On the issue of technology process for intelligent machine tools

Auf die Frage der Automatisierung der technologischen Vorbereitung für intelligente Werkzeugmaschinen

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Abstract — In recent years the industrial progress is with the platform "Industrie 4.0" mentioned at the trade fair in Hannover in 2013. The concept is based on leading solutions from SIEMENS for digital product development and production. These solutions are designed to address the conditions, as well as the automation of the entire life cycle of a product, as well as the integration of cyber-physical systems, which represent a virtual representation of the real world in order to manage physical production processes and to make distributed decisions itself.

***Zusammenfassung* —** In den letzten Jahren der industrielle Fortschritt ist mit der, auf der Messe in Hannover im 2013 erwähnten Plattform „Industrie 4.0“. Das Konzept ist basierend auf führenden Lösungen von SIEMENS für digitale Produktentwicklung und Produkterstellung. Diese Lösungen sollen die Bedingungen sowie zur Automatisierung des gesamten Lebenszyklus eines Produkts, als auch zur Integrierung von Cyber-Physical Systemen, die eine virtuelle Darstellung der reellen Welt abbilden um die physikalische Produktionsprozesse zu verwalten, um zu kommunizieren und um selbst verteilte Entscheidungen zu treffen.

I. Introduction

The enhancement of modern machine-building production is closely related to the development of technology as a result of the development of information technology, technics and the ever-increasing requirements of the market.

The design of the technological processes is one of the main activities of the technological preparation of the production, which at the present stage of development is characterized by a number of peculiarities resulting from the changes in the mechanical engineering production. Hence, there are a number of requirements for manufacturers to increase the level of automation of all technological processes in the field of small and serial production, and to shorten the timeframe for technological preparation as well as the whole production cycle.

One of the most important procedures in order to fully automate the technological preparation for the realization of a manufacturing process for machining is:

1) Formalization and identification of the production site;

2) Addressing and assigning the object to a relevant class of details;

3) Choice of type / group technological process from database;

4) Selection of sequence of technological operations / route technology from the database.

The purpose of this development is to demonstrate the feasibility of implementing the above procedures by using popular software such as Microsoft Office Access 2003-SP2.

II. Formulation and Implementation

The identification of the object to be processed is carried out by its parametric description, addressing and assignment to the relevant type of detail in the database for which the relevant type technology (DB_3) has been developed. The description of the object can be performed based on typical primitives of typical surfaces (cone, cylinder, parallelepiped, sphere, etc.) by parameterization of its main characteristics to a given coordinate system so that it is uniquely identified in the database.

If the object of the production task is designated by X, it can be represented as a union of the classes of the rotational symmetric parts KL_1, the planar surfaces PS, the additional primitives DP1 and the plurality of the prismatic-shell elements KL_2, i.:

$$X \in KL1 \cup KL2. \qquad (1)$$

The statistical distribution of the details in machine building is relatively constant over time, with the relative share of rotational symmetrical details and prism-body details being greatest (about 90%). Therefore, more attention will be paid below them.

The set of rotational symmetrical details (KL_1) can generally include subsets of primitive parts with different surfaces: cylindrical (C), cone (Co), spherical (S) or planar (P) surfaces. The subdivision of these subsets is necessitated by the fact that the respective surfaces are analyzed analytically with different parameters and this facilitates their formalization.

In that regard, it follows that

$$KL_1 = \{C, Co, S, P\} * DP_1. \qquad (2)$$

The set of additional primitives can be represented by the expression:

$$DP1 = Ph \cup K \cup KZP \cup ShK \cup ShL \cup RRO \cup ZRO \cup O \cup R, \qquad (3)$$

where: Pf is the set of chamfers; K - the set of channels; KZP - the set of zigzag ring grooves; ShK - the set of key channels; ShL - the set of slots; RRO - the set of radially spaced holes; ZRO - a set of centrally located openings; O - the set of holes displaced by the symmetry axis; R - the set of threads.

Each code description of the object of type (2) corresponds to the code KD_i^3 and address $A_i^{KD^3}$ in DB_1.

The plane / detail (PS) parameterization is considered as a composite figure {i, j}, calculated as the sum of the parameters of the individual elements i and j in the right-aligned two-coordinate system (corresponding to the orientation and layout of the work piece).

Each code description of the object corresponds to the code KD_i^2 and address $A_i^{KD^2}$ in BD_2.

In Figure 1 is given the organization of DB_1 for parameterization and description of the object processing unit of type KL_1. The structure of DB_1 consists of three parts: database name, catalog, and memory. The name of the database contains data about the physical address of the catalog, memory address, and free space and memory address. In this way, it is possible to analyze the correctness of storing information and possibly overloading the memory.

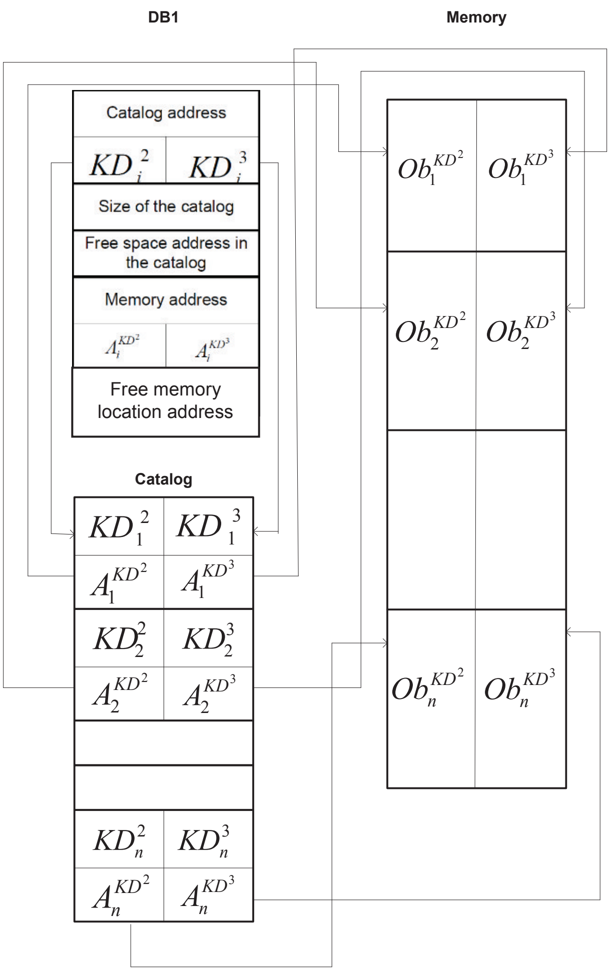

Fig. 1. Organization of DB_1 for parameterization and description of object processing unit of type KL_1

The DB_1 catalog is intended to determine the match between the block name symbol and its physical address. It has a sequential file structure, each record containing a symbolic name of the parametric object model, the physical address in the memory, and the length of the block in which the object model is recorded.

For complex objects of the prismatic-corporeal details, the formalisations are made by primitives (Pr); surfaces (Su); ribs (Ri); resulting from the intersection of two surfaces; vertices (V) - points obtained from the intersection of three surfaces and a boundary (D) corresponding to the line of the line graph defining the order of the peaks. In this way, the object model consists of two parts: B_i, Xi, Yi, Zi coordinates and a topology of their union set by cycles or boundary outlines in the order of their crawling with a type of cycle (surface or hole entry).

The mathematical model M of a complex prismatic-corpus piece (PR) composed of n primitive can be represented by the dependence

$$M = \bigcup_{i=1}^{n} PR_i \tag{4}$$

Obtaining the coordinates of the points of attachment of the individual primitives needs to be transformed into the coordinate system of the final object (FO), i.

$$Xcv = M_{transf} M_{rot} B_{\kappa.vertices} \tag{5}$$

where X_{cv} is the vector of the coordinates of the vertices of the Pr in the coordinate system of the FO; M_{transf} - a matrix of 4 x 4 for transforming *Pr*; M_{rot} - a matrix of 4 x 4 of the rotation of the coordinate system of the Pr in that of the FO; $B_{\kappa.vertices}$ - a vector of the coordinates of the vertices of the PR in its own coordinate system.

Thus, the position of Pr_i is determined by six numbers: the transform vector $\vec{T_i} = (\Delta x, \Delta y, \Delta z)$ and the angles of rotation $(\alpha_i, \beta_i, \gamma_i)$ of the coordinate system relative to that of the FO. Hence, in the node B of the G column of the FO, the origin of the coordinate systems of the primitives is located, and the frames of the graph Pg depict the type of the relations between the primitives.

The algorithm for parametric description of complex KL_2 objects is given in Figure 2.

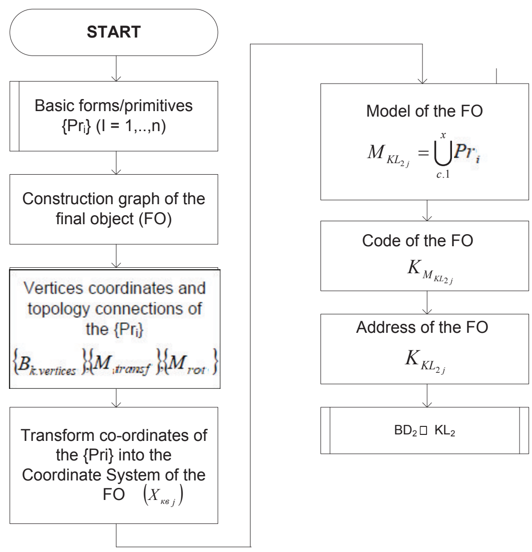

Fig. 2. Block diagram of the algorithm for parametric description of complex objects of type KL_2

In organizational terms, the structure of DB_2 is analogous to that of Figure 1.

III. Practical Implementation

In this part the Assignment a site to relevant details and class and the data organization for technological processes is described. Figure 3 shows the general program structure and the input screen for describing the parameters.

On the right side of the screen, there is an example of the developed in the Microsoft Office Access 2003-SP2 environment.

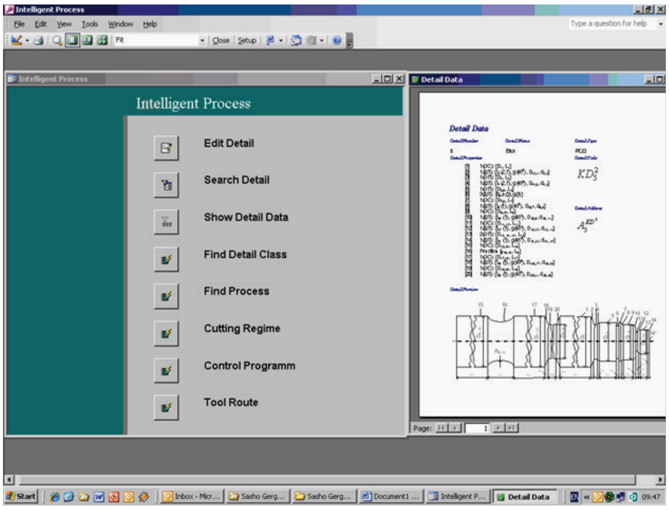

Fig. 3. Input data to describe the detail

On each parameterized object KL_{1i} or KL_{2i}, as seen above, an appropriate code $A_{KL_{1i}}$ or $A_{KL_{2i}}$ is assigned. With the help of the detail code and the corresponding search procedure, there is a BD_2 object that contains two parts - respectively for objects of class rotational parts (KL_{1i}) or prismatic parts (KL_{2i}).

The object code A_{KL} is described by elements of algebraic parameterization as a system

$$A_{KL\,ij} = \{E_{KL_{ij}}\}, \tag{6}$$

where $\{E_{KL_{ij}}\}$ is the set of objects elements..

If there is an analogue detail in BD2, dependence (6) accepts the species

$$A_{KL_{ij}} = (e_1, e_2, \dots, e_n) \tag{7}$$

where e_i are the elements of the j object of the i-th kind of details.

In the case of incomplete matching of the elements e_i with those of the analogue part, the new detail is obtained by adding or subtracting corresponding elements from the closest analogue object (detail-type representative).

The search procedure P_{KL} is the type

$$P_{KL} = R_{KL} P_{KL,i}, \tag{8}$$

where R_{KL} is a ranking procedure and $P_{KL,i}$ is the procedure for searching an object with identical address.

The ranking procedure helps to reduce the analyzed set of analog objects. Ranking is done in accordance with the rules.

$$(N_n, B_n) = \{A_{KL}\} \tag{9}$$

where N_n are the number of elements (parameters) in the algebraic description of the object and B_n is the type of elements in the algebraic description of the object.

The input data for describing the part parameters apart from serving for its identification and based on them, it receives the corresponding code and address in the BD_1 (Fig.4).

Through the code and address thus obtained and the corresponding procedure an analogue object of the relevant class KL_{1i} (rotational parts) or KL_{2i} (prismatic parts) is searched in DB_2 (Fig.5).

In the event of finding such an analogue, the type of technological process is detected by the BD_3 workpiece address (Figure 6).

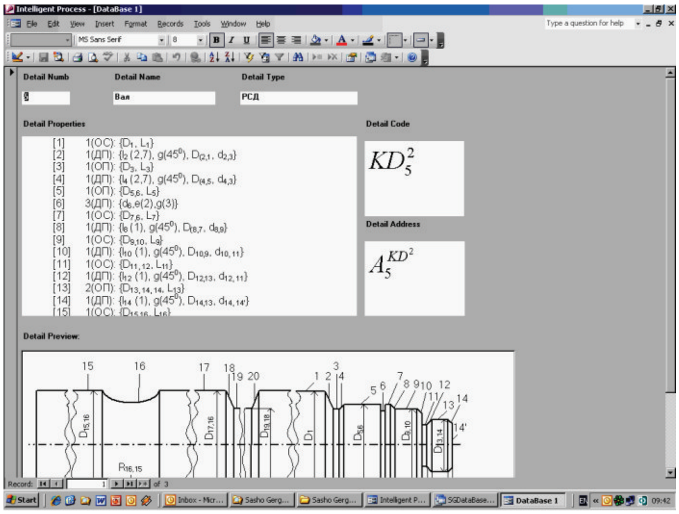

Fig. 4. Parameters, code and batch address of BD_1

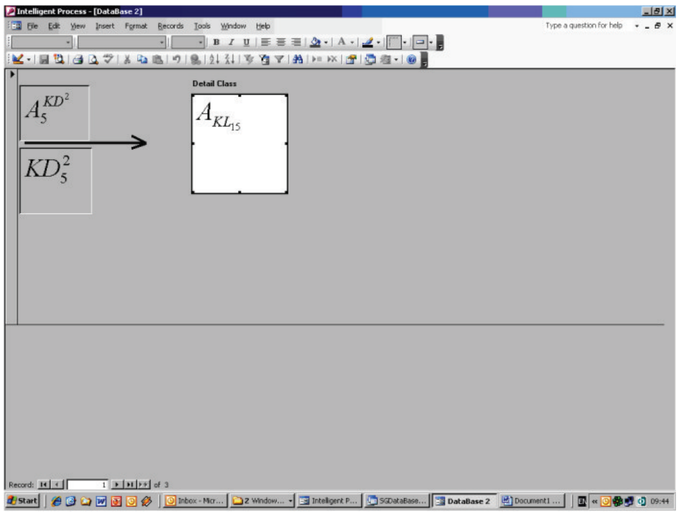

Fig. 5. Assigning the workpiece to a relevant class (BD_2)

Next, it is necessary to determine the sequence of the route of the technological operations (BD_5), but because for the given example they are only turning in Fig. 7, only the cycle of movement of the tool in the workpiece is shown.

In the case of an undetected detail-analog in DB_2, a control procedure is performed by the M-CREATE operator and by appropriate procedure a new object is created, which is recorded in the BD_2. The procedure is then repeated for the other DBs (BD3 and BD_4).

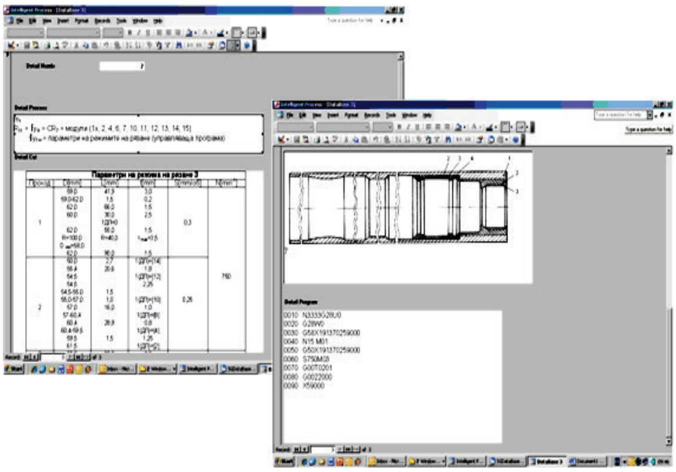

Fig. 6. Choosing a Type / Group Technology Process

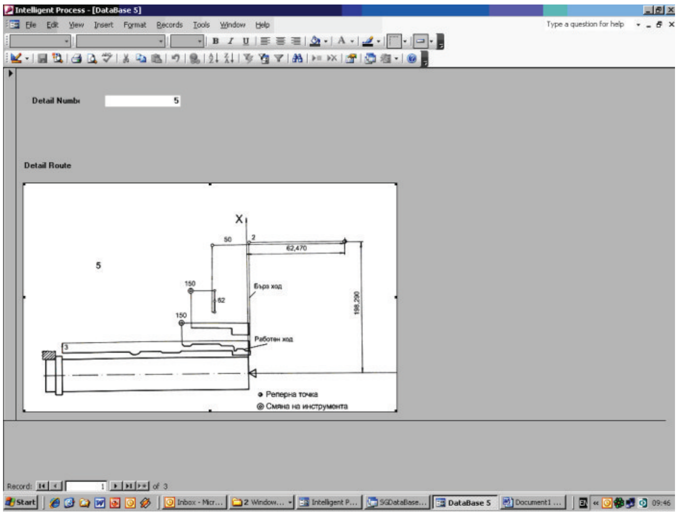

Fig. 7. Cycle of tool movement (BD_5)

IV. Conclusions

The current development of information technology makes it possible for information management in the industry to penetrate rapidly into areas that are not related to information management at first sight. Production processes are becoming more and more complex, and appropriate methods, procedures and tools will meet the challenges.

This work provides an integrated process for jointly contributing different intelligent techniques to increase the efficiency of the production machines. The proposal includes the creation of new machine structure, which includes intelligent function components, application of heuristics to determine optimal parameters, and finally, the approach of a management architecture that simultaneously performs the information exchange and management of the intelligent machine.

Other tasks that can be solved are the creation of appropriate data structures, data handling procedures and the optimization of the information exchange process in the direction of real-time function and by machine learning the creation of new machine structures

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