Improving the quality of planning due to automated generation of a normative card based on digital technological processes

A I Sidorova*, O V Zhelezov, Yu V Polyanskov and P Yu Pavlov

Ulyanovsk State University, Competence Center ‘Digital production of high-tech products in mechanical engineering’, 42 Leo Tolstoy str., Ulyanovsk, the Russian Federation

*alena280194@mail.ru

Abstract. Improving the quality of planning is one of the main problems of any multinomenclature enterprise. This article discusses the development of models for an automated calculation of time standards, which are necessary not only for an accurate regulation of digital technological process operations, but also for the correct maintenance of production normative cards. Parameters for the automated generation of a normative card are determined, which are used for accurate planning of the main production capacities of the enterprise. An algorithm for obtaining planned operational labor intensity based on the digital technological process of an aircraft building enterprise is developed.

1. Introduction

The realization of “Just In Time” concept is one of the important tasks of any high tech productions. This principle of work is based on many key indicators, one of them is accurate planning of the main production capacities.

To achieve this indicator, full automation is required not only at the level of production resource management system, but also at the level of process design system considering automated standardization of operations. In this article, as an example, we consider the automated production management system (ASU PR) and ‘TeMP2’ automated technical process design system used at large Russian machine-building enterprises.

To automate the regulation of technological processes of machine-frame production, information support was developed that includes not only a list of operations and transitions, algorithms for selecting technological equipment, algorithms for selecting labor protection instructions and technical requirements, but also models for calculating time standards and cutting modes. The developed information support will improve not only the development quality of technological processes and the quality of the technological documentation set being developed, but also the correct and accurate automated calculation of the time standards for operations in accordance with the collections of work standards regulated at the enterprise.

The calculation of labor intensity of manufacturing parts is necessary to perform one of the tasks of the subsystem ‘Capacity Requirements Planning’ in ASU PR. Such a task is to obtain and calculate the planned operational labor intensity of manufacturing parts based on digital technological processes. Since the development of digital technological processes will enable us to automatically obtain the
values of time standards, the main task of this work is to develop algorithms and a software module for obtaining the time standards from CAPP to MES, considering the automated formation of a normative card.

At present, CAPP ‘TeMP2’ and ASU PR do not have a direct connection between database systems. Employees of the Bureau of Labor and Wages (BLW) manually enter all parameters for the normative card in accordance with the paper technological process, which significantly increases the time for developing the normative card, and therefore, for planning production resources of the enterprise. Having developed an additional software module for receiving and transferring the planned operational labor intensity from CAPP ‘TeMP2’ to ASU PR, it will be possible to generate a normative card automatically.

In this regard, the planning quality of production resources of an enterprise can be improved through implementation of automated production of operational labor intensity and generation of a normative card for the manufacture of parts based on digital technological processes.

2. Problem research

Currently, the design and regulation of technological processes is carried out mainly manually, which significantly increases the time costs for the development of one technological process, and also reduces the quality of a complete set of technological documentation. All the main stages in the development of a technological process, which are carried out manually by the technologist at the moment (‘as it is’) are presented in Figure 1.

![Figure 1. The main stages of the technological process development ‘as it is’](image)

To automate the design and regulation of technological processes at the enterprise, a modern CAPP system is required, which operates in a single information space of the enterprise. One of the modern and adapted to the processes of Russian engineering enterprises is CAPP ‘TeMP2’. For its implementation at the enterprise, it is necessary to develop information support (IS), which is adapted directly for the machining of parts.

The information environment of CAPP ‘TeMP2’ includes [1]:
- database of models of production system elements;
- a database of normalized and standardized products that are used in aircraft construction;
- integrated technological modules and basic technological modules, which are responsible for the formation of technological operations and transitions.

The use of CAPP ‘TeMP2’ allows not only to minimize the time costs in the development of digital technological processes, but also to store all technological processes in the system database, make changes and apply it for planning. All main stages of the development of technological processes using the CAPP (‘as it will be’) are presented in Figure 2.
To begin the development of an algorithm for automated generation of a normative card, the main areas of work were formed that can allow implementing the automation functionality for obtaining the operational labor intensity of manufacturing parts, namely: developing models of operations and transitions, models for choosing technological equipment, models for automated calculation of time standards and cutting modes. For generation of a normative card, the main role is played by standardization models and models for calculating cutting modes, which for CAPP ‘TeMP2’ are developed in the programming language of the standardization engineer ‘YAPRIN’.

The development of standardization models cannot be carried out without the use of collections of working time standards, which are different for each company not only in the composition of collections and standardization cards, but also in terms of the applied ratios to the time standard. Standardization models contain the following parameters: constant standardization factors, variable standardization factors, coefficients. Constant normalization factors do not directly affect the time standard calculation in the standardization model: PC - profession code, JC - job category, OC - operation code, WCT - work code type. Variable factors depend on the normative card from the normative book. The coefficients, in turn, depend on production and the entire enterprise.

The development of standardization models is carried out according to established formulas, according to the conditions for choosing a specific time, depending on the processing parameters, according to a formula using computer time.

To calculate the cutting modes, the data that is filled in the input window of the rationing factors in the CAPP ‘TeMP2’ and displayed in the rationing protocol are divided into three types (for example, milling operation) [2]:

− the data that a user needs to enter manually when normalizing the technological transition (processing length in mm, number of passes in pcs, milling depth in mm, milling width in mm, tool overhang in mm, material temporary resistance, coolant use, surface condition, processed surface roughness, the number of simultaneously processed parts in pieces, correction factors for cutting speed and feed);

− the data that are automatically substituted using the ‘Automated filling of rationing factors’ function: this function substitutes the necessary values depending on the selected equipment, tool, tooling or materials (size group of the machine, mill diameter in mm, number of teeth in pcs, material code, tool cutting material);

− the data obtained as a result of automated calculation during normalization of the technological transition (feed per tooth in mm/tooth, minute feed in mm/min, cutting speed in m/min, spindle speed in rpm, tool life).

After the development of all standardization models, an analysis of the normative card generation ‘as it is’ and ‘as it will be’ was carried out using the module for automated production of operational labor intensity for the normative card based on the developed digital technological process in CAPP.

The development of a normative card in BLW is mainly carried out in a special software module ‘AS’, which enables an employee to manually formulate a normative card, correct and print it through this system. The normative card is also stored in this system, and this system does not have a direct connection with other enterprise systems. One of the drawbacks of this system is the lack of not only
automated generation of a normative card, but also the lack of the ability to automatically transfer the received data to ASU PR for further correct and accurate resource planning.

The normative card includes the following data: a normative card number, workshop code, foremaster group, part designation, integrated rate code, type of work, operation number, operation name, equipment code, lot size, type of standard, tariff grid, category of works, piece time, mastering coefficient, code of working conditions, unit of measure, labor intensity paid. The stages of forming a normative card at present (‘as it is’) are presented in Figure 3.

**Figure 3.** The main stages of the normative card development ‘as it is’

Using the developed module for the automated generation of a normative card, the quality of planning will increase due to obtaining the exact operational complexity of manufacturing parts from a digital technological process, which is stored in CAPP. The main stages of developing a normative card using the developed module (‘as it will be’) are presented in Figure 4.

**Figure 4.** The main stages of the normative card development ‘as it will be’

Due to the automated generation of a normative card, the following parameters will be entered automatically from the digital technological process: workshop code, part designation, type of work, operation number, operation name, equipment code, batch size, category of work, technical specifications for a batch, piece time, code of working conditions. All other parameters are either filled in manually by a BLW employee, or the system automatically sets the default settings.

In this module, the BLW employees and the employees of the Labor and Wages Department (LWD) will be able to make changes to the normative card immediately through the developed form in CAPP ‘TeMP2’. At the same time, after the normative card is approved by LWD, information technology department will not need to manually transfer data from one system to another. Due to the automated standardization and the formation of a normative card, the time costs are minimized when maintaining a database of operational labor intensity for manufacturing parts in ASU PR, as well as accuracy of calculating the planned operational labor intensity is improved.

**3. Solution to the problem**

After information support has been developed, all developed digital technological processes are stored in CAPP; therefore, all the data that are necessary for the normative card are in the database of the system.

To obtain the operational labor intensity of manufacturing parts from an digital technological process, an algorithm and a software module for automated data acquisition have been developed.
When entering the process number on the cover page of the technological process, the part number and workshop number from the table \textit{table} \textsubscript{i} of the ‘TeMP2’ database using the \textit{ti} \textsubscript{1} field, we obtain the technological process number. After designing and standardizing the technological process, all data about the operation are stored in the table ‘Transitions of technological process’ \textit{table} \textsubscript{j}. Thanks to the found process number in the field \textit{ti} \textsubscript{1} from \textit{table} \textsubscript{i}, we find in \textit{table} \textsubscript{j} the operation number \textit{tj} \textsubscript{1}, the operation text \textit{tj} \textsubscript{2} and \textit{tj} \textsubscript{3}, the work type code \textit{tj} \textsubscript{4}, the standardization factors \textit{tj} \textsubscript{5}, the group of factors (piece time, rank of work, number of workers) \textit{tj} \textsubscript{6}, preparatory and final time \textit{tj} \textsubscript{7}. From the rationing factors we get the number of parts in the party and the working conditions. From the field ‘Group of factors’ we obtain the unit time and the job category. A description of the information flows of data obtained from the table of the title page and the table of technological transition is presented in Figure 5.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{diagram.png}
\caption{Figure 5. Retrieving data from title page and technological process tables}
\end{figure}

When designing a technological transition, resources (equipment, tools, auxiliary materials) are added to each operation. Each type of service field has its own characteristic, i.e. belonging to one or another type of equipment. To get the equipment code from \textit{table} \textsubscript{k}, the equipment sheet \textit{tj} \textsubscript{8} was taken, from the equipment sheet in \textit{table} \textsubscript{k}, a unique identifier was used to determine the feature of everything presented in the service field (regardless of the equipment). If equipment is found, then with the help of the unique identifier in the table ‘Linking user folders’ by field \textit{td} \textsubscript{1} the equipment code \textit{td} \textsubscript{2} is found. If the equipment is not in operation, then by default a five-digit code ‘99999’ will be displayed in the normative card. A description of the information flows of data from obtaining information from the technological transition table, equipment and tool tables, and user folder link tables is shown in Figure 6.
After obtaining the necessary information from the digital technological process, all data are output to the developed form of the normative card through ‘TeMP2’ system. The parameters that are not in the technological process, the standardization engineer enters manually and updates the table of time standards. Then all the data are transferred to the corresponding fields of the table of operational labor intensity for the manufacture of parts table_TR in ASU PR.

Workshop number _ti_2 is recorded in field TR_1, operation number _tj_1, operation text _tj_2 and operation text _tj_3 in field TR_2, job type code _tj_4 in field TR_3, job category _tj_6 in field TR_4, piece time _tj_6 in field TR_5, preparatory - final time _tj_7 - in field TR_6, working conditions and the number of parts in a batch _tj_5 - in fields TR_7 and TR_8, equipment code _td_2 - in field TR_9.

The description of information flows of data obtained from the tables of ‘TeMP2’ database in the table of operational labor intensity of manufacturing a part of ASU PR is shown in Figure 7.
Due to the developed algorithm and the programmed code for obtaining operational labor intensity from the digital technological process, and the automated generation of the normative card, correctness of the time standards calculation will significantly affect planning accuracy.

4. Conclusion
The presence of a digital technological process allows not only to minimize the time costs of technological preparation of production, but also to affect the correctness and accuracy of planning of production resources. Interconnection of the enterprise’s internal systems for the receipt, generation and storage of all the necessary information for planning will help employees quickly fulfill their tasks.

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