MECHANISM OF AUTOMATED EQUIPMENT SELECTION BASED ON THE USE OF MULTI-AGENT TECHNOLOGIES

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Abstract: In the process of technological preparation of production, the task of analyzing product manufacturing routes and selecting suitable equipment is the most responsible and time-consuming. The selection of a technological route with the help of a specialist is characterized by multiple solutions and will require a lot of time. For such tasks, it is advisable to use multi-agent technologies used for the dynamic management of network resources. The columns of the matrix reflect the groups of features that determine the required conditions for the formation of the surfaces of the part. When modeling technological routes for manufacturing a part, the source data are compared with the calculated data at each level. This allows you to develop a mechanism for a software agent that will convert input data to output data in the form of a list of equipment. Based on the use of agents, a full range of calculations is carried out, on the basis of which a final decision is made on choosing the most effective version of the technological route for manufacturing the part.

KeywordsTechnological route, equipment, part, agent, the mechanism for analyzing technological routes

1 Introduction

The process of technological preparation of production involves the use of a large amount of information, the use of various tools and information systems.

In the process of technological preparation of production, the task of analyzing product manufacturing routes and selecting suitable equipment is the most responsible and time-consuming. The selection of equipment to fulfill the order only with the help of a specialist is characterized by multiple solutions and will require a lot of time. For such tasks, it is advisable to use multi-agent technologies used for the dynamic management of network resources, which have advantages when used in a distributed environment (Yablochnikov et al., 2010; Balabanov et al., 2015). In more detail, a multi-level structural model of an information system for managing flows in alternative technological routes at the stage of technological preparation of production using multi-agent systems was presented in the same article (Simonova et al., 2019; Kowalski & Marut, 2012).

2 Methods

The basis of the system is to take a multi-level structural model of an information system for managing flows in alternative technological routes. It will be implemented on the joint work of such components as a block of decision rules for determining production routes for manufacturing an order, a block of rules for managing agents, their decomposition and placement. You will also need a block of rules to interact with other agents. Using the control module, it is possible to implement the reactive behavior of agents in the system. The control module responds to a change in the state of the working memory. The key to this architecture is the three-level organization of knowledge. Such a three-level functional division of knowledge into subject knowledge, knowledge of withdrawal procedures and control knowledge greatly simplifies their presentation, reuse, and operation, since this knowledge can be created and maintained independently.

The level of specific subject knowledge contains technological routes, typical technological processes, a database of equipment of the enterprise, data on the production schedule (orders) and a database of available resources. Subject knowledge does not contain any information on how to use it, only the properties of the subject area are presented here. The subject knowledge in the database is structured in the form of a psychological model of a person's memory and consciousness, representing an object-oriented model of knowledge representation, called a frame model.

The knowledge level about the withdrawal procedures (interface level) contains declarative withdrawal rules that should be applied to the subject knowledge of a particular part to determine the most optimal route for manufacturing it, depending on the input parameters. This level is the main one in architecture. The knowledge base is dynamic, constantly updated with new rules, based on the analysis of precedents developed in the face of uncertainty and the process of managing agents.

The level of control knowledge uses knowledge about the output process to subject knowledge, which allows generating an output scheme if new knowledge is added to the working memory.

The human-machine interface defines the interaction scheme between the system and the user, since this multi-agent system is not autonomous, which is associated with the user's personal responsibility for making decisions.

To build a flexible integration system for CCI automation, the concept of an agent needs to be expanded. The technology agent should be endowed with a number of additional functions that allow it to participate not only in one-rank interaction within the integration network but also in classic centralized control systems.

The use of MAS for solving the problems of the CCI will allow creating an open environment for the integration of technological data and knowledge, built on a simple model of expanding the functionality and horizontal scaling of the information space of technological preparation of production.

3 Results and discussion

Based on a multi-level structural model, a mechanism has been developed for automated selection of equipment and typical technological routes.

Using a search engine for technological purposes, analogous parts are found. Search in the system is carried out using the design and technological classifier, in which a complete description of the part is made. A complete description refers to a phased description of a part that includes elements and the relationships between them. In accordance with the principle of phased coding, the description of parts is divided into parts (modules): general characteristics, elements, communications.

Each module is divided into separate components called operators and having certain semantic completeness.

To search for an analog part, the user only needs to tell the system which parameters of the part should match (or not match) with the new part and the analog part. The system independently generates a temporary code, taking into account the selected characters. This code serves as a search key in the parts database. If the system fails to find a suitable match, then it suggests repeating the procedure for selecting another combination of parameters or proceeding to the search for a typical part and typical technological processes.

Information about dimensions, features on the workpiece surfaces and other requirements can be described using special coding tables developed for each type of part or group of types. The technological route to the analog part is used as the initial option, which allows you to go to the next level of design - the level of equipment selection. By adjusting the process in relation to the parameters of the part, you can get the necessary workflow.

Consider the proposed methodology, for example. Initially, we will encode the general characteristics of the part. The general characteristics module has the OBSHCH header, which can be followed by the OSV (general), KONF (part configuration), SHERKH (surface roughness) operators, and other operators that carry information on additional processing of the encoded part.

Example: Part designation OD - K3647101, part name ND - sleeve, material grade MARK - steel 45, material group according to the technological classifier GM - 12, mass of the MAS part - 0.125 kg, then the general information operator is written as follows:

Obshch
OSV
OD = K3647101, ND = SLEEVE,
MARK = STAL '45, GM = 12,
MAS = 0.125.

The following set of parameters has been set for the operator KONF : YESKD - part form according to the qualifier YESKD, L, D, DM - length, maximum diameter, minimum internal diameter, respectively.

KONF
YESKD = 711200, D = 60, L = 28.

The operator SHERKHis used to enter information about the surface quality of a part. For this operator, a set of parameters is selected in accordance with GOST 2789-73.

For example, RZ is the height of the irregularities at ten points, RA is the arithmetic mean deviation of the profile, RMAX is the highest height of the irregularities of the profile, etc.

SHERKH RZ = 20.

The coding of parts with the smallest structural unit is an elementary surface, for example, a plane, a cylindrical surface, a sphere, etc.

Elementary surfaces are combined into standard or standard elements. They can be divided into two categories: elements obtained by the operation of “connection” (elementary bodies), and elements obtained by “clipping”. The first group includes convex bodies: a cylinder, a cone, a sphere, a convex polyhedron, or their convex parts. In the second category are structural elements of the type: grooves, ledges, holes.

Part elements are described using the following operators: FORM - element shape, SHERKH - roughness, OSOB - surface features of the element, OTKL - shape deviations, POKR - local coating, TERM - local heat treatment. Classifiers have been developed for all structural elements, designed in the form of corresponding tables, containing their codes and a list of parameters by which they are characterized. For example, 1 - metric thread, 2 - inch thread, ... 10 - knurling straight, etc.

The operator OSOBis used to encode features. For example, right-hand thread M4x0.5 7H. Has the code:

OSOB VID = 1, S = 0.5, T = 7N.

Relations between elements are fixed using a special module. This module describes the relative positioning of elements (RASP operator), dimensional (coordinating) relationships between elements (KOOR operator) and technical requirements for the accuracy of their relative position (OTKL operator). The RASP operator has the following parameters: VID (location code), SOPR (pairing code), EL (list of items), BEL (base item). The SOPR parameter has the following codes: 1 - connection of elements, 2 - clipping, 3 - intersection, 4 - overlapping, etc.

The arrangement of elements with respect to each other can be different, therefore, for the parameter VID the following codes are used: 1 - coaxial arrangement of elements, 2 - at right angles, 3 - at an arbitrary angle, 4 - with parallel axes, 5 - around the circumference, etc (Simonova & Rudnev, 2005).

The parameters described above are structured and presented as a matrix of source data. Matrix rows reflect the hierarchy of structural levels of technology: order, manufacturing process, manufacturing process, operation, installation, position, transition, working stroke. The columns of the matrix reflect the group of signs that determine the required conditions for the formation of the surfaces of the part and, accordingly, the restrictions on the implementation of these conditions, laid down in the design of technical equipment (Francisco et al., 2019; Gu et al., 2019; Ildarkhanova & Safiullin, 2017).

When modeling technological routes for manufacturing a part, the source data are compared with the calculated data at each level. For this, a pair of matrices are compared: a source data matrix and the corresponding matrix of processing conditions inherent in the equipment (Figure 1).

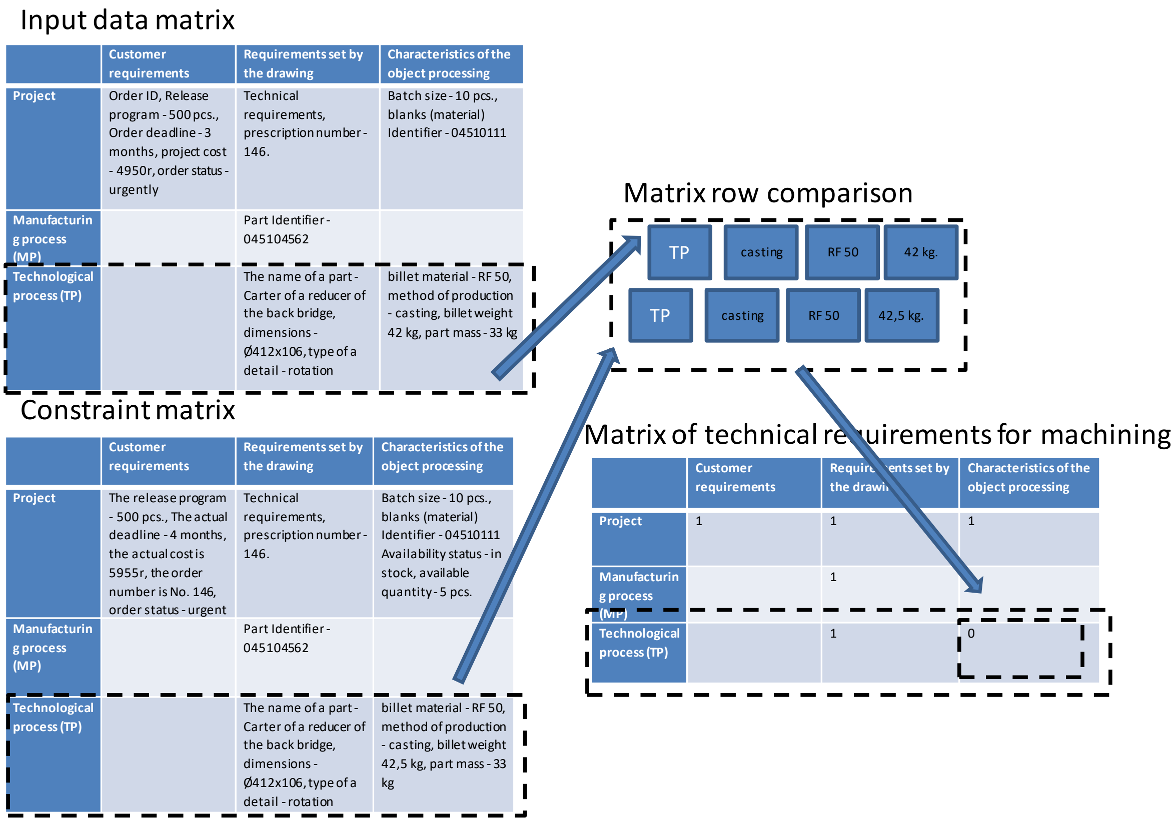

Figure 1. An example of the formation of alternative technological routes for manufacturing TP

4 Summary

The presentation of the sequence of these actions will allow us to develop a mechanism for a software agent that will convert the input data, namely, the characteristics of parts, into the output information in the form of a list of equipment.

The following functions are assigned to the agent:

- comparing the values of the parameters of parts and capabilities of the equipment and the output of preliminary information indicating the equipment with which you can make this part;
- analysis of characteristics of enterprise resources and process requirements;
- listing equipment that meets the requirements of the order in the form of a list of equipment identifiers;
- activation of subsequent agents.

Each input procedure is a selection or calculation of restrictions on the value of a parameter of a structural element of the matrix. At the end of the design of the technological route, in this way, not one value of the structural element can be established, but a whole set or interval of values, which allows you to get alternative routes for manufacturing the part at any stage.

In each of the variants of the technological route, a current database is formed, which is the initial information for further calculations. Based on the results of the agent's work, the user receives a list of equipment, the capabilities of which allow the machining of the part along the technological route. Then the operator makes a decision on the possibility of implementing the technological route with the proposed equipment based on the obtained numerical values of the parameters.

This stage involves the final selection of equipment in accordance with the time and cost limits. The solution to this problem is proposed to partially shift to a software agent, namely, to implement the automatic ordering of equipment according to ratings calculated on the basis of an analysis of the conditions for fulfilling the order. The key success criteria for any project include time, cost and quality. Unlike the first two characteristics, the quality indicator in direct action is not reduced to a quantitative criterion and requires clarification. The quality of the results can be established by the response of the workshop: in the absence of returns to finalize the product or repair, it should be considered that this workshop "fulfilled" the order in a "high-quality" manner. Based on this, the quality will be determined by the history of work with the workshop (Julian & Botti, 2019; Kamdar et al., 2018).

The degree of influence of the values of the above parameters on the choice of equipment is determined by weighting factors, the values of which, depending on the details, will not always be the same and in each specific situation can vary.

After determining the weight coefficients and having done the analysis of the offers, the user receives a list of equipment with calculated ratings. Equipment whose rating is of the greatest importance will be primarily considered as an executor.

5 Conclusions

This mechanism of automated selection of equipment based on the use of agents allows the whole range of calculations to determine technical and economic indicators. As a result, the amount of costs for the implementation of the technology is determined, on the basis of which a final decision is made on choosing the most effective version of the technological route for manufacturing the part.

Acknowledgments

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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Primary Paper Section: B

Secondary Paper Section: BC, BD