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Formation of initial data when planning for custom manufacturing

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Formation of initial data when planning for custom manufacturing

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Abstract. The formulation of the problem of production planning for custom small-scale electronic production is considered. In order to increase the efficiency of solving automation planning problems, an approach has been developed to generate optimal initial data for planning, taking into account their dimensionality. An improvement in the execution time of production plans at the first stage of manufacturing an order by an average of 5-10% is shown.

1. Introduction

When changing the portfolio of orders, which is typical when a product is manufactured in a small series "on order", it is necessary to dynamically adjust production schedules and the corresponding operational processes, which may lead to a decrease in the production rhythm. A similar situation arises when new (unscheduled) orders are included in the approved production plan, often not related to the current production. Such conditions are characteristic of small-scale custom-made production, in which an order is taken as a planning and accounting unit, and execution control is carried out according to aggregated planned indicators.

To increase the efficiency of planning and managing small-scale custom-made production, it is necessary to develop a set of optimality criteria designed to assess the quality of solving the optimal planning problem and dynamically adjust the values of the objective function in the face of frequent changes in the order portfolio. This statement of the problem belongs to the class of multidimensional combinatorial optimization problems, the effective solution of which requires the development of heuristic procedures. Given the complexity of solving the problem, the nature of the production process, a significant amount of heterogeneous information and data, as a preliminary step in finding a solution, a procedure for the unified preparation of data on production processes should be proposed. Such a procedure can be useful in the systematization and accumulation of information, its subsequent processing, analysis and use in order to find the optimal solution to the problem of planning and managing small-scale order production.

2. Criteria for optimal planning

A well-known effective means of planning production activities is the optimization of the production schedule based on appropriate methods and tools. The purpose of the production schedule is to produce products in the planning period with maximum economic efficiency in the given restrictions. A prerequisite for solving the optimization problem is the presence of an optimality criterion, as an indicator with a value characterizing the achieved economic efficiency of the plan.

Table 1 shows the main optimality criteria proposed for use in solving the problem of creating a flexible production plan in small-scale custom production. These optimality criteria are proposed based on the results of a study of tactical and operational planning processes carried out at the enterprises of the electronic industry. Optimality criteria are ordered depending on applicability at an appropriate level of management and planning.

Table 1. A set of criteria for optimal planning.

Management levels of production		Optimality criteria for production planning
Financial and economic		Maximizing profit; Minimizing WIP; Minimize stocks.
Production	interplant	Minimizing lead time / order portfolio; Minimizing the time of interplant goods waiting; Batch size optimization.
	intraplant	Minimizing lead time / order portfolio; Minimizing the time of intraplant goods waiting; Batch size optimization.

Minimizing lead time / order portfolio can be represented by the expression [1]:

$$F = f(T_i, i = \overline{1, N}, \sum_{i=1}^{m} T_{\text{ц}_m}, T_{I_i}) \rightarrow \min \qquad (1)$$

where $T_i, i = \overline{1, N}$ – production time of parts and assembly units (PAU), planned at the first stage according to the documentation that passed the technological preparation of production;
$\sum_{i=1}^{m} T_{\text{ц}_m}$ – picking time in central warehouses;
T_{I_i} – production time of PAU on the basis of a change in the production plan that arose as a result of the end of development of design documentation, technological processes and technological preparation of production absent at the stage of launching an order into production.

The production plan for the production of the order, according to expression (1), is feasible, takes into account restrictions on the directive dates, optimal launch lots, etc., but is not optimal from the point of view of finding the extremum of the multicriteria objective function, the criteria of which are presented in table 1.

3. The method of forming the source data for planning

The development of an order manufacturing plan begins with the creation of a structural-technological decomposition scheme that shows the structure of the manufactured product in accordance with the technological procedure for its manufacture [2]. In small-scale custom production of complex electronic equipment, assembly technological processes predominate, and when developing technological schemes, they are guided by well-known principles [3]:

- the scheme is drawn up independently of the product release program;
- assembly units are formed subject to the independence of their assembly, transportation and control;
- the scheme must have the property of continuity, that is, each subsequent assembly level cannot be implemented without the previous one.

The development of a technological route for the manufacture of an electronic complex in small-scale custom-made production of electronic equipment is based on decomposition — the explode of the product into its assembly units — parts and blocks of varying degrees of complexity [4-6]. After the product is blown up, a sequential production flow chart of the product assembly is drawn up for the components included in it, which is a schedule for the assembly of several products included in the order and the order as a whole. In such a mechanism, the concept of the operating time of the production system and the integration of the optimality criterion is deciphered as follows:

- the operating time of the production system when the PAU is launched into production by identifier;
- the operating time of the production system when the PAU is put into production in accordance with the calculations of the planning subsystem.

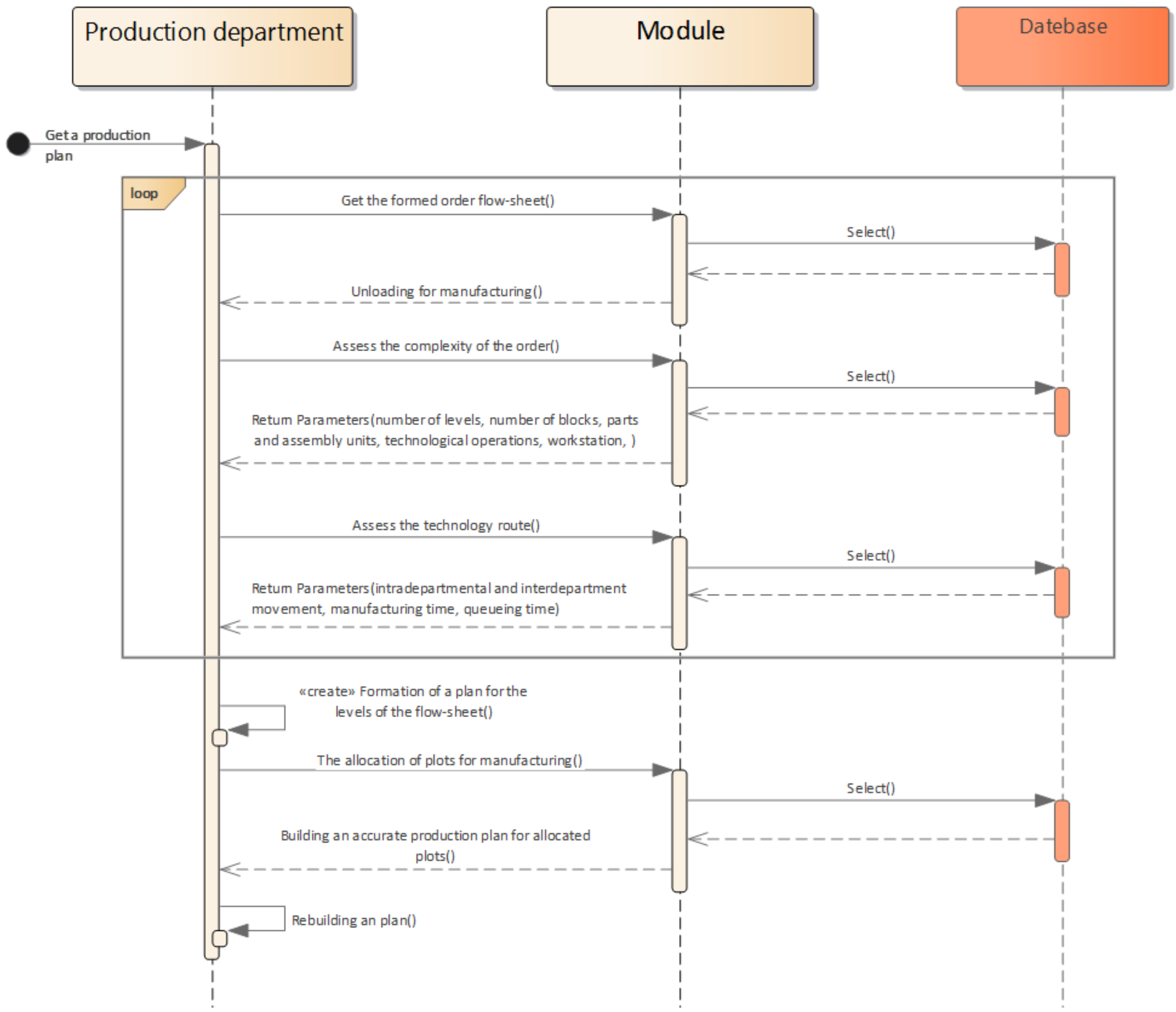

Figure 1. The algorithm for the formation of production plans.

The disadvantage of this method of planning is that the resulting plan is not optimal from the standpoint of launching an order into production. The advantage of such a plan is that the execution time of the order (planned) is known and it is possible to decompose the order according to the levels of its constituent units. Thus, the development of production plans for the implementation of technological processes for the production of complex electronic complexes at the first stage is to determine the completion date of the order.

The typical structure of an order for the manufacture of a complex product can be represented as an assembly technological scheme consisting of 6 levels of nesting, 155 parts and assembly units, 50 blocks (similar data correspond to a typical assembly process for the production of electronic equipment or a complex). An order is made by two workshops, at 196 workplaces when performing 1144 technological operations. A preliminary assessment of the dimensionality of the production planning problem for such an order shows that such initial data do not clearly allow it to be solved using methods for generating an accurate production plan due to the high cost of computing resources [7-10]. Therefore, to solve the planning problems in the conditions of custom small-scale production, an approach was developed for the formation of production plans with optimization of the initial data, the algorithm of which is presented in the sequence diagram in figure 1.

An example of the implementation stage of the allocation of manufacturing sites (figure 1) for the order XXXXXXX includes at each level of the technological scheme:

- compilation of the applicability table for each part / block with the allocation of technological routes within the framework of level 2 of the considering order, using two, three or more workshops;
- selection of a group of parts at level 2 of order XXXXXXX with technological routes that correspond to the type of task “flow line”.

As a result, for order XXXXXXX at level 2, 7 parts with the technological route Department 1 - Department 10 - Department 5 were identified, the spaghetti diagram for which is shown in figure 2, indicating jobs in the form of a rectangle with the abbreviation "WS№№".

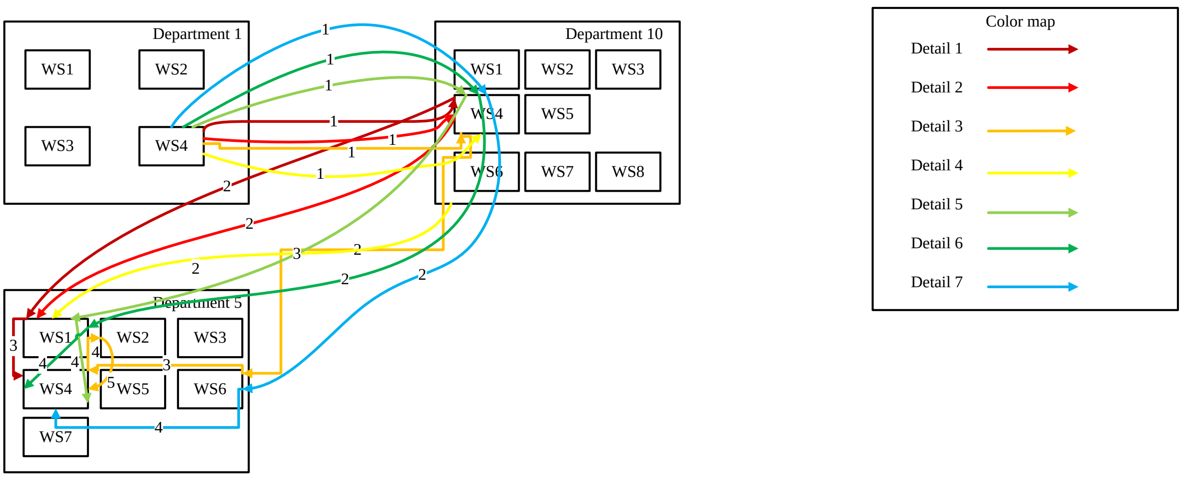

Figure 2. Spaghetti Chart Route 1-10-5.

Visualization of the technological routes of manufacturing an order using the example of an order (XXXXXXX) confirms the correctness of the algorithmization of the stage of allocation of manufacturing sites. The interplant and intraplant presentation of the trajectory of movement of parts during the execution of technological routes for manufacturing an order shows the possibility, at the stage of generating the initial data for planning, to allocate groups of parts / blocks in order to build exact sections of the production plan for them with further integration into the general plan for manufacturing the order.

On the basis of the APS-system, a production plan was obtained for the production of the order from the start date without taking into account the interlant transitions for a selected group of 7 parts with a technological route 1-10-5 with the following order of putting the parts into production: Detail 1, Detail 2, Detail 3, Detail 4, Detail 5, Detail 6, Detail 7. The operating time of the production system when the PAU was launched into production with direct planning was 339 minutes. After applying the planning method based on the branch-and-bound method, the optimal order for starting the parts into production was obtained: Detail 3, Detail 5, Detail 1, Detail 7, Detail 2, Detail 6, Detail 4, and the

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production system's operating time was 296 minutes. This algorithm was tested on other technological routes and order levels XXXXXXX and showed a generally 5% -10% reduction in the execution time of the production production plan, as well as an average 4-5% reduction in equipment downtime.

4. Conclusion

A methodology has been developed for the formation of optimal initial data for planning the manufacture of orders as planning and accounting units for small-scale ordering with account of the dimension of the initial data for planning. A technique is proposed for combining APS planning technology and the formation of accurate plans, taking into account the type of production planning tasks using the "flow line" example, and it shows an improvement in the execution time of production plans at the first stage of manufacturing an order according to documentation by an average of 5-10%.

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