

Some aspects of problematics in designing technological complexes

A S Vasiliev, A A Goncharov

Bauman State Technical University, 5, 2-nd Baumanskaya, Moscow, 105005, Russia

E-mail: vas@bmstu.ru

Abstract. The methodical approach to the analysis of the production program for the designed technological complex has been developed. The approach allows to select the parts planned for production, to group them according to the commonness of the structural and technological features, preliminary determine the composition of the complexes sections and the production program for each of them.

1. Introduction

The growth of economy is inseparably connected with the creation of new productions and modernization of the existing ones. It is fully related to its major branch – mechanical engineering. The basis of the last one is formed by the modern technological complexes.

The Technological Complex (TC) is a set of functionally interconnected means of technological equipment for performing the set engineering procedures or operations in the regulated conditions of production [1]. Any TC is a big, targeted system which creation is connected with implementation of its design and its physical implementation in particular technical and organizational conditions.

The modern methodology of designin TC is insufficiently developed in procedures. The idea of actions of the modern TC designer consists in developing the project satisfying with the most general rules of technological design and requirements of numerous documentary standards [2],[3]. Actually the designing process is insufficiently formalized, and its results are subjective and directly depend on the experience and knowledge of the designer. Thus, it leads to unnecessarily increasing costs on the development and implementation of the project, increasing terms of designing or even inefficiency of the project in general.

The structured aspect of designing TC, which result is structuring both the complex in general and its separate subsystems and subdivisions, in many respects defining efficiency of the project, has practically no science-based procedural framework.

This defines the urgent necessity to improve methodology for designing TC, its science-based formalization and to create effective technical equipment of its automatization.

2. Analysis of the production program

The set production program (R) contains the major data about the designed TC. For complexes of cars parts production:

$$R = [I_i, N_i]; \quad i = 1, \dots, n \quad (1)$$

where I_i is the name (identifier) i of parts from the set nomenclature list; n is the number of part



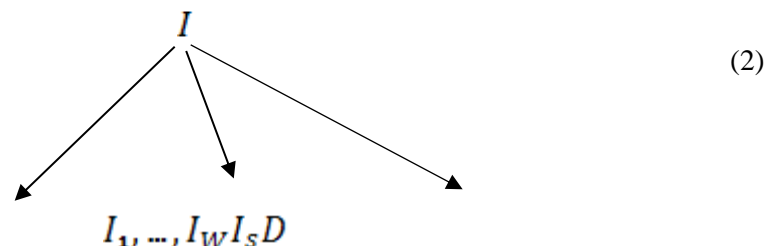
names from the set nomenclature list; N_i is the output volume i of a part for the fixed time period.

In combination with data of CAD models of the parts which are planned to be produced we can preliminary estimate the production type of the designed TC [4] and its most probable specialization by their weight (1). In single-unit production it is most probable the technological specialization of TC. Batch production is characterized by constituent part specialization. Large-volume and mass productions are characterized by using parts specialized flow lines [5], [6]. The results of the traditional empirical analysis of the production program [7] are not connected directly with results of project designing. The labor input of the analysis is not less than 10-15% of the general labor input of designing TC.

The developed in MSTU of N.E. Bauman approach to the analysis of the production program of the designing complex is based on the consecutive implementation of three design procedures [8]:

- a) preliminary selection of parts, planned to be produced in the designed TC according to the structural and technological features, and separation of the parts which cannot be produced in it (purchased parts; made in cooperation; having technical specifications in production, etc.);
- b) groupings the parts according to common constructive and technological characteristics and on preliminary formation of production programs for production departments (operational units) which are presumably a part of TC;
- c) creating the list of the units which are presumably a part of TC, and specifying their specialization.

The selection of the nomenclature of the parts which are planned be produced in the designed TC is carried out on the basis of the developed parts classification system, which is not considered in this research. Its feature is steady separating the disordered list of parts into groups only on the basis of five constructive and technological characteristics, which values are easily defined by the CAD models of the parts list. Plenty of parts names (I) are divided according to the scheme:



where I_1, \dots, I_W subsets of the parts belonging to macrogroups 1, ..., W on using classification; I_S – subsets of the parts, planned be produced, but do not belong to any of created macrogroups; D – multitude of parts, are beyond the production in the designed TC.

$$\begin{cases}
 I_1 = I_{11}, \dots, I_{1V} \\
 \dots \dots \dots \\
 I_W = I_{W1}, \dots, I_{Wt}
 \end{cases} \tag{3}$$

Where $I_{11}; I_{1V}$ is serial part identifiers of the first macrogroup, having a capacity of V ; $I_{W1}; I_{Wt}$ is serial part identifiers of the macrogroup W , having a capacity of t .

Part identifiers in (3) correspond to identifiers of parts in a multitude I .

The term "macrogroup" underlines its non final composition as it can be specified at the subsequent design. Each macrogroup complies with the structure matrix (1) characterizing the

production program of manufacturing the parts united in it. For example, for a macrogroup I_1 the output program R_1 is presented by the formula:

$$R = \begin{bmatrix} I_{11} \cdot N_{11} \\ \dots \\ I_{1V} \cdot N_{1V} \end{bmatrix}. \quad (4)$$

As a result, the production program of part manufacturing output of TC (R) is divided into separate production programs or acquisition for each of the created groups and subsets, and is represented in the following way:

$$R = \begin{bmatrix} R_1 \\ \dots \\ R_W \\ R_{I_s} \\ R_D \end{bmatrix}, \quad (5)$$

where R_{I_s} is the possible production program of manufacturing the parts which do not belong to one of the created macrogroups; R_D is the acquisition program (order) of the parts which are beyond the production in the designed TC.

Updating of the nomenclature consists in making decision on the place of part manufacturing from the subset I_s (previously) with possible joining them to some macrogroups or distinguishing their production into independent structural unit, and also in excluding the part multitude D from the nomenclature. When updating the nomenclature the boundary conditions for the analysis of the production program are considered [8].

The adjusted output program (R_K):

$$R_K = \begin{bmatrix} R_1 \\ \dots \\ R_{W_K} \\ R_{I_s_K} \end{bmatrix}, \quad (6)$$

as well as the data about processes of manufacturing the parts, planned to be produced, are used to specify the assessment of the part production type of macrogroup. Herewith, the multitude of the set production processes can be incomplete as engineering procedures of manufacturing some, or even many parts, may not be included. The standard processes demanding adjustment can be presented.

The part production type assessment of each macrogroup is carried out by the developed technique providing less discrete gradation of production types in comparison with the existing one (all-Union State Standard 3.1121-84).

To determine production programs and specialization of production units the following strategies are used:

- 1) each macrogroup can be produced in a certain production unit;
- 2) specialization of units should correspond to production type.

The targets of production programs synthesis are:

- 1) to define the list of the main production units forming the structure of TC;
- 2) to form production programs for manufacturing the parts for production units taking into account the production type and their specialization.

The number of production units and output programs can be changed by the combination of macrogroups and their possible merging and separating.

It is considered that:

- 1) the number of production units should be necessary and sufficient for steady performance of the set production program by the designed TC;
- 2) types of production units, which are a part of the TC can be different. But providing for effective interaction of units with different types of productions requires additional costs;
- 3) if reducing the number of units (their enlargement) the violation of unit controllability is possible. When the number of units increases, the administrative structure grows, and the violation of complex controllability is possible.

Completely carried out analysis of the output program of TC allows to define the structure of its units and the production program of manufacturing parts for each of them, that, in turn, gives the opportunity to allocate parts-representatives for each unit, and to develop technology procedures of production in case of their absence.

3. Development of design solutions using analogs

When developing new TCs it is prospectively to use of TC-analog projects (or their fragments) forming the basis for creation of the complexes satisfying the tasks design specifications. If the project analog is found reasonably, then the subsequent actions of TC developers come down to its adjustment (structural and parametrical modification and adaptation to requirements of the specification or even conditions of the subsequent project implementation. It drastically reduces time and costs for design at high quality of design solutions. However, application of such approach is restrained by lack of the formalized techniques of searching TC analog projects [9].

The problem of developing such techniques consists in high complexity of exploration object, its multilevel structural organization and a possible existence of several difficult searching keys leading to the various results of the last one. Existing powerful documentary databases do not guarantee finding the project analog, closer to desirable. The high labor input of its transformation to the project corresponding to the T-complex tasks design specifications can destroy all advantages of the considered design approach.

Nowadays it is difficult to consider proven that between the design decisions connected with developing mechanical engineering T-complexes there can be established the formally expressed relations of identity and similarity [10]. The formalized relations of design solutions can be effectively used for searching design solution-analog which by modification can be transformed to the project of the developed complex at minimum labor costs. Such approach was successfully approved at the organization of searching route technological processes analogs [11].

The main idea of the organization of searching TC- analogs projects is that a similar combination of characteristics values of input and output data on projects can correspond to their similar contents.

Input data of the project of TC are:

- 1) the nomenclature list of the parts which are planned be produced in the designed TC $\{I\}$;
- 2) multitude of CAD models of the parts which are planned be produced $\{K\}$;
- 3) multitude of engineering procedures of manufacturing the parts in the designed TC $\{P\}$;
- 4) multitude of the planned part output volumes by the designed TC $\{N_I\}$.

Output data of the project of TC is presented by:

- 1) multitude of part output volumes provided to the developed TC $\{N_o\}$, generally $N_o \geq N_I$, for simplicity $N_o = N_I = N$;
- 2) multitude of the actual values of labor intensity of part production in the developed TC $\{T\}$;
- 3) multitude of parameters (technical and economic indicators) of the designed TC.

Information objects of various structures can be used as the search keys at the organization of searching TC-analog projects of as input and output data on projects with multitude search can be incomplete [12].

The most complete input and output data on the compared projects TK^A and TK^B can also be presented in the form:

$$TK^A = \begin{bmatrix} I_1^A K_1^A & P_1^A N_1^A T_1^A \\ \dots & \dots \\ I_n^A K_n^A & P_n^A N_n^A T_n^A \end{bmatrix}; \tag{7}$$

$$TK^B = \begin{bmatrix} I_m^B K_m^B & P_m^B N_m^B T_m^B \\ \dots & \dots \\ I_m^B K_m^B & P_m^B N_m^B T_m^B \end{bmatrix};$$

where n, m – the sizes of nomenclature lists of the parts, manufactured by complexes TK^A and TK^B respectively. Each column in (7) is presented by the elements of the multitude of the same name. When comparing complexes projects for each pair of compared columns (multitudes) quantitative assessment of their similarity can be defined. Thus, for example, for multitudes I^A and I^B in (7) the quantitative assessment of similarity of their structure $[(S)_I]_{A,B}$ can be determined by the formula [9]:

$$[(S)_I]_{A,B} = \frac{2c}{n + m} \tag{8}$$

where c is the number of pairs with identical elements in multitudes I^A and I^B ; n, m – total number of elements in compared multitudes. When estimating the TC project-analog the nomenclature lists of produced parts (I^A) and the parts which are planned be produced (I^B) are compared first. It is possible to compare multitudes K, P, N, T only for identical products compared by TC. The small value of assessment of the nomenclature similarity for projects TK^A and TK^B practically excludes the consideration of the project TK^A as a possible analog of the designed complex TK^B . Defining the general assessment of the compared projects similarity on (7) is inexpedient. The analog is chosen by comparing partial similarity estimates. Searching the analog projects on the basis of their representation (7) is complicated by the incompleteness of information and the necessity to compare project characteristics, excessively completely defining their content.

When comparing the projects TK under the conditions of limited information about them the information objects of other structure can be used:

$$TK = \begin{bmatrix} I_1 N_1 T_1 \\ \dots \\ I_m N_m T_m \end{bmatrix}; \tag{9}$$

$$TK = \begin{bmatrix} I_1 N_1 \cdot T_1 \\ \dots \\ I_m N_m \cdot T_m \end{bmatrix}; \tag{10}$$

$$TK = \begin{bmatrix} I_1 N_1 \\ \dots \\ I_m N_m \end{bmatrix}; \quad (11)$$

When searching the project analog in the database it is expedient to use sequentially several search keys with the subsequent comparison and the analysis of its results.

The formalized nature of the described methodical approaches to the performance of the major stages for developing TC allows to create effective means of design automation processes on their basis.

4. Conclusion

1) The perspective of designing mechanical engineering TC, focused on improvement of its methodology, on its formalization and creation of technical means of complexes design automation is on the front burner.

2) The developed methodical approach to the analysis of production programs of the designed TC allows to select the parts which are planned be produced, to group them according to the common structural and technological features, to predefine the structure of complexes units and the production program of each of them.

3) Reducing of the time and costs on designing TC can be reached by the reasonable use of the available project-analogs as the bases of the developed project of TC. The automated search of the closest project-analogs can be carried out on the basis of the offered approach to the formation of search keys and use of quantitative estimates of similarity characteristics of the compared projects.

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