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Tool Creation and Operation System Development for Large Engineering Enterprises

[1]Sergey Danilovich Kugultinov,
[2]Ravil Mirgalimovich Khisamutdinov and [2]Marat Ravilevich Khisamutdinov

[1]Izhevsk State Technical University, 426069, Republic of Udmurtia, Izhevsk, Student Street, 7
[2]Kazan (Volga Region) Federal University, 420008, Kazan, Kremlin Street, 18

Abstract: On the basis of JSC "KAMAZ", the article describes a new concept of the automated tool creation and operation (TCO) system with tool identification at all stages of the life cycle with the possibility of adaptation to any machine-building enterprise. Russian machine-building companies have traditionally made over 80% of the tool themself. Therefore, the concept of TCO system is wider than adopted in the European countries Tool management (TM) concept. A general structure of the classification is developed for all kinds of tool manufacture. The system allows the assignment of a unique code to each tool. This permits to create the preconditions for the development of subsystems of its purchasing, design, production and operation.

Key words: Concept · System · Classification · Tool creation · Tool operation

INTRODUCTION

For a modern large engineering enterprise is characterized by continuous increase of complexity and cost of technological pre-production. This is mostly due to the fact that the products are from year to year more and more complicated. And the larger the company, the greater is the need to develop and equip the technological processes in the creation of new or upgraded products. Pre-production of a new product on the machine-building enterprises of Russia and CIS takes a quite long time and requires significant investment [1]. One reason for this fact is a huge range of cutting, measuring tools, accessories and tooling, consisting of hundred thousand units. Russian machine-building companies have traditionally made over 80% of the tool themself. Therefore, the concept of tool creation and operation (TCO) system is wider than adopted in the European countries Tool management (TM) concept. TCO system covers the whole life cycle from the tool design (including intellectual support by TCO subsystem for tool design optimization in the designing process) to disposal, while TM covers logistics and recovery (or disposal).

In such circumstances, the cost of design, production and purchasing of tools and tooling are huge and goes up to billions of rubles. This puts the Russian machine-building enterprises in difficult economic conditions. Specialists of enterprises and scientists are trying to change the situation by automating existing systems. However, the example of Russian companies in this important area shows that the quality of products is not changed and their production cost continues to rise.

The Main Part: Analysis of the known scientific works and research the experience of Russian and foreign engineering companies showed that the existing tool creation and operation (TCO) system does not take into account the need for intellectual support design and selection tool. Moreover, no system covers the entire life cycle of the tool. The development of the domestic system, adapted to the conditions of Russian production and guaranteeing an adequate level of quality and cost- effective for production is required.

Developing a radically new TCO system in a united integrated enterprise system is a challenge because the tool is a key element of production and determines the level of the manufacturing process, consequently product quality, productivity and its adequate cost of production. That is why managing and controlling the entire life cycle of the tool can be effective impact for improving the efficiency of pre-production and the engineering production itself.

Corresponding Author: Sergey Danilovich Kugultinov, Izhevsk State Technical University, 426069, Republic of Udmurtia, Izhevsk, Student Street, 7.

Research and analysis of production process and technological process show that the functional model of the TCO system may include:

- Information about dimension-types and every tool at any time (this information should be available to interested services of the enterprise);
- Strict synchronization of many thousands of manual and computer TCO system operations across the enterprise ;
- TCO system responsiveness to any changes in the standards and other regulatory documents of the enterprise, establishing the procedure and rules of tool maintenance;
- Automating the process of developing and adjusting enterprise standards;
- Decision making in the case of unforeseen situations.

The analysis showed that for increasing the effectiveness of the TCO, it is reasonable to present it on multiple levels of decomposition.

On the first level the TCO system can be represented as technological B_i blocks, which show a complete algorithmic description of this process and are implemented on a united physical database and software in a closed loop works. The blocks may be defined by the [2]:

- B_1-purchase trial lots of tools and comparative operation tests the result of which are used in decision making to purchase specific brands;
- B_2-maintenance and monitoring of contracts with tool suppliers;
- B_3-acceptance and placement on the central warehouses purchased tool;
- B_4-forming tool applicability statements;
- B_5-intellectual tool design support (design information, mathematical and software to automate the design of special tools and equipment), etc.

Thus, the level of B can be represented as a sum of processing units:

$$\sum_{i=1}^{n} B_i = B_1 + B_2 + \ldots . + B_n$$

Relying on technological B*i* blocks of TCO process can be represented as an operator:

$$TCO = F\left(B\middle|\Omega_\beta\middle|\right)$$

Here F-operator is an interaction algorithm with B_i blocks, leading to the achievement of the objectives and the optimal solution for TCO system; Ω_β-the implementation of a vector parameter *B* that characterizes the possibility of parametric changes in the TCO process, depending on the technological Bi blocks. This capability is necessary for automated operational settings Software package and TCO information system to any changes in the processes associated with the tool and, not least, for the automated development of enterprise standards.

Separation of technological B_i blocks, naming of them, formation of the operator F can be considered as the first step in system analysis, formalization and algorithmization goals and objectives of the TCO system. Thus, we form a first level of detalization, describing the process of the TCO.

As this TCO process further analysis show the next more detailed level description of its goals and objectives is required. This is achieved by separation of process modules Mj (j = 1, 2, …n) in the B_i blocks and the description of B_i blocks using these modules. Modules characterize the set of actions in the TCO process and implement a complete operation (identified and described in various standards and other regulatory documents) with their input and output data sets that are used throughout the information space of the TCO. In this process module is implemented in one continuous (technical breaks are possible) cycle of action.

Mj process module examples of TCO process can be:

- M_1 -"preparing and sending documents to the supplier on the results of check and called a representative " module.
- M_2 -the actual tool flow calculation module ;
- M_3-generating unit mass of data on the characteristics and applicability of the tool module;
- M_4-generating unit data set of cutting mode;
- M_5-generating of algorithms and software for the design of special tools module, etc.

Relationship between technological B_i blocks with M*j* modules in general can be represented as the following ratio:

$$B_i = F_i^B\left(M/\Omega_\mu\right)$$

where F_i^B is the interaction algorithm with technological modules of M, which leads to the achievement of the goals and objectives of B_i blocks;

Ω_μ-Implementation of the set of parameter M, characterizing the realization of F_i^B algorithm.

If the operator F_i^B is given, then the realization of the B_i block is to implement a well-defined set of actions, having single valued name, the values of elements of M space and the parameter value $\mu \in \Omega_\mu$.

Formation of process modules, naming them, the construction of M space, F_i^B operators and B_i blocks is the second level of the TCO process.

With this level, we can describe the process of using the TCO process modules of M and variance parameters *B* and μ, as a complex function of the relevant data.

At the third level (it is the last one in this system) detailing the TCO process is produced. It is made by allocating systematically repeated single valued parameters in time and in structure of action as employees (engineers, financiers, supervisors, storekeepers, etc.) and hardware (computers, automation and mechanization, etc.). These actions are called technological elementary operations (EO) and further are defined as $e_\rho (\rho =1, 2, 3, ...k)$.

As EO of TCO process can be:

- e_1-address of tool placement in warehouses (automated and non-automated);
- e_2-the automated tool choice for elementary surface processing;
- e_3-automated preparation of working drawings of the special tool from the database for processing the contoured surface;
- e_4-automated control of the tool movement;
- e_5-generation of information about the time and location of specific TCO process, etc.

EO can be represented as a function that depends on several parameters:

$$e_\rho = F_\rho^e(\alpha_i) ,$$

and a multitude with space $E\rho$.

The F_ρ^e operator is the name (code name) of EO and its state corresponding to a particular value of α-implementation of the EO. A substitution of the parameter α provides a well-defined action (human, computer or other equipment). It should be noted that the components of this parameter are characterized by their names and values.

When you automate the process of the implementation of $F_\rho^e(\alpha)$ is provided with the necessary means. A parameter α is an element in this setting EO e_ρ.

Through his introduction and selection of numerical values ??are operative setting algorithms and applications of the automated system for any changes of TCO processes associated with the tool, as well as automate the development of new and existing standards correction companies TCO system [4].

Separation and naming (indexes) EO, implementing dependency of EO on the determining factors in view of their scope, the construction of spaces E_ρ became third stage of system analysis, formalization and algorithmization of TCO process for JSC "KAMAZ".

The proposed three-tier method of TCO system composition process is not strictly necessary. Depending on the complexity of the processing steps by the TCO process level description may be less or more than three.

The main elements of this detailization are accordingly B_i blocks, M*j* modules and e_ρ EO. In this case, each element of the prior is the specific function elements of next level. Then, according to the accepted principles of our formalization of the rule or main forming elements (*i*-1)th the elements decomposition level of the *i*- th level will represent algorithm TCO process the *i*- th level.

Each of these algorithms may have different realizations, which are defined by specifying parameters of the respective predetermined areas of their possible values. These parameters $\beta \in \Omega_\beta$, $\mu \in \Omega_\mu$, $\varepsilon \in \Omega_\varepsilon$ and $\alpha \in \Omega_\alpha$ together with their fields of implementation can be attributed to the number of initial elements describing the appropriate level of TCO system.

Implementation of the main tasks of automation TCO system requires precise timing and control of multiple actions (manual, computer, mixed), as well as full transparency of information about the condition and location of each tool, the amount of which can go up to have in the hundred thousands of units in the large engineering companies.

Control and functional algorithms to implementation discussed above, should include the operators of creation and transmission to a central database protocols after each EO e_ρ, process module Mj and technological block B_i. Further, the control program must ensure the transfer of a central database of information on the sequence and timing of them according to company standards and other regulatory documents. Thus in the automated TCO system formation of a closed information loop that allows to validate the reliability of operations TCO process and to meet the required standards, regulations and rules.

CONCLUSIONS

According to the above, for the implementation of the TCO system at JSC " KAMAZ " on the basis of unification created classifier [5] of the cutting tool and tooling developed enterprise standard selection cutting, information, mathematical and software for the design of complex structure of the cutting tool (Hobs, broaches, shaper, modular milling) algorithms to ensure a standard tool in the process according to the required levels of quality, performance and cost, developed part of the regulatory instruments that will gradually introduce the TCO system into production. As a result of implementation a relatively small part, the economic effect is 18 million rubles for 11 months of 2013.

RESULTS

Based on simulation techniques, using graph theory, operations research and management theory is developed the basic idea of the TCO system building theory, which is important for the development of the theoretical foundations of management practices and a TCO system building in the engineering enterprise in terms of expanding automation and integration of united information system.

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