SOCAR Proceedings

Computer-aided engineering and information technology

journal home page: http://proceedings.socar.az

DECISION-MAKING IN THE CONDITIONS OF INTRODUCTION OF AUTOMATED DESIGN SYSTEMS OF TECHNOLOGICAL PROCESSES

S. A. Bogatenkov[1], N. S. Sazonova[1], N. D. Yusubov[2], H. M. Abbasova[2], B. B. Badalova[2], R. I. Bazhenov[3]

[1]South Ural State University, Chelyabinsk, Russia; [2]Azerbaijan Technical University, Baku, Azerbaijan; [3]Amur State University named after Sholom Aleichem, Birobidzhan, Russia

ABSTRACT

To ensure the effectiveness of professional activities in the face of increasing requirements for the scope of design work and production preparation time, computer-aided design of technological processes (CAD TP) systems are used. However, there is a problem of safe implementation of CAD TP. The aim of the study is to develop a decision-making methodology for adapting CAD TP to the conditions of enterprises and to the work of personnel based on a systematic approach to threat analysis. The methodology includes methods for choosing CAD TP, using text and graphic prompts when entering information, as well as applying methods for unifying various CAD systems and adapting them to enterprise conditions at the database level. The results of the study are implemented in CAD for operations performed on multi-spindle horizontal automatic lathes and are used at South Ural State University and Azerbaijan Technical University.

KEYWORDS

Technological process;
Computer-aided design;
Decision making;
Design methods;
Ways of adaptation.

Designing the technological process of manufacturing a part is a complex multifactorial task, starting with the selection of a work piece and ending with the formation of output technological documentation. Modern mechanical engineering is characterized by an increase in the share of small-scale and single-piece production, which leads to an increase in requirements for the volume of design work and production preparation time. The use of computer-aided design of technological processes (CAD TP) ensures high efficiency of professional activity in the face of increasing requirements for the volume of design work and production preparation time [1, 2].

According to experts from the American Project Management Institute (PMI), the amount of irreparable losses of organizations due to the poor quality of project management is $109 million for every billion US dollars. Only 40% of ongoing projects in the world are completed on time and within budget, i.e. about 60% of projects end unsuccessfully [3, 4].

Approximately the same picture is observed with the implementation of complex and mega projects in Russia, including the implementation of CAD TP. At the same time, the process of design automation is accompanied by increased risks for professional activities.

Firstly, a class of new threats has emerged, associated with the emergence of a large number of CAD systems that differ in functional and cost characteristics. For example, at the end of the last century at the Chelyabinsk Polytechnic Institute, at the Department of Machine Building Technology, a number of CAD systems were developed and implemented, covering the design of both technological process route and operational technological processes on various machines, including automation of normalization of operations. Similar CAD systems were developed in institutes of other cities. There was a problem of economically justified choice of CAD.

Secondly, the process of introducing CAD (especially at the stage of trial operation) is accompanied by unreliable work, leading to distortion of information. New threats have appeared that require duplication of the work of process engineer, both with the help of CAD and in the traditional version, which leads to an increase in the labor intensity of the work.

Thirdly, the process of introducing CAD is accompanied by a change in the structure of the enterprise and the job responsibilities of the staff. A class of new threats has appeared, related to the need to form the readiness of personnel to work with CAD.

The analysis of these threats indicates the relevance of the problem, which consists in the need to develop a decision-making methodology for the use of CAD according to the security criterion [5, 6].

1. Statement of research objectives

Studies of the security problem are contained in the works of a number of scientists. In the works of A.V. Vozzhennikov, S.A. Proskurin, A.L. Prokhozhev, S.V. Smulsky and others reflected the general theoretical problems of national

**E-mail:* nizami.yusubov@aztu.edu.az

http://dx.doi.org/10.5510/OGP2022SI100691

security. They defined the concepts, structure, content and functions of security, substantiated the need to study security issues for various branches of life. Foreign scientists Brian Denman, Grant McBurney, Jeffrey Alderman, Jan Grof and others, while studying the problem of security, focus on the prevention of extremism and the formation of a tolerant culture.

Table 1 summarizes process design practices that minimize these hazards.

However, despite the progress made, the problem of safe implementation of CAD TP has not been sufficiently resolved.

The aim of the study is to develop a decision-making methodology for adapting CAD TP to the conditions of enterprises and to the work of personnel based on a systematic approach to threat analysis. The methodology includes the methods given in table 2.

2. The choice of CAD TP according to the criterion of economic security

The criterion of economic security involves the choice of CAD TP based on correspondence tables and decision tables. The choice of TP depending on the nature of production and the type of metal-cutting equipment is carried out using a table of standard solutions (table 3).

The choice of the technological process, depending on the nature of production, is carried out using the correspondence table (table 4).

3. Using text and graphic prompts when entering information

When designing technological processes, the process engineer mainly works with a mass of graphic documents. These include drawings of the workpiece, parts, tools, fixtures, operational sketches, graphic images of transitions,

Table 1
Methods for designing technological processes

№	Threat content	Method content
1	Designing plans for surface treatment on automatic lathes with insufficient productivity	Improving the productivity of multi-tool machining on automatic lathes by optimizing surface treatment plans [7]
2	Design of multi-tool double-carriage adjustments with insufficient productivity	Improving the productivity of multi-tool machining on automatic lathes by optimizing the placement of tools by machine positions [8]
3	Insufficient performance in multi-axis machining	Optimization of multi-axis machining [9]
4	Insufficient milling performance	Optimization of the milling operation [10, 11]
5	Non-optimal tool path when machining on CNC machines	Optimization of the tool path when machining on CNC machines [12]
6	Insufficient cutting speed	Optimization of cutting speed based on the model of the shear plane scheme during the formation of chips in the cutting process [13]
7	Tool wear is not taken into account when changing the cutting force during turning	Optimization of turning, taking into account tool wear when changing the cutting force [14]
8	Insufficient time, cost and product quality	Optimization of time, cost and quality of the product [15]
9	Excess power consumption when turning	Optimization of cutting conditions during turning in order to minimize energy consumption [16]
10	Insufficient grinding performance	Optimization of automatic grinding cycles [17]

Table 2
Decision-Making Methods for Safe Implementation of CAD of TP

№	Threat content	Method content
1	Unreasonable choice of CAD of TP	The choice of CAD TP according to the criterion of economic security
2	A large amount of input information that requires its graphical representation	Using text and graphic prompts when entering information
3	The lack of unification of databases of various CAD of TP and the difficulty of adapting CAD of TP to the conditions of the enterprise	Application of methods for unifying various CAD systems and adapting them to the conditions of the enterprise at the database level

Table 3
The choice of technological process by the nature of production and the type of metal-cutting equipment

Nature of production	TP type		
	TP Route	Group and typical TP	Local TP for operations, analysis of multiple options, optimization
Small-scale	Universal machines	0	0
Medium series	0	Customized and CNC machines	0
Large scale and mass production	0	0	Multi-spindle horizontal machines

etc. The development of efficient TPs is achieved as a result of solving complex problems, such as structural-parametric optimization, dimensional analysis, and synthesis of TPs. To solve such problems, a system of graphical objects is needed, for example, dimensional chains. In addition, the technologist (process engineer) has to solve auxiliary design tasks that require working with graphic objects, for example, designing cams for automatic machines. Table 5 discloses methods for minimizing the threat associated with a large amount of input information, implemented in the TOPAZ application package [18].

4. Application of adaptation methods of CAD TP

Information support containing information about the standard decisions of the technologist (process engineer) and the rules for their adoption, at the early stages of the development of CAD TP was presented in the form of a direct block algorithm that performs the choice of standard solutions, and was implemented at the level of a computer program. However, this form of presentation has economic threats.

Firstly, the volume of the program increased significantly due to the complexity of adapting block algorithms to the organization of unified procedures. For example, to select a tool, it is necessary to develop an algorithm and a program for each type of tool.

Secondly, it is impossible to quickly correct CAD TP in conditions of a changing production situation, for example, when replacing machines, as this is due to the need to correct the program code.

Thirdly, when creating a CAD TP that includes all existing transitions, there is a redundancy in the program code, which leads to an increase in the time and laboriousness of the software.

This situation is due to the direct placement of the characteristics of standard solutions and technological transitions in the program.

The identified threats of an economic nature will be minimized if a number of requirements for information support are met.

First, the characteristics of typical solutions must be transferred from algorithms and programs to the information level, i.e. the requirement that the characteristics of typical solutions be independent of algorithmic support must be ensured.

Secondly, the procedure for determining standard solutions should be the same for various tasks, i.e. it is necessary to ensure the presentation of the characteristics of standard solutions in a universal form.

Thirdly, it is necessary to transfer technological transition design algorithms from algorithms and programs to the information level.

Table 6 discloses decision-making methods for minimizing the threat to economic security associated with the problems of adapting CAD TP.

Table 4

The choice of TP by the nature of production

Nature of production	TP type		
	Route or route-operational TP	Operational TP with calculation of cutting conditions and time standards, registration of a list of required equipment, cutting and measuring tools	Single TP, analysis of multiple options, optimization, dimensional analysis
Single and small series	1	0	0
Medium series	0	1	0
Large scale and mass production	0	0	1

Table 5

Using text and graphic prompts when entering information

№	Threat content	Method content
1	Making the wrong decision due to the inability to see the entire structure of the multi-tool adjustment on the screen	Implementation of panoramic input based on the translation of the classifier of technological transitions to command lines. This introduces a virtual two-dimensional table of transition names. The columns of the table correspond to the working positions of the multi-spindle machine, the rows correspond to the carriages.
2	Errors associated with a large amount of input text information	Default algorithms are proposed, which, based on the given values of the primary parameters, will determine the most probable value of the corresponding secondary parameters.
3	Input errors associated with the ambiguity of textual information that requires its graphical representation	Use of graphic hints to eliminate the ambiguity of the entered information
4	Information entry errors associated with the lack of control over the entry of the adjustment structure in graphical form	Implementation of control over the input of the adjustment structure in graphical form on the monitor screen with the possibility of correcting the input information

Table 6

Application of adaptation methods of CAD TP

№	Threat content	Method content
1	The impossibility of prompt correction of CAD TP in the conditions of a changing production environment due to poor adaptation of block algorithms to the organization of unified procedures	Ensuring the independence of the characteristics of typical solutions from algorithmic support as a result of the use of reference and algorithmic tables, decision tables and correspondences
2	When creating a CAD TP, including all existing transitions, there is a redundancy of the program code, leading to an increase in time and laboriousness of work due to the direct placement of technological transition design algorithms in the program.	Ensuring the independence of the design algorithms of technological transitions from the program code as a result of changing the principles for constructing the algorithmic support of CAD TP, i.e. replacing codes with command lines and using an invariant resident algorithm on a single data field.

Conclusion

1. Decision-making methodologies have been developed to adapt CAD TP to the conditions of enterprises and to the work of personnel based on a systematic approach to threat analysis.

2. The methodology includes methods for choosing CAD TP, using text and graphic prompts when entering information, as well as applying methods for unifying various CAD systems and adapting them to enterprise conditions at the database level.

3. The results of the study are implemented in CAD for operations performed on multi-spindle horizontal automatic lathes [18] and are used at South Ural State University and Azerbaijan Technical University.

References

1. Korchak, S. N. (1988). Computer-aided design of technological processes, devices and cutting tools. *Moscow: Mashinostroenie.*

2. Kondakov, A. I. (2010). CADS of technological processes. *Moscow: Academy*.

3. Navigating Complexity: A Practice Guide, PMI. URL: http://www.pmi.org/en/PMBOK-Guide-and-Standards/Standards-Library-of-PMI-Global-Standards.aspx

4. (2013). Navigating Complexity. Part of Pulse of the Profession®, The High Cost of Low Performance 2013 series. *Project Management Institute*.

5. Murugov, V. (2021). New Vertical technology - a modern tool for a process engineer. *CADS and Graphics*, 5, 20-27.

6. Bykov, A., Karabcheev, K. (2020). Direct 3D editing and automatic technology development in the ADEM system. Notes on artificial intelligence CADS. *CADS and Graphics*, 1, 40-45.

7. Bogatenkov, S. A., Sazonova, N. S., Yusubov, N. D., et al. (2021). Increasing the productivity of multitool machining on automated lathes by optimizing the machining plan. *Russian Engineering Research*, 41(11), 1071-1074.

8. Bogatenkov, S. A., Sazonova, N. S., Guzeev, V. I., et al. (2021). Increasing the productivity of multitool machining on automated lathes by optimizing the tool positions. *Russian Engineering Research*, 41(11), 1075-1079.

9. Langelaar, M. (2019). Topology optimization for multi-axis machining. *Computer Methods in Applied Mechanics and Engineering*, 351, 226-252.

10. Vijay, S., Krishnaraj, V. (2013). Machining parameters optimization in end milling of Ti-6Al-4V. *Procedia Engineering*, 64, 1079-1088.

11. Park, H.-S., Qi, B., Dang, D.-V., Park, D. Y. (2018). Development of smart machining system for optimizing feedrates to minimize machining time. *Journal of Computational Design and Engineering*, 5(3), 299-304.

12. Petunin, A. A., Stylios, C. (2016). Optimization models of tool path problem for CNC sheet metal cutting machines. *IFAC-PapersOnLine*, 49(12), 23-28.

13. Pritchard, T., Smith, C., Ghadbeigi, H., et al. (2019). Modelling orthogonal and oblique cutting via discontinuity layout optimization. *Procedia CIRP*, 82, 37-42.

14. Kuntoğlu, M., Sağlam, H. (2019). Investigation of progressive tool wear for determining of optimized machining parameters in turning. *Measurement*, 140, 427-436.

15. Chávez-García, H., Castillo-Villar, K. K. (2018). Simulation-based model for the optimization of machining parameters in a metal-cutting operation. *Simulation Modelling Practice and Theory*, 84, 204-221.

16. Hu, L., Tang, R., Cai, W., et al. (2019). Optimisation of cutting parameters for improving energy efficiency in machining process. *Robotics and Computer-Integrated Manufacturing*, 59, 406-416.

17. Pereverzev, P. P., Akintseva, A. V. (2015). Automatic cycles multiparametric optimization of internal grinding. *Procedia Engineering*, 129, 121-126.

18. Koshin, A. A. (1986). Application software package TOPAZ. *Moscow: OFAP, CADS T and APCS*.

Принятие решений в условиях внедрения систем автоматизированного проектирования технологических процессов

С.А. Богатенков[1], Н.С. Сазонова[1], Н.Д. Юсубов[2], Х.М.Аббасова[2], Б.Б. Бадалова[2], Р.И. Баженов[3]
[1]Южно-Уральский государственный университет, Челябинск, Россия;
[2]Азербайджанский технический университет, Баку, Азербайджан
[3]Приамурский государственный университет им. Шолом-Алейхема, Биробиджан, Россия

Реферат

Для обеспечения эффективности профессиональной деятельности в условиях увеличения требований к объему проектных работ и срокам подготовки производства применяются системы автоматизированного проектирования технологических процессов (САПР ТП). Однако существует проблема безопасного внедрения САПР ТП. Целью исследования является разработка методологии принятия решений для адаптации САПР ТП к условиям предприятий и к работе персонала на основе системного подхода к анализу угроз. Методология включает методы выбора САПР ТП, использования текстовых и графических подсказок при вводе информации, а также применения способов унификации различных САПР и адаптации их к условиям предприятия на уровне баз данных. Результаты исследования реализованы в САПР операций, выполняемых на токарных многошпиндельных горизонтальных автоматах, и используются в Южно-Уральском государственном университете и Азербайджанском техническом университете.

Ключевые слова: технологический процесс; автоматизированное проектирование; принятие решений; методы проектирования; способы адаптации.

Texnoloji proseslərin avtomatlaşdırılmış layihələndirmə sistemlərinin tətbiq edilməsi şəraitində həllərin qəbul olunması

S. A. Boqatenkov[1], N. S. Sazanova[1], N. D. Yusubov[2], H. M. Abbasova[2], B. B. Bədəlova[2], R. İ. Bajenov[3]
[1]Cənubi Ural Dövlət Universiteti, Çelyabinsk, Rusiya; [2]Azərbaycan Texniki Univesiteti, Bakı, Azərbaycan; [3]Şolom Aleyxem adına Priamur Dövlət Universiteti, Birobidjan, Rusiya

Xülasə

Layihələndirmə işlərin həcminə və istehsalın hazırlanması müddətlərinə tələblərin artırılması şərtlərində peşəkar fəaliyyətin səmərəliliyini təmin etmək məqsədilətexnoloji proseslərin avtomatlaşdırılmış layihələndirmə sistemləri tətbiq olunur (TP ALS). Lakin TP ALS-də təhlükəsiz tətbiq edilməsi problemi mövcuddur. Tədqiqatın məqsədi TP ALS müəssisələrin şəraitinə və personalın işinə adaptasiya olunması üçün təhlükənin analizinə sistemli yanaşması əsasında həllərin qəbul edilməsi metodikasının işlənilməsidir. Metodologiyaya TP ALS seçilməsi üsullarını, informasiyanın daxil edilməsi zamanı mətn və qrafiki şəklində olan köməkdən istifadə, həmçinin müxtəlif ALS-in unifikasiya üsulların tətbiqi və onların verilənlər bazası səviyyəsində müəssisənin şəraitinə adaptasiya edilməsi daxildir.Tədqiqatın nəticələri horizontal çoxspindelli torna avtomatlarda yerinə yetirilən əməliyyatların ALS-də reallaşdırılaraq, Cənubi-Ural Dövlət Universitetində və Azərbaycan Texniki Universitetində istifadə olunur.

Açar sözlər: texnoloji proses; avtomatlaşdırılmış layihələndirmə; həllərin qəbul olunması; layihələndirmə üsulları; adaptasiya üsulları.