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The Use of Artificial Intelligence Methods of Technological Preparation of Engine-Building Production

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Abstract The ways of application of artificial intelligence methods for optimization of design, perspective and directive technological processes of engine-building production in this publication are shown. The different choices of optimization of technological processes of engine-building production for providing the competitiveness of new products by means of the Elman and Jordan neural networks with elements of fuzzy logic and genetic algorithm are developed.

Keywords: *technological process, optimization, artificial intelligence, technological preparation of production*

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1. Introduction

The innovative policy of the state and formation in the country of modern innovative economy provides now mobilization of budgets of all levels on development of innovative activity. It is known that innovative activity includes:

- researches, developmental or skilled and technological works on creation of innovative production, including the new or advanced technological processes intended for practical application;
- activities for advance of innovative production on the internal and world markets;
- technological re-equipment and production preparation for release of innovative production, introduction of new or advanced technological processes;
- implementation of tests of the innovative production new or advanced technological processes;
- release of innovative production, application of new or advanced technological process;
- preparation, retraining and professional development of shots for implementation of innovative activity;
- activities for carrying out examinations, rendering consulting, information, legal and other services for creation and (or) practical use of the innovative production, new or advanced technological processes and other kinds of activities directed on creation of innovations and their introduction in a civil turn.

The concept of the innovative project includes system of the actions providing creation, production and realization of a new type of production or technology during the set period of time in purpose to receive profits or other useful effects.

The innovative projects have to meet the following requirements to contain:

- the offers united by the uniform purpose of creation of innovations;
- technical justification and expediency of implementation of the innovative project;
- the documents confirming novelty and right security of the innovative project;
- an economical justification, including, confirming return of means to the budget of the investor;
- the program of implementation of the innovative project.

All these requirements become feasible in the conditions of use of the automated systems of technological preparation of production (ASTPP). Modern ASTPP even more often develop with use of artificial intelligence techniques including on the basis of application of artificial neural networks and genetic algorithms.

The kernel of innovative activity and ASTPP now is technologies. These technologies matter for development not only innovative economy, defence of the country or safety of the state, but also for increase of competitiveness, quality and a technological level of production. The analytical review of scientific and technical literature shows that the main problem of effective development of such technologies is insufficient scientific and methodical and scientific and technical ensuring their design for application in innovative activity. In article some solutions of this problem with use of methods of artificial intelligence and other means of technical design are

shown. The developed methods are applied to technological support of creation of aviation engines of new generation and to development of projects of modernization of aviation construction for statement on production of new equipment that is shown in offered article.

2. Optimization of Design Technological Processes

The purpose of such works most often is structural optimization of design technological processes by fund savings criteria for production modernization. The application of artificial intelligence techniques in the form of a logic-genetic method [1] for structural optimization of design technological processes consists in use of network counts and the genetic algorithms are known from the theory of artificial intelligence, for production and development modernization of:

- technological routes by goods turnover criteria minimum for formation of the sheet of technological routes;
- route technological processes for optimum design of production structure of cases, shops and enterprise sites.

The algorithm of this method is presented in Figure 1. Here the phenotype of a chromosome represents a set of values of numbers of shops, otherwise, a production route. For example, ch (chromosome) = (1 4 3 2) for 4 shops.

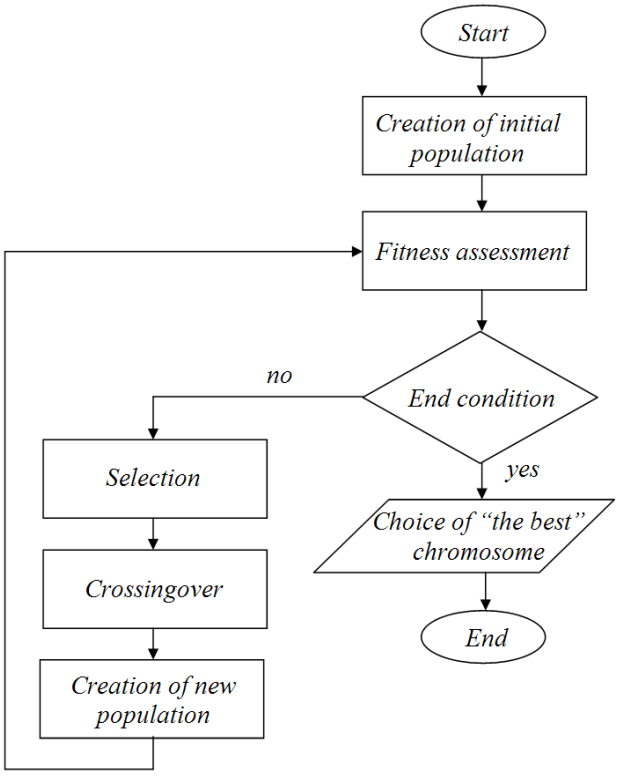

Figure 1. The flowchart of genetic algorithm of finding of an optimum technological route

At a stage of initialization, formation of initial population, a chromosome check on performance of statements of the problem, thereby it is possible to create the "rational" chromosomes meeting conditions of innovative design.

Estimation of fitness of a chromosome in population consists in calculation of function of fitness, in calculation of total goods turnover.

The selection of chromosomes is made by a roulette method. The method of a roulette is rather in detail described in scientific literature [1]. The essence of this method consists in the following: the roulette wheel sector which size is established in proportion to value of function of fitness of this chromosome is compared to each chromosome. Therefore the more value of function of fitness, the is more sector on a roulette wheel and probability of a choice of this chromosome as the parent.

In this algorithm one genetic operator – the operator of crossing (crossover) is used. The single-point crossover which essence consists in a casual choice of a point of crossing (a crossover point) or gap points in which both chromosomes share on two parts is used and exchange them.

Formation of new population is made at the expense of association of parents and descendants. The condition of a stop of work of algorithm – achievement of expected optimum value.

The program is developed for the solution of this task "The chamber of Commerce and Industry" (Figure 2) which is executed in the environment of MS Visual Studio 2008 programming.

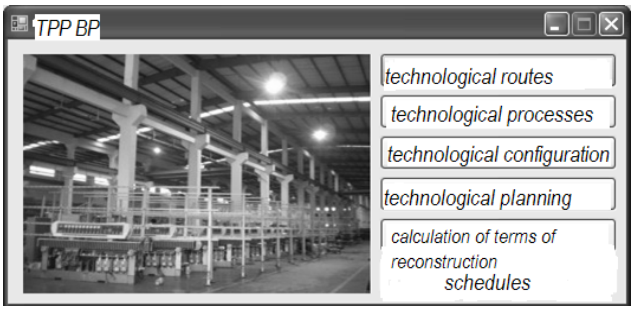

Figure 2. The program interface «TPP BP»

By pressing the «Technological Routes» button there is a program window which allows making optimization of technological routes by means of a logic-genetic method.

At approbation of this program on the example of production optimization of the module air heat exchanger the following data were obtained. Such calculations allowed to create subject the closed (specialized) production of the called products that sharply reduced a counter cargo transportation between platforms of the enterprise and ensured essential economic effect (more than 38,0 million roubles).

By results of technological routes optimization by criterion of a minimum of goods turnover it is possible to start the solution of tasks on optimization of technological processes. The priority criteria of optimization of development of route charts of design technological processes resource-saving indicators in shops act.

For automation of the solution of a problem of multicriteria optimization of fund savings technological process on the basis of creation multiple structural model of perspective technological processes it is also offered to use the genetic algorithms realized in the environment of MS Visual Studio 2008 programming. Thus, technological process can be presented in the form of the network count where tops of the count – technological operations of

processing, and arches define possibility of their consecutive performance.

In this case design by means of a logic-genetic method optimum technological processes criteria of optimization have to minimize both sizes of business assets, and sizes of operating time funds use of the equipment and workers. The most rationally of these funds of time are used at time per piece minimization.

Estimation of suitability function in this case consists of criterion function calculation which pays off on a method of a resultant indicator of quality. The essence of this method is that private criteria unite in one generalized criterion, and then there is a maximum or a minimum of this criterion. The generalized criterion is determined by application of the additive criterion which criterion function was received by adding rated values of private criteria.

Estimation of suitability function in genetic algorithm is carried out as follows: more the value of suitability function, more the sector on a roulette wheel and higher chromosome choice probability as a parent.

Thus, this program allows for optimization of the design technological processes on the basis of use of a logical -genetic method by capital investments criteria in the equipment, the areas and time per piece [1].

3. The Artificial Jordan Neural Networks Use for Perspective Technological Processes Optimization

For the solution of a multi-criteria optimization problem of perspective resource-saving technological processes in MATLAB system it is possible to use artificial intelligence methods in the form of recurrent artificial neural networks [2] (Jordan, Elman, etc.), Figure 3 and Figure 4. Before beginning optimization procedure by resource-saving criteria, it is necessary to construct mathematical technological process model of production (Figure 5).

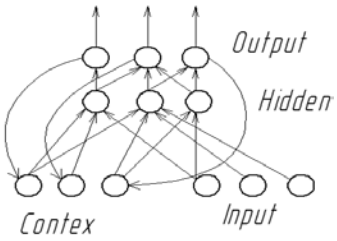

Figure 3. The Jordan's networks structure

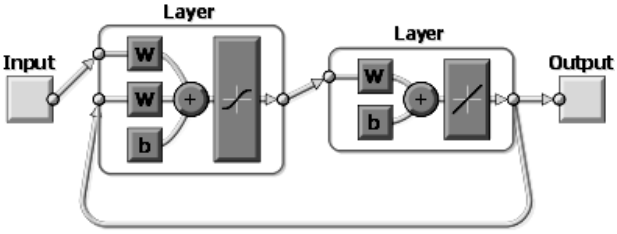

Figure 4. The Jordan's networks scheme for the solution of a problem of multicriteria optimization of resources savings perspective technological processes in the environment of MATLAB

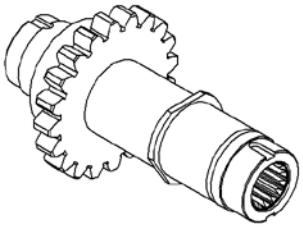

Figure 5. 3D model of detail-representative "gear wheel"

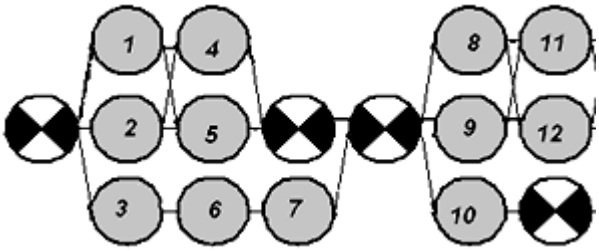

Figure 6. Fragment of the "gear wheel" detail production process count

The multiple network count is such model, [2] (Figure 6) which was created on the factory technology and added with other operations which provide process changes, new methods and modes of processing, manufacturing area structure of new processing equipment.

The Jordan network use for a multi-criteria optimization problem, also as well as in cases of genetic algorithm applications, it is necessary to make linear convolution of input parameters – optimization criteria (to lead input parameters to dimensionless size on conditions for application of multi-criteria optimization methods).

As numerical assessment parameters of perspective technological process in this case the following criteria are used:

- three indicators (the given expenses, production piece time, a capital intensity) for which the minimum values are defined,
- one indicator (material efficiency) for which the maximum value is defined.

It is used for providing the maximum materials savings in perspective production.

Thus, the considered network artificial intelligence method allows to carry out multicriteria optimization of perspective resource-saving technological processes that provides production resources saving.

4. Directive Technological Processes Optimization on the Elman's Neural Network Basis

In innovative projects the directive technological processes documentation sets have different purpose then perspective resource-saving technological processes documentation sets. They are made to provide creation and set new competitive product production or new equipment.

For ensuring new products competitiveness at research and development stages skilled and technological works it are recommended to consider as the main directive technological processes optimization criteria:

- the highest values of new products technological level parameters which provide directive technological processes, and also
- the smallest processing or assembly labour input,
- minimum expenses and
- the smallest risk (first of all from defects at new technology introduction).

For implementation multi-criteria optimization of directive technological processes by the criteria described above the program MATLAB environment and a Neural Network package is used. The hybrid network is applied to an objective in the form of Elman's recurrent network (Figure 7) with indistinct logic elements. The developed software product contains two main parts for optimum directive technological process definition.

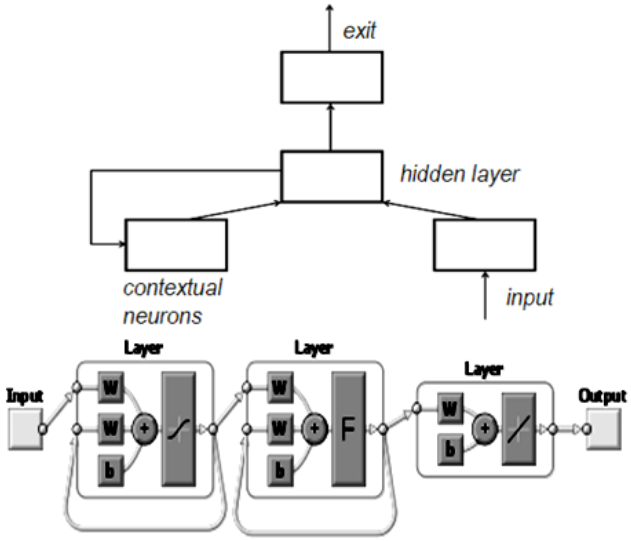

Figure 7. The Elman's three-layer neural network structure for a directive technological process optimization

The first part of criteria is determined by product's technological level parameters. They can be presented in the form of three linguistic variables:

- technologies which don't influence a product's technological level, for example, at engine draft resources, reliability, etc.,
- the technologies having weak impact on a product's technological level,
- the technologies which have strong impact on a product's technological level.

	C, руб	T, мин	R	FL	
1	81.47	9	0.12		0.213502
2	91.33	6	0.25		0.8875
3	79.85	5	0.2		0.246154

Figure 8. The data input table structure

The accepted way of called optimization criteria definition assumes fuzzy logic (FL) methods use (Figure 8) which widely applies in the artificial intelligence theory. The maximum values of such product's quality parameters allow to define a priority of technologies.

The second part of software product criteria (Figure 8) contains numerical estimates (the C – expenses, T – piece time and R – risks) that allows for the use of artificial neural networks for multicriteria optimization.

For use of a Elman network in multi-criteria optimization problems, also as well as in the cases of genetic algorithms use of Jordan's artificial neural networks which was shown above, it is necessary to make reduction of input parameters to dimensionless size in the beginning on conditions of multi-criteria optimization methods application. This part of works provides use in the environment of method MATLAB linearly – additive convolution [3]. For method realization linearly-additive convolution it is necessary to establish in the beginning the weight of priorities from 0 to 1:

- for labour input in this case the priority 0,35 is appointed;
- for expenses – 0,35;
- for risk criterion [4] – 0,3.

Let's consider in more detail procedure of use of a neural Elman network for multi-criteria optimization of directive technological processes.

Process of created neural Elman network training in MATLAB system is graphically shown in Figure 9 where dependence of time (quantity of the periods of training) and a mistake (an average square mistake) calculation is shown.

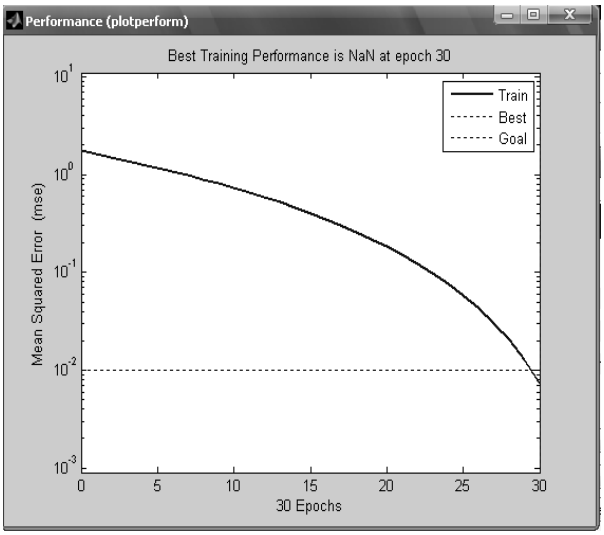

Figure 9. The schedule of training of a neural network of Elman

Working off considered above a applied programs package of directive technological processes multi-criteria optimization is considered on the example of optimization of diffuser of combustion chambers directive technological processes (Figure 10). The position 5 in Figure 10 designated a combustion chamber detail "Rack", directive which technological process is optimized in this case.

For the solution of a considered optimizing task also as well as in cases of use of Jordan's artificial neural networks genetic algorithms or it is necessary to construct the multiple network count of directive technological processes. Data of the count are entrance data for the software product (Figure 8).

On the basis of data of the count various options of directive technological processes which were divided into 3 groups depending on a type of processing are calculated the directive technological processes based on the soldering, argon-arc welding and electron beam welding

that allowed to choose Pareto-optimal option of directive technological process by the criteria called above taking into account the established dependences.

Thus, use of the artificial intelligence hybrid computing system on the Elman's neural networks basis with elements of indistinct logic provides directive technological processes multi-criteria optimization.

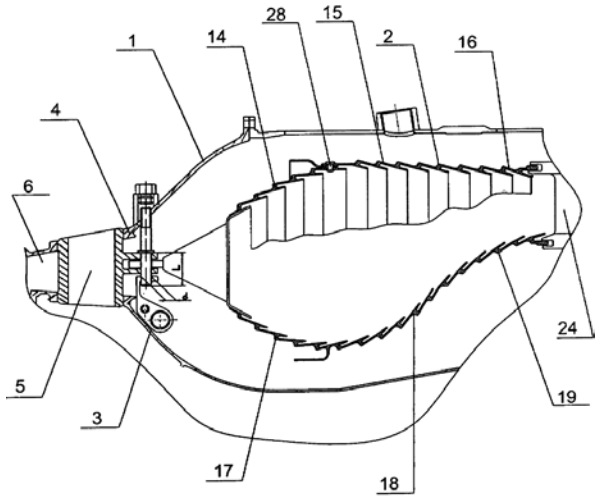

Figure 10. General view of a diffusor of the combustion chamber of the aviation engine (the position 5 - detail 'Rack')

5. Conclusion

It is established that the development methods of innovations considered above in the form of design, perspective and directive technological processes meets the innovative design optimization requirements. Such developments can be added, by continuing research with use of innovative projects imitating modelling.

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