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Erratum

there was a small change

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DEVELOPING ALGORITHMS FOR AUTOMATING THE PROCESSES OF FORMING THE OPTIMAL STRUCTURAL COMPOSITION OF PRODUCTION - TECHNOLOGICAL MODULES

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Abstract: *In this research, we developed appropriate algorithms for the formation of the optimal structural composition of production - technological modules (PTM) based on the automation of the processes of determining and ensuring the functional-parametric compatibility (FPC) of their components. These algorithms are based on the developed mathematical models on the basis of the use of analytical methods for implementing the interconnection between the main components of the PTM.*
Keywords: *automation, functional - parametric compatibility, algorithm, production - technological modules.*

Аннотация: *Ишда таркибий қисмларининг функционал-параметрик мослигини (ФПМ) аниқлаш ва таъминлаш жараёнларини автоматлаштириш асосида ишлаб чиқариш технологик модулларнинг (ИЧТМ) оптимал структуравий таркибини шакллантиришнинг тегишли алгоритмлари ишлаб чиқилган. Келтирилган алгоритмлар ИЧТМнинг асосий компонентлари ўртасидаги боғлиқликни амалга оширишнинг аналитик усулларидан фойдаланишга асосланган ишлаб чиқилган математик моделларга асосланган.*
Таянч сўзлар: *автоматлаштириш, функцонал параметрик мослик, алгоритм, ишлаб чиқариш технологик модуллар.*

Аннотация: *В работе разработаны соответствующие алгоритмы формирования оптимального структурного построения производственно-технологических модулей (ПТМ) на основе автоматизации процессов определения и обеспечения функционально-параметрической совместимости (ФПС) их компонентов. Приведенные алгоритмы основываются на разработанных математических моделях, ориентированных на использовании аналитических методов реализации взаимоувязки между основными компонентами ПТМ.*
Ключевые слова: *автоматизация, функционально-параметрическая совместимость, алгоритм, производственно-технологические модули.*

Introduction

PTM by its structural composition is a complex technological object that includes components that, by their functional purpose, must be combined with each other, as well as by their spatial location relative to each other, meet production (regulatory) restrictions.

The method of controlling the process of selecting effective functional-parametric relationships between the components of the PTM is based on the use of the modular principle of constructing a complex of mathematical models, methods, algorithms, information and software in the machine synthesis of complex technological objects.

According to the results of research [1, 2-4], this paper presents algorithms for automating the processes of selecting rational technological routes for processing a complex of parts, forming the structural composition of the PTM, distributing operations for processing parts according to the PTM and determining their degree of interconnectedness, determining and calculating control parameters to optimize the sequence of functioning of the PTM and placing them on the production area with minimizing the time spent on auxiliary operations and transportation of parts. An enlarged flowchart of these algorithms and their relationship are shown in Figure 1. Now let's look in detail at each algorithm included in the enlarged flowchart.

Stage 1. The Vtm algorithm is designed to form rational variants of technological routes for processing a complex of parts. The Vtm algorithm is executed in the following sequence:

Start. Input of the source data. N – the number of parts, ml-the number of types of technological equipment, the use of which is expected to process a complex of parts, X-the total time spent on performing the operation and o_l in technological equipment, j-ro for functional purposes; L – the number of technological operations for the complete processing of a complex of parts. Reading from the database (DB): information matrix $X=\{x_{lj}\},\ l=\overline{1,L},\ j=\overline{1,m1};$ and $T=\{t_{lj}\},\ l=\overline{1,L},\ j=\overline{1,m1}$ time spent on performing the operation o_l in process equipment j-th functional purpose; $MX=\{mx_l\},\ l=\overline{1,L}$ – sets of process operation code; $C=\{c_j\},\ j=\overline{1,m1}$ – reduced costs for 1 hour of operation of j-th process equipment for functional purposes; $K1=\{k1_i\},\ i=\overline{1,N}$ – the number of technological operations performed to process the part d_i ; matrix $M=\{o_{ik}\},\ i=\overline{1,N},\ k=\overline{1,k_i}$ – sets and sequence of technological operations for part processing d_i ; vector $TR=\{tr_j\},\ j=\overline{1,m1}$ – the name of the j-ro process equipment for functional purposes.

Calculating the value $y_i,\ l=\overline{1,L}$. Start of cycles for i and k. Definition o_{ik} matrixes X и T. Check condition $y_\lambda=1$. If the condition is met, the transition to block 8 is performed, otherwise-to block 7. Determination of the time and technological cost for performing the operation o_{ik} in technological equipment of the j-th functional purpose and verification $x_{\lambda j}\neq 0$. Determining the process equipment to perform the operation o_{ik} and accepting values to_{ik} and ct_{ik} to perform the k-th operation of the part. End of the i and k cycles.

Printing process routes for processing parts $mm_{ik},\ i=\overline{1,N},\ k=\overline{1,k1_i}$ and with the characteristics to_{ik} and ct_{ik}. Removing from the list of unused process equipment groups and changing them accordingly $mm_{ik},\ i=\overline{1,N},\ k=\overline{1,k1_i}$. Generating the tip.dat file and writing it to the DB. Changing the matrix $MM=\{mm_{ik}\},\ i=\overline{1,N},\ k=\overline{1,k1_i}$ to the matrix $MM=\{mm_{ik}\},\ i=\overline{1,N},\ k=\overline{1,km_i}$. Forming matrices TO and CT from matrices TO_1 and CT_1, accordingly. Printing and writing to the DB $MM=\{mm_{ik}\},\ i=\overline{1,N},\ k=\overline{1,km_i}$ and variable values to_{ik} and ct_{ik}.

Based on the method described in [1], the Ko algorithm (step 2) was developed to determine the structural composition of PTM and is carried out in the following sequence.

The general algorithm for automating the construction of the optimal PTM structure for processing a complex of parts and choosing solutions for the rational placement of PTM is shown in Figure 1. To solve this problem, it is carried out in the following sequence. Input of the source data. The parameters N, m, L are entered. Reading from the database: t – the number of MTE varieties after deleting their unused part; matrices $TO=\{to_{ik}\}$ and $CT=\{ct_{ik}\},\ i=\overline{1,N},\ k=\overline{1,km_i};$ the array $NN=\{nn_i\},\ i=\overline{1,N}$ – the planned production volume for each type of parts; $FR=\{fr_j\},\ j=\overline{1,m}$ – the annual fund of the operating time of the j-th functional purpose MTE; $KM=\{km_i\},\ i=\overline{1,N};$ the matrix $MM=\{mm_{ik}\},\ i=\overline{1,N},\ k=\overline{1,km_i}$; the array $TIP=\{tip_j\},\ j=\overline{1,m}$.

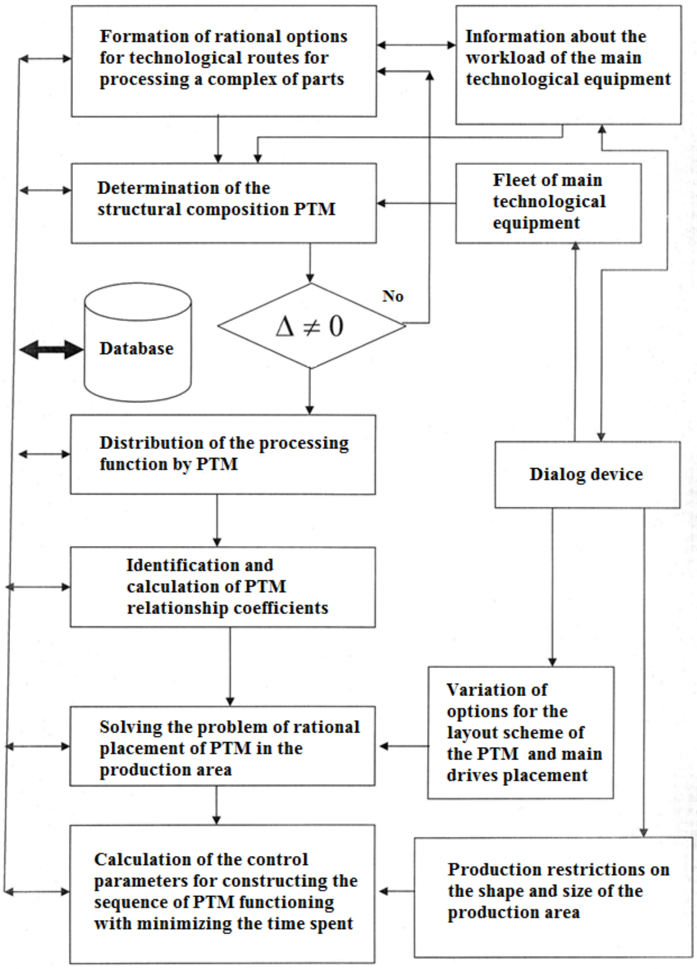

Fig. 1. ***General algorithm of the methodology for constructing the optimal structure of the PTM.***

Step 2. Next, the value is calculated $tob_{ij},\ i=\overline{1,N},\ k=\overline{1,m}$, start of the software cycle $j,\ j=\overline{1,m}$, calculating the value $T_j^p,\ ko_j$, calculation of the MTE load factor j-th for functional purposes – k_j, checking the validity of a value k_j in the dialog with the user, change the value k_j, the specified value is requested and the condition is checked $ko_j \le ko_j^{rear}$, the calculation is carried out $r_p = ko_j - ko_j^{rear.}$, the beginning of the cycles for i and k, the definition of the operation o_s and o_{ik}, performed on the MTE j-th functional purpose, check $y_s = 1$. Transfer of operation o_{ik} on MTE of other functional purpose and calculation tb_j, calculating the value ε and ps, $ps = r_p - tb_j / fr_j$, if $|ps| < \varepsilon$, end of cycles for i and k.

According to this algorithm, a block diagram of the algorithm for solving the problem of forming the quantitative composition of PTM is compiled.

Step 3. The npd algorithm is designed to distribute the processing functions over the PTM. It is based on the results of the research presented in [2]. As a result of its operation, the following results are obtained: K – the number of PTMs used; array $KP=\{kp_i\},\ i=\overline{1,K}$ – information about the functional purpose of the PTM; array $K=\{k_i\},\ i=\overline{1,K}$ – PTM load factor kp_i; array $KPD=\{kpd_i\},\ i=\overline{1,K}$ – the number of types of parts processed in the PTM position kp_i; the matrix $KPD=\{kpd_{ik}\},\ i=\overline{1,K},\ k=\overline{1,kpd_i}$ - code of the k-th part to be processed in the PTM position kp_i; the matrix $KPDD=\{kpdd_{ik}\}$, $i=\overline{1,K},\ k=\overline{1,kpd_i}$, – information about the volume and intensity of movement of the workpieces of the k-th part processed in the PTM position kp_i.

Step 4. The pd algorithm is designed to identify and calculate the coefficients of PTM relationships, based on the method described in [1, 2]. The following is the sequence of its implementation: input of the source data as parameters, N, m, and K. Read from the DB: array $KM = \{km_i\},\ i = \overline{1,N}$; the matrix $MM = \{mm_{ik}\},\ i = \overline{1,N},\ k = \overline{1,k1_i}$, the array $KPDD = \{kpdd_{ik}\},\ i = \overline{1,K},\ k = \overline{1,N}$ – batch information details $d_i \in D$; the array $TIP = \{tip_i\},\ i = \overline{1,m}$; the array $KP = \{kp_i\},\ i = \overline{1,K}$; the array $KZ = \{kz_i\},\ i = \overline{1,K}$; the array $KPD = \{kpd_i\},\ i = \overline{1,K}$; $NPD = \{npd_i\},\ i = \overline{1,K}$; the matrix $ND = \{nd_{ik}\},\ i = \overline{1,N},\ k = \overline{1,kpd_i}$. Next, the beginning of the cycle no $i,\ i = \overline{1,K}$, checks whether ram drives (RD) is considered as a PTM kp_i. If yes, go to block 8, otherwise-to block 14, start the cycle by $k,\ k = \overline{1,K}$, from among the PTMs mm_{k_1}-th the functional purpose is the PTM, which is intended for processing the k-th part, the relationship between the modules is established i and i_2 in the form of tm_{i,i_2} and an indicator of the degree of their interrelationships – trm_{i,i_2}, the compliance of the part volume is checked k, processed in modules kp_i and kp_{i_2}. If they match, the excluded modules are re - introduced into consideration kp_{i_2}, excluded PTM with mm_{k_1} functional purpose in order to determine the relationships of other PTMs of that functional purpose with the module kp_i. Then the software cycle begins j.

Now let's consider the hm algorithm, which is used to calculate the control parameters for constructing the sequence of PTM functioning with minimizing the time spent on transporting parts, which is based on the method described in [1, 2]. The algorithm is executed in the following sequence: entering the parameters K, t and reading from the array DB $EP = \{ep_j\},\ j = \overline{1,K}$, reading from the matrix DB $TM = \{tm_{ij}\},\ i = \overline{1,K},\ j = \overline{1,K}$ – an indicator of the degree of interconnectedness and an array $TIP = \{tip_j\},\ j = \overline{1,m}$, matrices are formed $TRM = \{trm_{ij}\}$ and $TV = \{tv_{ij}\},\ i,j = \overline{1,K+1}$, and according to the selected variant of the layout scheme of the PTM placement, matrices are formed $Z = \{z_{ij}\},\ i,j = \overline{0,K+1}$ according to $KP = \{kp_i\},\ i = \overline{1,K}$, checking the correctness of Z in accordance with the KP under the appropriate restrictions, calculating the value $h_{ij},\ i,j = \overline{0,K+1}$, $h_{ij},\ i,j = \overline{0,K+1}$, target function, matrices $C = \{c_{ij}\},\ i,j = \overline{0,K+1}$, checking the existence of at least one $c_{ij} < 0$. [4, 5]

Step 6. To solve the problem of rational placement of PTM on the production area, according to Figure 1, the following sequence of procedures is implemented: Input of initial data. As parameters, enter K and m, the values $x_0, y_0, z_0, T_h, t_{ycm.}, t_{CH}, v$. Reading from DB: arrays $A = \{a_j\}$ and $B = \{b_j\},\ j = \overline{1,m}$ – dimensions of the area of placement of the j-th PTM for functional purposes; symmetric matrix $HH = \{hh_{ij}\},\ i,j = \overline{1,m}$ – standards for inter module distances; arrays $H = \{h_i\},\ KH = \{kh_i\}$, $KHH = \{khh_i\},\ j = \overline{1,K}$ and matrices; arrays $XN = \{xn_j\},\ YN = \{yn_j\},\ j = \overline{1,m}$ – the coordinates of the placement of the j-ro PTM storage device for functional purposes in the coordinate system of the module itself, the determination of the coordinates of the placement of the center of the automated warehouse of the site and its position of reception and delivery, the determination of the maximum elements of the array B and the HH matrix, the beginning of the cycle for $i,\ i = \overline{2,K}$, calculation of the radius of possible positions of the PTM module placement $h_i \in H - R_i$, determining the number of possible PTM placement positions $h_i \in H$ and their placement coordinates xx_j and $yy_j,\ j = \overline{1,i_1}$, in these positions, the coordinates of the location center of the PTM drive are calculated $h_i \in H$ for all positions $tz_j,\ j = \overline{1,i_1}$, the time spent on intermodule transport is calculated for all $tz_j \in TZ,\ j = \overline{1,i_1}$ and the position is selected $tz_k \in TZ$ to place the PTM $h_i \in H$, position $tz_k \in TZ$ assigned to place the PTM

$h_i \in H$, end of the cycle for i, printing the placement coordinates x, y, xn, yn_i , PTM $h_i \in H,\ i = \overline{1, K}$, and writing them to the DB, accessing the graf subroutine and getting a graphical image of the coordinates of the PTM placement center. [6,7,8]

Conclusion

These algorithms are on the basis of the mathematical support for the formation of the optimal structural composition of PTM based on the automation of the processes of determining and ensuring the functional and parametric compatibility of their components. Ultimately, they allow you to automate the processes of forming integrated production and technological systems, in particular, PTM of domestic and foreign production.

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