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Approach to Determining Order of Production of Parts and Assembly Units of Engineering Products in Production Process Planning

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Abstract

The paper investigates the production planning process. Due to the large dimensions and complex constraints of the production sequencee of parts and assembly units, the process-planning problem belongs to the NP-complex class. The aim of the work was to develop an algorithm that allows forming a feasible schedule, which is close to the optimum, minimizing the length of the production cycle. The authors propose an algorithm for determining the order of the item and assembly processing units of the product to entitle it "Falling Leaves". The algorithm is based on a stratified cutting the end vertices (leaves) of the tree structure of electronic products and ranking the group leaves depending on the duration of the production path. This approach allows us to start the production of products with the parts having the longest production cycle. Computational experiments on the products of varying complexity and the comparison with the existing algorithm have been conducted to determine the order of processing of parts and assembly units at the level of entry into the structure of the product. The results show that the developed algorithm "Falling Leaves" decreases the production cycle of products by 2% to 30%.

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Keywords: mechanical engineering; production planning; heuristic algorithms; product structure; layering sequencing.

1. Introduction

During the production process on a modern machine-building enterprise, much attention is paid to improving production efficiency. This aspect has become particularly important in connection with the individualization of products. Orders from customers that require individual distinguishing characteristics of the product, causing additional difficulties in the organization of the production process [1].

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To solve these problems requires the development and implementation of effective systems and manufacturing process planning algorithms. However, the complexity of the planning process and a large amount of information being processed is not possible to find a solution within a reasonable period. Most of the existing productions planning problems belong to the class of NP-hard **Ошибка! Источник ссылки не найден.**,**Ошибка! Источник ссылки не найден.**]. As a rule, these problems do not have solutions in general, so they have a simplified setting for finding particular solutions. However, the urgency of this problem is attracting her studies of many scientists.

The use of computer technology has allowed to significantly expanding the possibility of solving production-planning problems. Automated process of production planning has become a key component of any integrated production control system. In recent years, it has been widely used metaheuristic algorithms. They are used to improve the efficiency of the planning process, for example, a genetic algorithm (GA), annealing algorithm (SA), particle swarm optimization (PSO), tabu search (TS), ant colonies optimization (ACO) [**Ошибка! Источник ссылки не найден.**].

In this paper, we propose an approach based on the development plan for the construction of production algorithms to generate the production plan is close to optimal. This approach provides a very efficient production plan without the use of optimization and trying different options for the procedure, which saves time and computational resources.

This article describes an algorithm for determining the order of the manufacture of parts and assembly units "falling leaves" based on the layered "cutting" the leaves of the tree of the electronic structure and ranking of "cut" leaves the group along the length of the path of manufacturing, which allows to start planning with item-assembly of the critical path units, minimizes technology product manufacturing cycle [**Ошибка! Источник ссылки не найден.**].

The article is structured as follows. Section 2 is devoted to the review of publications on the topic of production planning, in section 3 worded problem statements, Section 4 describes the algorithm in Section 5 presents the results of experimental studies and the introduction of an automated system based on the developed algorithm. Section 6 presents conclusions and prospects for the submitted work.

2. Review of publications

The relevance of the production planning problem is due to the possibility and necessity of its application at each plant. The introduction of even some planning elements can significantly increase the efficiency of the production process. However, the complexity and volume of this problem is not possible to get a decision in general terms. Therefore, we designed and developed a large number of algorithms and methods for solving problems that are particular cases, or individual elements of the overall planning objectives.

Exact and approximate methods of solution are used in solving the planning problem. Among the most effective methods of exact is considered Brooker's algorithm [5,6]. The basis of this algorithm is a method of branches and borders [7]. The emerging practice of large dimension problems is solved by approximate methods. They can be divided into two types: design and improve [6]. Constructive methods at each step of building a partial solution, adding to the constructed schedule unscheduled operation. As a result, always get a feasible schedule. Proximity to the optimal schedule is determined by algorithms and rules that are used at each step of solving the problem.

Methods to improve (metaheuristics) used some initial schedule and produce its improvement (optimization). Review of publications on these methods is given in [3], where it is noted that the development of this class of methods is widespread throughout the world. Known algorithms such as genetic algorithm (GA) [8], an algorithm that simulates the annealing (SA) [9], Hybrid GA and SA algorithm [10], the search algorithm tabu search (TS) [11], optimization algorithm particle swarm (PSO) [12], an improved genetic algorithm (non dominated sorting genetic algorithm II (NSGA-II)) [13,14], the algorithm imperialist competition [3].

In [15], the authors consider the use of multi-purpose hybrid algorithm backtracking to plan not only the major (technological) operations, but takes into account transport operations.

However, it should be noted that all these algorithms have some drawbacks. Disadvantages are explained by the simplifications or private elements accepted in problem definitions in case of development of an algorithm. Sometimes newly introduced innovations allow sufficiently develop efficient algorithms, but narrows the possibility of their use in real-world conditions.