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USE OF CRITERIAL SYNTHESIS AND ANALYSIS FOR MODERNIZATION OF OBJECTS OF MACHINE BUILDING PRODUCTION

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Modernization problems of known equipment now are actual enough for different branches of the mechanical engineering. Therefore, a lot of time and efforts is spent on rationalization and automation of synthesis and analysis of modernized objects. The known methods and the software tools for synthesis and analysis of schemes of different equipment and technologies for the machine building production are not enough universal and labor-intensive, because a significant part of work for their realization is fulfilled by high-qualified specialists without of use of computers. There is an improved method of criterial synthesis and analysis elaborated in this article. This method allows with relatively small expenses of time to receive effective variants of different equipment with consideration of the all main initial conditions and parameters and with a possibility of determination with help of simple formulas of the most important criterions of their evaluation for founded selection of the most effective variant. Under realization of the proposed method as main initial parameters of the projected equipment for machining, loading-unloading or transportation are used: equipment destination, its admissible dimension, mass, working capacity, cost, power-consuming, accuracy. Taking in consideration these initial parameters at the next stages are selected admissible variants of modernization. Final evaluation and selection of the most prospective variants are made under criterions of admissible dimension, mass, working capacity, cost, power-consuming, degrees of standardization, unification and automation. At basis of the proposed method can be elaborated a computer program of automated synthesis and analysis for high-effective modernization of modern equipment and technologies for the machine building production.

Key words: *method of criterial synthesis and analysis, initial parameters, high-effective modernization.*

F. 19. Fig. 1. Ref. 10.

1. Problem formulation

With a complication of technique and technologies and in course of an acceleration their development a task of improvement of elaboration methods of new technical processes and objects (so called methods of engineering creativity [1]) became more and more actual [2, 3]. A significant part of engineering creativity tasks is modernization tasks of known equipment and technologies. Main characteristics of the method engineering creativity are: specific expenses of time for synthesis and analysis of certain number of variants of a projected technical system; the number of criterions of their evaluation; quality and efficiency of the selected system variant, a volume of information about this system, that we receive in the result of it analysis, a possibility of computer realization of method. By these criterions majority of known methods of the engineering creativity [3 – 7] have insufficient efficiency and demand improvement.

2. Analysis of last researches and publications

In particular, a predictor-corrector method [1, 2] is enough irrational and labor-consuming since it based on an accidental enumeration of variants.

In a method of control questions [2, 5] is not considered a specific of a projected technical object or process (are used the same questions for determination of improvement possibilities of different systems). All the labor, connected with analysis of the received answers about possible system prototypes is fulfilled by one or several specialists, which solve the projection task and actually make it without of a help of computer technique. This brings to increase of labor content of the process.

The methods of brain attack and senectics [2, 5] are realized on a base of collective discussion with participation of specialists of possible variants solution of the creative task. For this reason the methods do not provide of examination of a big enough number of prototypes and their analysis at basis of a great number of criterions. Under use of these methods computers application is also limited.

In course of realization of heuristic devices method [5] is not considered the specific of task conditions and properties of the elaborated system. Because of a great number of heuristic devices, task analysis with use of the examined method demands a lot of time and in some cases does not provide problem solution.

One more labor-intensive method of the engineering creation is a cost analysis [5]. The method foresees a division of the projected object at elements, a formulation of elements function and an improvement of object structure at the expense of an abbreviation of excessive elements and an improvement of other elements. This improvement is fulfilled on basis of cost analysis of elements functions. In course of this analysis can be used flow block algorithms and computer calculations. Last provides a possibility for an increase of method efficiency, but in spite of that, a main part of the projection works is fulfilled without of use of computers. Moreover, in this method are used basically economic analysis and evaluation is paid not a proper attention to technical criterions.

The most complete creative method of the heuristic group [5] is an algorithm of invention tasks solution [5]. A main advantage of this method is assurance of the most rational search of task solution (without of analysis of the all possible variants) on basis of an elimination of contradictions and with the maximal approximation to an ideal final result (IFR) [5, 6]. At the fig. 1 is presented an algorithm of method's sequence stages [5]. There were attempts of creation of computer databases for method realization [6], but in spite of this it is a labor-consuming method, that consists a lot of obligatory stages. Search of a solution goes on basis of analysis of multiple ways of elimination of technical contradiction (TC) [5]. Therefore, this method also demands of an improvement.

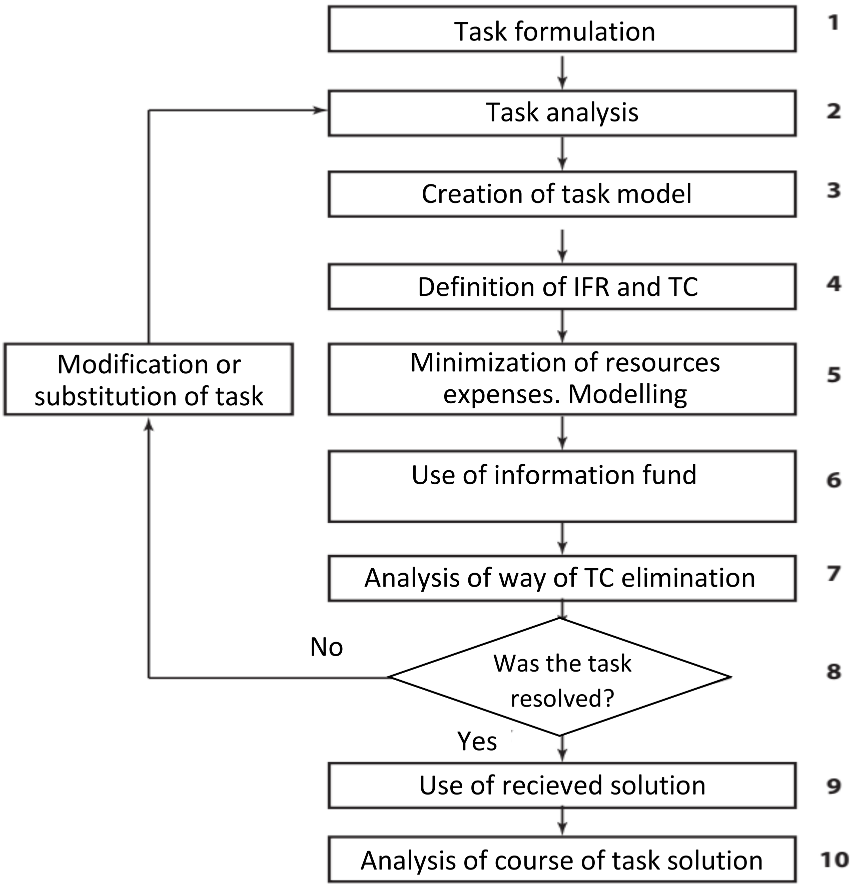

Fig. 1 – Stages sequence of the algorithm of invention tasks solution

Under realization of the method of automated analysis and synthesis of variants technical solutions [1, 2], that based on the method of morphological analysis and synthesis [1, 2, 5], there is need very much time for an examination of prototypes of the elaborated system. This examination envisages system division on units and elements, a definition of design characteristics of elements, a formation of demands list, a creation of an evaluation model of the variants of technical decisions, an elaboration of a computer program of automated analysis and synthesis. All this demands of significant expenses of an unproductive high-intellectual labor, which fulfills without of computers use. Besides, the formulas of the evaluation model [1] do not allow to determine the above indicated evaluation criterions.

Methods of computer-aided projection [4, 7] include some elements of the above examined heuristic methods, means of physical and mathematical modelling, a modern software for computer-aided projection and optimization. At the first stage of realization of these methods is carried out a division of the elaborated system on elements with elaboration of a design documentation for each of these elements. There are found and used a ready design documentation for standard elements and for elements of the other systems of similar destination, which elaborated earlier with help of CALS-technologies. This allows to spare time and money recourses. The next stage of methods realization is a mathematical modelling at the micro- and at the macro-level at the foundation of multi-variant analysis (a determination of state parameters of elements, units and whole system at the different stages of it functioning). Then are realized structural synthesis (a formation of variants of the system composition and analysis of theirs) and parametrical synthesis (determination of functional parameters of the variants and their parametrical optimization). There is leaded repeated analysis of synthesized system variants at basis of the main optimization criterion for determination of the most effective variant.

Powerful means of a computer projection of modern technological processes and objects are CAD-, CAM-, CAE-systems [4, 7], providing: determination of technological and kinematical parameters of elaboration process; tools selection; automated preparation of technological documentation (flow process charts, operation sheets, control programs); 3D- and 2D-modelling of details, units and machines; automated fulfilment of durability calculations.

The tasks of structural synthesis are solved mainly in an interactive regime and therefore they demand a lot of time and engaging of high-qualified specialists. The computer methods allow to take in consideration accidental factors, connected, for example, with unstable physical-mechanical characteristics of elaborated material or with it supply. This is realized at the foundation of analysis of the one worst possible variant or under results of statistic analysis of many possible variants. The system projection on the assumption of the worst variant brings to it excessive mass and price, while statistic analysis demands of significant time expenses.

On modern machine-building enterprises as a kind of the method computer-aided projection are used virtual production systems (VPS) [4], which provide a multi-object technological projection with an intellectual management in distributed production systems. Specific computer programs select a production equipment (that can be the equipment of different shops and even various enterprises) for fulfilment approximately similar production orders with minimal equipment readjustments, minimal production cost, maximal equipment utilization and maximal productivity. These computer programs are used databases with an information about production orders and available equipment.

As it is already above indicated, all the methods of the computer-aided projection are realized in the interactive regime, under active participation of high-qualified designers, technologists and programmers. Known methods of parametrical synthesis, parametrical optimization and determination of the main criterion give not of universal approaches and general formulas for creation or modernization of different technological objects and processes. Therefore, a task of these methods improvement for decrease of labor-intensity is remained actual.

3. Aim of research

The aim of this work is elaboration on the basis of the known heuristic and computer-aided methods of engineering creativity of a new effective method of criterial synthesis and analysis of variants technical decisions, that provides a less number of iterations for elaboration of rational schemes of modernized technological, loading-unloading or transport objects with consideration of specific conditions and parameters subsequent utilization of theirs. Also the aim of creation of the proposed method is a minimization of a volume of an interactive work for definition of object effectiveness criterions and the main valuation criterion of object variants for selection of most effective one. The proposed method, as it was indicated above, is intended, first of all, for solution of modernization tasks.

4. Results of research

Main directions of metal-cutting equipment modernization are presented in the work [8]. Modernization directions for loading-unloading and for transport machines basically are the same as for technological equipment. At present a wide spread method of the modernization is an increase of equipment automation degree. For technological machines can be realized the automation of main processing operation and helps operation (part blank loading, detail unloading, change of operation mode or tool). Equipping of the object with a more modern control system (more productive and compact) also belongs to this type of modernization. The next method of the modernization is a widening of technological possibilities of the equipment at the expense of its equipping with additional technological aggregates (for machine tools – milling spindle unit, boring head, power table with inclined guides and so on). In the tasks of the modernization can be included an increase of machine accuracy at the expense of utilization of devices for a correction of clearance in connections of details, installation of bearings of higher class or use of more rigid elements. For an increase of equipment productivity are realized a mechanization and an automation of main and helps functions fulfilment. The modernization program of machines also includes an application of means for an improvement of operation parameters, for example, at the expense of use of wearproof materials and a coating, hard-alloy cover plates at the worked surfaces of the executive elements, which can be quickly changed.

Thus, before the starting of problem solving with utilization of the proposed method there is need to define the modernization directions of the examined object.

In course of preparation for problem solving is collected and systematized an information about the projected object and about the conditions of its operation.

For a technological processing equipment such main characteristics and parameters are: destination, carrying capacity, productivity, mass, dimension, accuracy and degree of automation. There is need to gather more information about additional units and details, which are introduced in equipment structure with aim of its modernization and can have an original or standard construction. That can be multispindle head, milling spindle unit, boring head, power table with inclined guides. In these cases there is need to point out: a range of rotation velocities of the spindle or table feedings; turning moment, rated force or capacity on the executive element; allowable radial and end beats or an accuracy of lineal movement of this element; a control method and a type of control system; allowable dimension and given location of the projected unit or the element relatively other object elements. Also there is necessary to know main parameters of details, which are planned to process at this equipment (their type, geometry, accuracy parameters, quantity); characteristics of an equipment, that will work in complex with the projected machine; data about a premise for its installation (dimension of area, disposition of communications).

For a loading-unloading equipment the main parameters are: mass, dimension, loading capacity; form and dimension of working area; velocities of executive elements relatively datum lines of working area; mass, form and dimension of objects, which this equipment will load and unload; type of control system; accuracy of objects manipulations. New or modernized units of this kind equipment have drives for providing of different movement of executive elements. Then there is need to indicate main parameters of these drives and also parameters of surroundings.

In case of elaboration of improved transport machines there is need to point out for them: pulling power, mass, dimension, necessary loading capacity, velocity of transportation, operation mode (continuous or periodical), type of control system, parameters of transportation objects, characteristics of connected with the projected transport machine a technological and loading-unloading equipment, parameters of a shop for installation of the transport machine.

For a selection of prototypes are formed databases the known equipment (there are must be separate bases of technological (TM), loading-unloading (LUM) and transport machines (TrM)) and also bases of separate units of corresponding class of equipment from the bases TM, LUM, TrM and other separate appropriate units. For the machine tools (base TMU) such units are: spindles, rests, speed gear-boxes, feeding gear-boxes, milling spindle units, boring heads; for industrial robots (base $LUMU$) – electric motors, reducers, gripping devices, transmissions screw-nut rolling, control elements; for transport machines (base $TrMU$) – different variants of power and transmission units, conveyor bands of different wide).

Each variant in the bases TM, LUM, TrM receives a code, that corresponds to a destination of the machine or of the unit. For example, a lathe provides fulfilment of such operations as: turning, boring, drilling, facing, threading, which are marked with corresponding letters: $T,\ B,\ D,\ F,\ Th$. And the first variant of the lathe – VTM_1 in the database of technological equipment – TM has a description formula:

$$VTM_1 = T + B + D + F + Th. \quad (1)$$

Thus, in case of modernization of the lathe, at the first stage of problem solution with use of the proposed method from the base TM are selected all the variants VTM_1, VTM_2,…, VTM_m, which have designation and description, corresponding to the formula (1); m – quantity of equipment prototypes of the corresponding destination.

Also all selected equipment variants must have technical characteristics, which correspond to characteristics of a modernized object. Thus, a group of additional conditions for a selection of prototypes variants for the second stage of the modernization are:

$$L_{a.i} \le L_{ad},\ B_{a.i} \le B_{ad},\ H_{a.i} \le H_{ad},\ m_{a.i} \le m_{ad},\ N_{a.i} \le N_{ad},\ Q_{a.i} \le Q_{ad},\ d_{a.i} \le d_{ad}, \quad (2)$$

$$i = 1 \div m,$$

where $L_{a.i},\ B_{a.i}, H_{a.i},\ m_{a.i},\ N_{a.i},\ Q_{a.i}, d_{a.i}$ – actual general length, width, height, mass, capacity of electric motor and deviation of executive element in course of functioning of the i-variant of the prototype; $L_{ad},\ B_{ad}, H_{ad},\ m_{ad},\ N_{ad},\ Q_{ad}, d_{ad}$ – given (admissible) length, width, height, mass, capacity of electric motor and deviation of the executive element in course of functioning of the modernized object.

For some kinds of equipment (machine tools, industrial robots) there is need to examine the condition $N_{a.i} \le N_{ad}$ for all the driving electric motors.

The productivity $Q_{a.i}$ can determine on the assumption of general time of fulfilment of main and helps operations for processing, manipulation or transportation of production objects [10].

The condition $d_{a.i} \le d_{ad}$ is examined for all equipment executive elements (this can be a control of radial or face motion variation, a control of parallelity or perpendicularity of reciprocal movements of executive elements [9]).

Hereby, for a solution of specific problem of the modernization on the basis of TM, LUM or TrM at the third stage, with use of the conditions (1, 2) is formed a database of the equipment – DBE.

As variants for bases TMU, $LUMU$, $TrMU$ could be taken schemes of known units and elements for the equipment from the bases TM, LUM, TrM. In the bases TM, LUM, TrM each variant also has its designation: $VTMU_1$, $VTMU_2$,…, $VTMU_n$ and provides a fulfilment of some operations (turning, boring, drilling etc).

For example, the first variant – $VTMU_1$ of a milling spindle unit can be described with the formula:

$$VTMU_1 = M + D + F + Th. \quad (3)$$

The number of variants of the units – n with some destination ($VTMU_1$, $VTMU_2$,…, $VTMU_m$) can be different from the number m.

For solution of the specific problem of the modernization the database of units and elements (DBU) is formed on the basis of TMU, $LUMU$ or $TrMU$ at the fourth stage, with provision for modernization directions and group of additional conditions (2). For instance, with aim of a widening of technological possibilities of a multi-head machine at the expense of ensuring of a milling procession at angle of 30 degrees to horizontal line in the machine construction must be brought in a milling spindle (the description formula (2)) and a powered (P) table with inclined at 30 degrees guide surfaces ($IS + 30D$), that can be described with the formula:

$$VTMU_j = P + IS + 30D. \quad (4)$$

Group of additional conditions for a selection of variants units at the fifth stage of the modernization are the same as for the equipment (see inequalities (2)). But, depending from some unit destination, these conditions can be extended. For example, for speed gear-boxes and feeding gear-boxes of machine tools there are need to point out an arrangement of fastening elements (openings for bolts), a disposition of input and output shafts for securing of possibility of its utilization in the construction of the modernized equipment and its effective interaction with other units and elements.

If after the selection of variants units with the examination of their destination, modernization directions and additional conditions their number amounts m, then at the sixth stage a general quantity of admissible variants of modernized prototypes p can be determined as:

$$p = m \cdot n. \tag{5}$$

At the seventh stage are realized a definition of assessment criterions of the admissible variants, a selection and an analysis of most effective variants. On the basis of an examination of other methods of the engineering creativity, the main evaluation criterions for technological, loading-unloading and transport equipment are: production space, mass, power consumption, degree of standardization, degree of unification, degree of automation, cost.

The production space for admissible object variants is determined with the help of the formula:

$$S_{a.k} = L_{a.k} \cdot B_{a.k}, \;\; k = 1 \div p. \tag{6}$$

For the conducting of analysis of object variants by this criterion there is need to make up a computer program for a ranking of the all p prototypes from the variant with minimal S_a to the one with maximal S_a. The structural formula of such program algorithm has the appearance:

$$RANKING\ \{S_{a1}, S_{a2}, \dots, S_{a.p}\}\ from\ S_{a.min}\ to\ S_{a.max}. \tag{7}$$

The mass $m_{a.m.k}$ of each modernized prototype can be calculated on the basis of the formula:

$$m_{a.m.k} = m_{a.k} - \sum m_{m.u-d.i} + \sum m_{a.u-d.j}\,, \;\; k = 1 \div p, \;\; i = 1 \div m, \;\; j = 1 \div n\,, \tag{8}$$

where $m_{a.k}$ – actual mass of each prototype, that was selected from bases TM, LUM or TrM as basic one for the modernization (see the inequalities (2)); $\sum m_{m.u-d.i}$ – summary mass of the all standardized units and details, moved off from the corresponding basic variant for its modernization; $\sum m_{a.u-d.j}$ – summary mass of the all standardized units and original details, added to the corresponding basic variant for its modernization; m – quantity of moved off units and details from the k-variant; n – quantity of added units and details to the k-variant.

For conducting of analysis of object variants by this criterion there is need to make up a computer program for a ranking of the all p prototypes from the variant with minimal $m_{a.m}$ to the one with maximal $m_{a.m}$. The structural formula of such program algorithm has the appearance:

$$RANKING\ \{m_{a.m1}, m_{a.m2}, \dots, m_{a.m.p}\}\ from\ m_{a.m.min}\ to\ m_{a.m.max}. \tag{9}$$

The power consumption can be characterized by the actual total capacity of electric motors each of the modernized prototypes, that can be determined by the formula, analogous to the formula for mass calculation:

$$N_{a.m.k} = N_{a.k} - \sum N_{m.u.i} + \sum N_{a.u.j}\,, \;\; k = 1 \div p, \;\; i = 1 \div m, \;\; j = 1 \div n\,, \tag{10}$$

where $N_{a.k}$ – actual total capacity of electric motors of some prototype, selected from the bases TM, LUM or TrM as a basis for the modernization (see the inequalities (2)); $\sum N_{m.u.i}$ – summary capacity of electric motors units, moved off from the corresponding basic variant for its modernization; $\sum m_{a.u.j}$ – summary capacity of electric motors units, added to the corresponding basic variant for its modernization; m – quantity of the moved off units from the k-variant; n – quantity of the added units to the k-variant.

The structural formula for the computer program algorithm, that provides the analysis of object variants by the electric capacity and the ranking of the all p prototypes by this criterion has the appearance:

$$RANKING\ \{N_{a.m1}, N_{a.m2}, \dots, N_{a.m.p}\}\ from\ N_{a.m.min}\ to\ N_{a.m.max}. \tag{11}$$

The degrees of standardization – $D_{s.k}$, unification – $D_{u.k}$ and automation – $D_{a.k}$can calculate with the help of the formulas [10]:

$$D_{s.k} = \frac{N_{\Sigma.k} - n_{o.k}}{N_{\Sigma.k}}, \quad D_{u.k} = \frac{n_{u.k}}{N_{\Sigma.k}}, \quad D_{a.k} = \frac{T_{a\Sigma.k}}{T_{\Sigma.k}}, \;\; k = 1 \div p, \tag{12}$$

where $N_{\Sigma.k}$ – general quantity of details in the structure of the k-variant; $n_{o.k}, n_{u.k}$ – quantity the of original and unified details in the structure of the k-variant correspondingly; $T_{a\Sigma.k}$ – the total duration of automated operation in course of functioning of the k-variant; $T_{\Sigma.k}$ – total duration of the all operation in course of functioning of the k-variant.

The structural formulas for the computer program algorithm, that provides the analysis of variants by $D_{s.k}$, $D_{u.k}$, $D_{a.k}$ and the ranking of the all p prototypes by these criterions have the appearance:

$$RANKING\ \{D_{s1}, D_{s2}, \dots, D_{s.p}\}\ from\ D_{s.max}\ to\ N_{s.min}, \tag{13}$$

$$RANKING\ \{D_{u1}, D_{u2}, \dots, D_{u.p}\}\ from\ D_{u.max}\ to\ N_{u.min}, \tag{14}$$

$$RANKING\ \{D_{a1}, D_{a2}, \dots, D_{a.p}\}\ from\ D_{a.max}\ to\ N_{a.min}. \tag{15}$$

The cost of the prototypes is determined as:

$$V_{a.m.k} = V_{a.k} - \sum V_{m.u-d.i} + \sum V_{a.u-d.j}\,,\;\; k = 1 \div p,\; i = 1 \div m,\; j = 1 \div n\,, \qquad (16)$$

where $V_{a.k}$ – actual cost of some prototype, selected from the bases TM, LUM or TrM as the basis for the modernization; $\sum V_{m.u-d.i}$ – summary cost of the all standardized units and details, moved off from the corresponding basic variant for its modernization; $\sum V_{a.u-d.j}$ – summary cost of the all standardized units and original details, added to the corresponding basic variant for its modernization.

There is the structural formula for a computer program algorithm, that provides analysis of object variants at the basis of the cost and the ranking of the all p prototypes by cost criterion:

$$RANKING\,\{V_{a.m1}, V_{a.m2}, \dots, V_{a.m.p}\}\,from\;V_{a.m.min}\;to\;V_{a.m.max}. \qquad (17)$$

At the eighth stage is realized a selection of the one or the several best variants of prototypes. A numerical score system is used for their valuation. The first ten prototypes in each ranking lists, formed after variants ranking by the formulas (7, 9, 11, 13, 14, 15, 17) receive the numerical scores, corresponding to theirs positions in the list: 1-st variant gets 10 scores; 2-nd – 9 scores and so on. The scores for each prototype in the different ranking lists are summarized and as a result a rating ($R_{\Sigma.i}$) of each variant is calculated as:

$$R_{\Sigma.i} = R_{S.i} + R_{m.i} + R_{N.i} + R_{Ds.i} + R_{Du.i} + R_{Da.i} + R_{V.i}, \quad i = 1 \div 10, \qquad (18)$$

where $R_{S.i}, R_{m.i}, R_{N.i}, R_{Ds.i}, R_{Du.i}, R_{Da.i}, R_{V.i}$ – scores, received for the i-prototype in the ranking lists, formed after variants ranking with the consideration of their production space, mass, power consumption, degrees of standardization, unification and automation, cost at basis of the formulas (7, 9, 11, 13, 14, 15, 17).

There is fulfilled a final ranking of the ten best prototypes by rating $R_{\Sigma.i}$ in accordance with the structural formula:

$$RANKING\,\{R_{\Sigma1}, R_{\Sigma2}, \dots, R_{\Sigma10}\}\,from\;R_{\Sigma.max}\;to\;R_{\Sigma.min}. \qquad (19)$$

The first one or the several prototypes in the final ranking lists are accepted for a further elaboration with aim of the problem elimination.

5. Conclusions

An actual problem for mechanical engineering is an improvement of methods automated modernization of different equipment with a minimal expense of time and recourses, with synthesis of a large enough quantity of prototypes and with their analysis under several main criterions for a well-founded selection of the best variant.

The known methods and the software tools for synthesis and analysis of schemes of different equipment and technologies for the machine building production are not enough universal and labor-intensive, because a significant part of the work for their realization is fulfilled by high-qualified specialists without of use of computers.

There is an improved method of criterial automated synthesis and analysis elaborated in this article. The method allows at the basis of initial data about a modernized object (equipment for machining, loading-unloading or transportation), a database of known equipment of the corresponding destination, a database of its units, directions of modernization and several main criterions, to select from the databases all the admissible variants of the modernization. A final evaluation and a selection of the most prospective variants are made under criterions of admissible dimension, mass, working capacity, cost, power-consuming, degrees of standardization, unification and automation.

In comparison with known methods and the software tools for the engineering creativity the proposed method allows with relatively small expenses of time and intellectual labor to synthesize and to analyze a large quantity of prototypes and to select well-founded a most effective variant.

On the basis of the proposed method can be elaborated a computer program of automated synthesis and analysis for the high-effective modernization of modern equipment and technologies for the machine building production.

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ВИКОРИСТАННЯ КРИТЕРІАЛЬНОГО СИНТЕЗУ ТА АНАЛІЗУ ДЛЯ МОДЕРНІЗАЦІЇ ОБ'ЄКТІВ МАШИНОБУДІВНОГО ВИРОБНИЦТВА

Проблеми модернізації відомого обладнання в даний час досить актуальні для різних галузей машинобудування. Тому багато часу і зусиль витрачатися на раціоналізацію та автоматизацію синтезу та аналізу модернізованих об'єктів. Відомі методи і програмні засоби для синтезу та аналізу схем різного устаткування і технологій для машинобудівного виробництва недостатньо універсальні та трудомісткі, оскільки значна частина робіт з їх реалізації виконується висококваліфікованими фахівцями без використання комп'ютерів. У даній статті розроблено вдосконалений метод критеріального синтезу та аналізу. Метод дозволяє при відносно невеликих витратах часу отримати ефективні варіанти різного устаткування з урахуванням всіх основних початкових умов та параметрів і з можливістю визначення за допомогою простих формул найбільш важливих критеріїв їх оцінки для обґрунтованого вибору найбільш ефективного варіанту. При реалізації запропонованого методу в якості основних вихідних параметрів проектованого обладнання для обробки, навантаження-розвантаження або транспортування використовуються: призначення обладнання, допустимий розмір, маса, працездатність, вартість, енергоємність, точність. З урахуванням цих вихідних параметрів на наступних етапах вибираються допустимі варіанти модернізації. Остаточна оцінка і відбір найбільш перспективних варіантів здійснюються за критеріями допустимого розміру, маси, працездатності, вартості, енергоспоживання, ступеня стандартизації, уніфікації та автоматизації. На основі запропонованого методу може бути розроблена комп'ютерна програма автоматизованого синтезу та аналізу для високоефективної модернізації сучасного обладнання і технологій машинобудівного виробництва.

Ключові слова: *метод критеріального синтезу та аналізу, вихідні параметри, високоефективна модернізація.*

Ф. 19. Рис. 1. Літ. 10.

ИСПОЛЬЗОВАНИЕ КРИТЕРИАЛЬНОГО СИНТЕЗА И АНАЛИЗА ДЛЯ МОДЕРНИЗАЦИИ ОБЪЕКТОВ МАШИНОСТРОИТЕЛЬНОГО ПРОИЗВОДСТВА

Проблемы модернизации известного оборудования в настоящее время достаточно актуальны для разных отраслей машиностроения. Поэтому много времени и усилий тратиться на рационализацию и автоматизацию синтеза и анализа модернизируемых объектов. Известные методы и программные средства для синтеза и анализа схем различного оборудования и технологий для машиностроительного производства недостаточно универсальны и трудоемки, поскольку значительная часть работ по их реализации выполняется высококвалифицированными *специалистами без использования компьютеров. В данной статье разработан усовершенствованный метод критериального синтеза и анализа. Метод позволяет при относительно небольших затратах времени получить эффективные варианты различного оборудования с учетом всех основных начальных условий и параметров и с возможностью определения с помощью простых формул наиболее важных критериев их оценки для обоснованного выбора наиболее эффективного варианта. При реализации предлагаемого метода в качестве основных исходных параметров проектируемого оборудования для обработки, погрузки-выгрузки или транспортировки используются: назначение оборудования, допустимый размер, масса, работоспособность, стоимость, энергоемкость, точность. С учетом этих исходных параметров на следующих этапах выбираются допустимые варианты модернизации. Окончательная оценка и отбор наиболее перспективных вариантов производятся по критериям допустимого размера, массы, работоспособности, стоимости, энергопотребления, степени стандартизации, унификации и автоматизации. На основе предложенного метода может быть разработана компьютерная программа автоматизированного синтеза и анализа для высокоэффективной модернизации современного оборудования и технологий машиностроительного производства.*

Ключевые слова: *метод критериального синтеза и анализа, исходные параметры, высокоэффективная модернизация.*

Ф. 19. Рис. 1. Лит. 10.

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