out preventive measures which don't suppose transition of technical system in a stage of stagnation and the subsequent degradation.

The analysis of the received dependences and mathematical models corresponding to them in the form of regresses of the system analysis and management of life cycle of development of aviation technics and technologies that allows to explain the law of alternation of generations of technics and technologies in an analytical kind is made and soundly to form systems of scientifically-technological preparation of manufacture of new technics. As a result of the analysis it is revealed that for alternation of generations of aviation technics radical updating of base technologies not only its uses (Stealth technology, Stovl), but also manufacturing quite often is required.

Mathematical modeling of laws of development of aviation engines where as the main criterion of a technological level draft of the engine is considered is made. Its changes as show the researches executed in ASSR-HCT also submit to the general laws of innovative development in kind sigmoid regresses and look like, presented on fig. 3 where the summary picture of laws and mathematical models of development of aviation engines of domestic destructive aircraft is received. The received schedule (fig. 3) allows to formulate a problem of technological maintenance of creation of aviation engines of new generation and to offer a method of the decision of the given problem. A method of the decision of a problem about overcoming of the outlined backlog which is visible from trends (regresses) of development is technological maintenance of creation of engines of new generation. It is connected by that in connection with the big expenses for research and development and skilled-technological works when the state can't finance wide front of workings out.

On the basis of the told the comparative analysis of laws of development of aviation engines for a choice of type of analytical dependence on an example of subsonic fighter aircrafts is carried out in the beginning. The question on is solved what S-shaped curve is a rational variant for construction of mathematical models of this kind for the analysis of parameters of a technological level of aviation engines. The conclusion that sigmoid (the S-shaped curve) which describes tangential function, is the well-founded and rational variant for construction of mathematical models of this kind as the maximum convergence in this case is observed that is the satisfactory acknowledgement of that the picked up variant of approximation in the best way approaches to available experimental data becomes.

The system analysis of laws of alternation of generations of flying machines and engines is carried out by artificial intelligence techniques.

For definition of laws and development tendencies engines it is offered neural generalized regression a network (GRNN) which solves problems of definition of regresses by approximation of various functions. Given artificial neural network GRNN [2] is the generalized model of development: any innovative project, set of innovative projects of analyzed generation of technics and technologies, and also laws of diffusion of new technologies. The rational functions describing development of is innovative-investment projects and sigmoid of law, describing development of generations of technics and technologies are established, legitimacy of the given position proves to be true for laws of development of aviation engines. The comparative analysis of investment of separately taken innovative project which allows to establish essentially best results on use of function of Fermi in comparison with logistical dependence. In this connection Fermi's function is more rational for use in problems of mathematical modeling and graphic display and a substantiation of are innovative-investment projects.

The analysis of a class of problems of Research ASSR-HCT for innovative designing with use of methods of modeling of development of technics and technologies on the technological level parameters, showing on smaller preference of logistical dependences for the analysis of innovative projects is carried out. The carried out analysis

allows to draw a conclusion that typical regress dependence in the form of an arctangent (a curve №2) in the form of a dashed line (fig. 3) unsatisfactorily describes law of development of aviation engines for interception aircrafts. It is connected with displacement of a curve because of unsatisfactory results of flight tests of some planes and their engines (R-11F-300, R-15, R-15-300, R-21F-300, R-13F-300, R-11F2-300) in the early sixties XX century that has caused a delay in development sigmoid the given generation of technics by formation of a small horizontal platform. The further development of aviation engines for the given type of planes is characterized by use single shaft gas-turbine engines with afterburner from cruise missiles on fighters-interceptors that has continued development sigmoid, but already in kind bilogistic dependences.

In following blocks (2, 3) functional model ASSR-HCT (fig. 2) are carried out research under the system analysis of the patent information and working out of technical offers for increase of a technological level and other indicators of innovative designing of aviation engines of new generations with a view of formation of uniform technology of new generation aviation engines.

4. The working out of uniform technologies in ASSR-HCT in engine-building manufacture

The developed electronic database of uniform and central technologies for innovative designing is a basis of system engineering designing and computer modelling of new generation aviation engines, the working out of high and critical technologies. In the described database the review of patent documents, namely the inventions, useful models and the industrial samples placed in a database of The Russian Federation patent for definition of uniform and central technologies in the field of creation by newest of aviation engines is spent. The analysis of tendencies of development of aviation engines on an electronic database has shown that there is the constant growth of quality expressed in improvement of profitability, decrease in noise levels and issue of harmful substances, increase of reliability and increase in a resource up to values of a resource of a glider of the flying machine. After the spent work on gathering of the perspective materials given about modern workings out and design plans on creation of engines of new generation, it is necessary to sort «It is not enough perspective» technologies and to generate «a kernel of decisions» for structural optimization of uniform technologies of creation gas-turbine engines in the form of a file of the best technological offers that №3 functional models of ASSR-HCT are carried out in the block.

The basis of a considered method application of the combined model on the basis of application of expert systems and a method of indistinct logic which are realized in system MATLAB 6.5 is accepted. These methods allow to make the system analysis of the electronic database developed in given research on central technologies. The package is applied to the decision of a problem of the analysis of the data of patent statistics on central technologies gas-turbine engine «Fuzzy Logic» [1, 3] systems MATLAB 6.5. With its help it is possible to carry out search «a kernel of decisions» which leans against results of the expert estimations consisting in selection of the best central technologies with a view of creation of jet engines of new generation. Then computing procedures of formation of system of input-output of the information, the description of work with a package «Fuzzy Logic», the task of functions of an accessory, set of rules for search of a kernel of decisions of uniform technology of aviation engines and demonstration of work of the received method of definition of "a kernel of decisions» are resulted. For the system analysis received «kernels of decisions» on a following step are under construction structural models in the form of multiple counts of development of uniform technologies of the aviation engine of new generation on whom the points of the high central technologies which have been selected on the previous step of the analysis with use of a method of the indistinct logic are generalized only. The constructed multiple count of development of uniform technologies is a kernel possible both design and design-technological decisions (in the form of preliminary complete sets of the technological documentation for working out of design, perspective and directive technological processes) for structural optimization of uniform technologies. After input in system MATLAB [3] data by an expert estimation of patent documents, estimations of their importance for increase in draft, degree of compression of the compressor, temperatures on the turbine according to the received multiple count, the surface of development of uniform technologies looks like, fig. 4.

It is offered to lead selection of the technologies getting to area of so-called high technologies from available variants of patents. On fig. 4 the S-shaped curve of development of central technologies of the fan of the aviation engine and a surface is shown, represents set of variants of development of central technologies from which it is possible to allocate a kernel of decisions for working out of uniform technology of the engine of new generation and the further working out of the preliminary complete set of the technological documentation and designing of directive technological processes.

Having defined central, base technologies from «a kernel of decisions» for the interesting knot of the aviation engine it is possible to carry out imitating modeling of innovative projects of manufacture of various assembly units and details gas-turbine engines.

Imitating modeling of innovative projects of manufacture of details of aviation engines from «a kernel of decisions» uniform technologies gas-turbine engines on an example of modeling of the innovative project of manufacturing of

a detail of the chamber of combustion "Segment" of the aviation engine of new generation is resulted. On the basis of the revealed patent documents, methods of drawing of coverings, properties of materials, and the equipment for reception of sheeting on drawing of a heat resisting covering the design technological documentation is developed for a considered detail of the chamber of combustion gas-turbine engines "Segment" that is necessary for creation of the innovative project, and №4 functional models of ASSR-HCT grow out of the block. Within the limits of conducted research the calendar plan-schedule of the innovative project of working out of perspective technological process for manufacturing of a detail of the chamber of combustion gas-turbine engines "Segment" is constructed. By results of a choice of high central technologies by means of a package «Fuzzy Logic» for a detail "Segment" the optimum heat resisting covering reflected in top of the multiple count of development of uniform technologies in a layer, corresponding to the chamber of combustion is defined. One of the basic sections of the innovative project is working out of the business plan which is described in the given section of head on an example of manufacturing of a detail of the chamber of combustion "Segment" according to the chosen patent document on drawing of a ceramic-metal covering, as a result of the spent imitating modeling and the constructed business plan the time of recovery of outlay of the project which has made 1,5 years is defined.

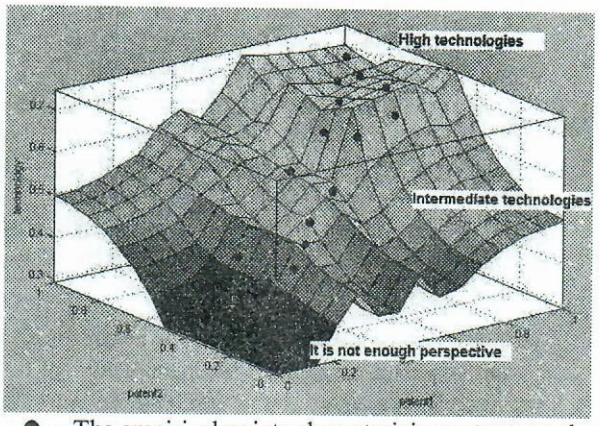
5. The research of methods of working out design and directive technological processes in ASSR-HCT

A set of various variants of directive technological processes are counted with reference to a detail of the chamber of combustion "Rack" which have been divided into 3 groups depending on a processing kind – the directive technological processes based on a ration, argon-arc to welding and electron beam welding. Then the counted up data is entered into the developed software product on multi-objective optimization of directive technological processes receiving the optimized values on an exit.

The dependences necessary for designing of directive technological processes of manufacturing of details gas-turbine engines and law of influence of directive technological processes on quality and a technological level of the new technics on an example of working out of directive technological process of manufacturing of "Racks" of chambers of combustion gas-turbine engines are investigated and received.

The dependences necessary for designing of directive technological processes of manufacturing of details gas-turbine engines which are shown on an example of research of variants of typical directive technological processes of a detail of the chamber of combustion "Rack" are received. The revealed dependences and laws have allowed to establish private (local) and global optimum with possibility of reception of Pareto-optimum decisions [4] to carry out imitating modeling on this basis and to use the software package for optimization of directive technological processes in engine-building manufacture.

The surface of development of uniform technologies of gas-turbine engines by results expert estimation of the patent statistics data is demonstrated on fig. 4.



● – The empirical points characterizing patents on the fan gas-turbine engine

Fig. 4. The surface of development of uniform technologies gas-turbine engines by results expert estimation of the data of patent statistics

Conclusion

- The functional model ASSR-HCT is adapted for existing systems of research and development, it different is constructed by that allows to develop methods of the system analysis, mathematical modelling and optimization of design-technological decisions for their use in applied the ASTTM problems for realization of technological maintenance of competitiveness of new technics (grocery innovations) during innovative designing.
- On the basis of definition of laws of aviation technics and technologies development methods of the system analysis are developed for maintenance of automation of innovative designing. Distinctive feature of the developed methods are the revealed and analytically proved rational regresses for the analysis of planes and their engines development.
- The ASSR-HCT methods of mathematical modelling and optimization of uniform technologies are developed for a substantiation of innovative projects with application of the indistinct logic allowing on the basis of the statistical data of the patent information visually and well to realize a search problem «kernels of decisions» for technological maintenance of works on creation competitive gas-turbine engines. By results of the review of the patent

information the electronic database on central technologies for optimization of uniform technologies and performance of the further works on maintenance of technological readiness for creation of new generation aviation engines is constructed.

- The method of a choice of high central technologies from «a kernel of decisions» uniform technology of new generation aviation engines with which help it is possible to define lists of high, critical technologies, and also «a kernel of decisions» on the multiple network count for formation of the uniform technologies necessary for creation gas-turbine engines is developed. The developed method differs that allows to allocate a number of the most perspective technologies for performance on their basis of skilled-technological works workings out of preliminary projects of the technological documentation and technological maintenance of new design decisions in innovative projects of gas-turbine engines.
- Methods of innovative designing automation of modernization for statement on manufacture of new aviation engines on an example of working out of the innovative project of the chamber of combustion with a new heat resisting ceramic-metal covering are proved. For a substantiation of calendar plans-schedules and business plans of the innovative project it is necessary to have the well-founded data on labour input of works of technological preparation of new technics manufacture that the developed electronic database for rationing of labour input of performance of stages of innovative projects allows to carry out.
- It is developed a method multi-objective optimization design and directive technological processes in the ASSR-HCT with use of an artificial neural network and a method of indistinct logic which allows to develop design and directive technological processes for new gas-turbine engines statement on manufacture and facilitates work of the technologist at maintenance of competitiveness of products.

References

1. Selivanov S. G., Guzairov M.B., Kutin A.A. "Innovation". The textbook for high schools. M: Mechanical engineering, 2008. P. 721.
2. Djakonov V. P., Kruglov V.V. "MATLAB 6.5 SP1/7/7 SP2 Simulink 5/6". Artificial intelligence and biocomputer science tools. A series «Library of the professional» M: SOLON-PRESS, 2006. P. 456.
3. Medvedev V. S., Potyomkin V.G "Neural networks: Matlab 6". M: DIALOGUE-MIFI, 2002. P. 496.
4. Shipachev V. S. "Higher mathematics: the textbook for high schools". M: Higher school, 1998. P. 479.