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CREATING THE DATA BASE FOR INTEGRATED PRODUCTIONS SYSTEMS

Summary. For automatized design process the information concerning range and technological capabilities of machine tool are necessary. In the paper a new method of analysing technological capabilities of machine tools in the form of a graph is presented. On base of generalized structure diagram it is possible to show detailed diagrams for different stands. This information in the computer data base is useful in the design of manufacturing processes.

1. Introduction

The basic component of planning systems in Computer Integrated Manufacturing is a data base. It is a source of information permitting the realization of subsequent stages of process planning. The information collected in the data base comprises the sets of fixed characteristics (concerning the workcells and their equipment) and the sets of variable parameters which are real-time related to the system status. The fixed data permits the making of hypothetically correct decisions, related to the process planning. By using the variable data and modifying the results it is possible to obtain real solutions. It involves the necessity of permanent updating of the data base contents as the result of the information flowing from the manufacturing system.

2. Elements of the technological process

Of basic importance in the technological process is the period of time in which the machined object undergoes the manufacturing process. The following elements can be distinguished in this period:

- the time when there are no changes with respect to the workpiece, e.g. when the workpiece stays in the buffer store or on the fixed pallet,
- the time when there are certain changes in the state of the system element, e.g. when the workpiece surface is machined.

Generally, the changes refer not only to the machined object but also to the tools, object and tool instrumentation, and to other elements of the system. They constitute a complex picture of changes in the production system. They results in the realization of the machining process. Detailed analysis of the system operation reveals, that the set of single events or activities performed in the system T can be divided into three subsets:

$$T_w = T_{TR} + T_{OP} + T_{ID}$$

where:

T_{TR} - operations changing the characteristics of the workpiece (the shape, dimensions, condition of surface) as the results of the action on the workpiece (called "the transformers");

$$T_{TR} = \{t_{r1}, t_{r2}, t_{r3}, \dots\}$$

The events $t_r \in T_{TR}$ can be described using the following model:

At_r - describes the change of shape and manufacturing properties of the workpiece;

Bt_r - describes the way of execution of the changes described above;

Ct_r - describes the parameters of execution.

$$t_r (At_r, Bt_r, Ct_r)$$

T_{OP} - events changing the position or orientation of the work-piece or the tool in the manufacturing system (called "the operators");

$$T_{OP} = \{t_{op1}, t_{op2}, t_{op3}, \dots\}$$

The events $t_{op} \in T_{OP}$ can be described using the following model:

At_{op} - describes the change of position or orientation of the workpiece in the manufacturing system;

Bt_{op} - describes the way of execution of the changes described above;

Ct_{op} - describes the parameters of execution.

$$t_{op} (At_{op}, Bt_{op}, Ct_{op})$$

T_{ID} - events describing and comparing the characteristics of the workpiece with the quality requirements at the particular stage of its processing;

$$T_{ID} = \{t_{id1}, t_{id2}, t_{id3}, \dots\}$$

The operation $t_{id} \in T_{ID}$ can be described using the following model:

At_{id} - describes the type of identification of the workpiece;

Bt_{id} - describes the way of identification;

Ct_{id} - describes the parameters of identification.

$$t_{id} (At_{id}, Bt_{id}, Ct_{id})$$

Thus the technological process is an ordered sequence of events which cause, directly or indirectly, the intended change in the state of the workpiece. The state should correspond to the final characteristics of the workpiece given in the documentation. The machining process plan is a selection of a certain sequence of events and their parametrization, which includes the characteristics of the workpiece and technological capabilities of the system. The technological capabilities of the system are comprised of the technological capacities of particular stands. Technological capabilities of a machine tool can be presented as a graph [2], [3], which nodes represent the elements of the system (Machine Tool - Instrumentation - Tool - Part), and its arcs describe their mutual relations as location, fixing and kinematics (Fig.1).

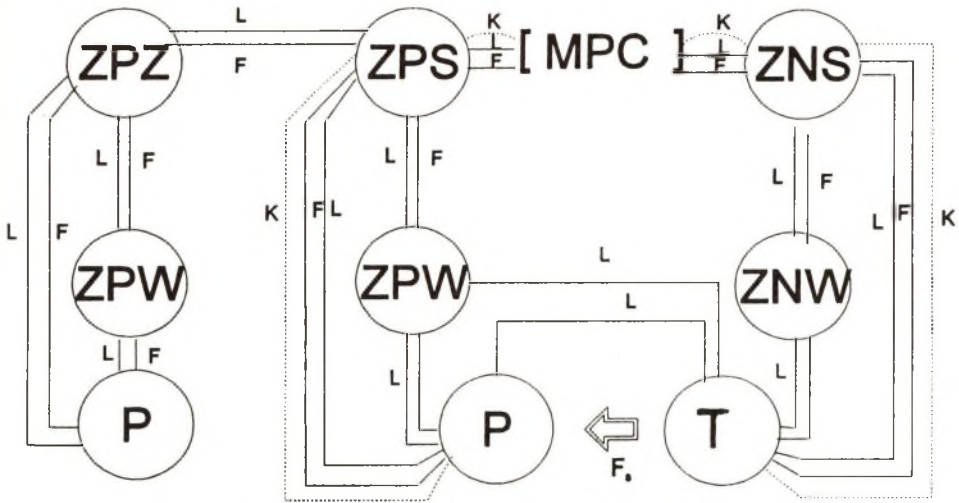


Fig. 1. Generalized Structure of the Machine Tool.

MPC - Machine body, Power, Control

ZNS/ZNW - Fixed/exchangeable/Tool Instrumentation

ZPS/ZPW - Fixed/exchangeable/Workpiece Instrumentation

ZPZ - Workpiece Feeding Instrumentation (pallets, robots)

P - Workpiece

T - Tool

Relation:

— location + fixing,

- - - kinematics

The sets of transformers, operators and identifiers which can be realized in a multi-stand system constitute its technological capabilities. Using their formalized description it is possible the creation of a data base for the system which defines its capabilities and tool

instrumentation, workpiece instrumentation and of cutting and measuring tools. The relations between transformers, operators, identifiers and the other elements of the manufacturing stands constitute a complex system.

3. Description of a relational database

3.1. Characteristics of relations

The stands of a manufacturing system are described by the following relations:

- R_o - relations of machine tools, which contain the characteristics of machine tools constituting the manufacturing systems,
- R_z - relations of feeding instrumentation (robots, manipulators), which contain the characteristics of feeding equipment,
- R_x - relations of measuring instruments (measuring machines), which contain the characteristics of measuring and checking equipment.

A detailed description of the relation R_o is given below.

A machine tool is described by the set of parameters U . The subsets which can be distinguished in this set are as follows:

- the subset referring to general features of the machine tool

$$U_o^o \{YO_1^{(o)}, YO_2^{(o)} \dots\}$$

- the subset referring to functional parameters of the machine tool

$$U_U^o \{YO_1^{(o)}, YO_2^{(o)} \dots\}$$

- the subsets of parameters describing the ZPS

$$U^{(ZPS)} = \{U_o^{(ZPS)}, U_U^{(ZPS)}, U_P^{(ZPS)}\} \text{ where:}$$

$U_o^{(ZPS)}$ - the set of general parameters of the ZPS,

$U_U^{(ZPS)}$ - the set of functional parameters of the ZPS,

$U_P^{(ZPS)}$ - the set of connection parameters of the ZPS.

- subsets of parameters describing the ZNS

$$U^{(ZNS)} = \{U_o^{(ZNS)}, U_U^{(ZNS)}, U_P^{(ZNS)}\}, \text{ where}$$

$U_o^{(ZNS)}$ - the set of general parameters of the ZNS,

$U_U^{(ZNS)}$ - the set of functional parameters of the ZNS,

$U_P^{(ZNS)}$ - the set of connection parameters of the ZNS.

ZPS and ZNS components of the machine tool are fixed to the machine tool. ZPS and ZNS features (especially connection parameters) are a part of the total characteristic of the machine tool. The relation R_o is illustrated in fig. 2. Exchangeable tool and part instrumentation are described by the following relations:

Relation R_0

Machine tool no.	Table of parameters contained in the relation R_0							
	General U_0^O	Functional U_U^O	Describing ZPS $U^{(ZPS)}$			Describing ZNS $U^{(ZNS)}$		
			General $U_0^{(ZPS)}$	Functional $U_U^{(ZPS)}$	Connection $U_P^{(ZPS)}$	General $U_0^{(ZNS)}$	Functional $U_U^{(ZNS)}$	Connection $U_P^{(ZNS)}$
1	$YO_1^{(O)}, YO_2^{(O)} \dots$	$YU_1^{(O)}, YU_2^{(O)} \dots$	$YO_1^{(ZPS)}, YO_2^{(ZPS)} \dots$	$YU_1^{(ZPS)}, YU_2^{(ZPS)} \dots$	$YP_1^{(ZPS)}, YP_2^{(ZPS)} \dots$	$YO_1^{(ZNS)}, YO_2^{(ZNS)} \dots$	$YU_1^{(ZNS)}, YU_2^{(ZNS)} \dots$	$YP_1^{(ZNS)}, YP_2^{(ZNS)} \dots$
2								
...								
K								

Fig. 2. Characteristic of the relation R_0

R_{ZPW} - relation containing the characteristics of exchangeable part instrumentation,
 R_{ZNW} - relation containing the characteristics of exchangeable tool instrumentation.
 The exchangeable part instrumentation ZPW is described by the following set of parameters:

$$U^{(ZPW)} = U_O^{(ZPW)}, U_U^{(ZPW)}, U_P^{(ZPW)}, \text{ where}$$

$U_O^{(ZPW)}$ - the set of general parameters of the ZPW,

$U_U^{(ZPW)}$ - the set of functional parameters of the ZPW,

$U_P^{(ZPW)}$ - the set of connection parameters of the ZPW.

The set of connection parameters for the ZPW $U_P^{(ZPW)}$ (exchangeable part instrumentation) consist of two subsets of connection parameters: parameters of the connection to the ZPS (permanent part instrumentation) and to the part (P).

$$U_P^{(ZPW)} = \{U_{P(P)}^{(ZPW)}, U_{P(ZPS)}^{(ZPW)}\}$$

The relation R_{ZPW} is illustrated in fig. 3.

Relation R_{ZPW}

Table of parameters contained in the relation R_{ZPW}				
	General $U_O^{(ZPW)}$	Functional $U_U^{(ZPW)}$	Connection	
			$U_{P(P)}^{(ZPW)}$	$U_{P(ZPS)}^{(ZPW)}$
1	$YO_1^{(ZPW)}, YO_2^{(ZPW)} \dots$	$YU_1^{(ZPW)}, YU_2^{(ZPW)} \dots$	$YP_{1(P)}^{(ZPW)}, YP_{2(P)}^{(ZPW)} \dots$	$YP_{1(ZPS)}^{(ZPW)}, YP_{2(ZPS)}^{(ZPW)} \dots$
2	⋮			
	⋮			

Fig. 3. Characteristic of the relation R_{ZPW}

The exchangeable tool instrumentation ZNW is described by the following set of parameters:

$$U^{(ZNW)} = \{U_O^{(ZPW)}, U_U^{(ZNW)}, U_P^{(ZNW)}\}, \text{ where}$$

$U_O^{(ZNW)}$ - the set of general parameters of the ZNW,

$U_U^{(ZNW)}$ - the set of functional parameters of the ZNW,

$U_P^{(ZNW)}$ - the set of connection parameters of the ZNW.

The set of connection parameters for the ZNW (exchangeable tool instrumentation) $U_P^{(ZNW)}$ consist of two subsets of connection parameters: parameters of the connection to the ZNS (permanent tool instrumentation) and to the tool (N).

$$U_P^{(ZNW)} = \{U_{P(N)}^{(ZNW)}, U_{(ZNS)}^{(ZNW)}\}$$

The relation R_{ZNW} is illustrated in fig. 4.

Relation R_{ZNW}

No. ZNW	Table of parameters contained in the relation R_{ZNW}			
	General $U_O^{(ZNW)}$	Functional $U_U^{(ZNW)}$	Connection	
			$U_{P(N)}^{(ZNW)}$	$U_{P(ZNS)}^{(ZNW)}$
1	$YO_1^{(ZNW)}, YO_2^{(ZNW)} \dots$	$YU_1^{(ZNW)}, YU_2^{(ZNW)} \dots$	$YP_{1(N)}^{(ZNW)}, YP_{2(N)}^{(ZNW)} \dots$	$YP_{1(ZNS)}^{(ZNW)}, YP_{2(ZNS)}^{(ZNW)} \dots$
2				

Fig. 4. Characteristic of the relation R_{ZNW}

The tools used in the manufacturing system are described by relations.

R_N - the relation containing the tool characteristics.

The tools are described by the following set of parameters:

$$U^N = \{U_O^{(N)}, U_U^{(N)}, U_P^{(N)}\}, \text{ where}$$

$U_O^{(N)}$ - the set of general parameters of the tools,

$U_U^{(N)}$ - the set of functional parameters of the tools,

$U_P^{(N)}$ - the set of connection parameters of the tools.

The relation R_N is illustrated in fig. 5.

The relations describing feeding and measuring stands and the relations describing the exchangeable components of their instrumentation (e.g. grippers, measuring probes, etc.) can be defined in a similar way.

Another kind of relations describing the manufacturing system are the relations defining the links between the event $t_w \in T_w$ and the other elements of the manufacturing

Relation R_N

	Table of parameters contained in the relation R_N		
	General $U_O^{(N)}$	Functional $U_U^{(N)}$	Connection $U_P^{(N)}$
1	$YO_1^{(N)}, YO_2^{(N)} \dots$	$YU_1^{(N)}, YU_2^{(N)} \dots$	$YP_1^{(N)}, YP_2^{(N)} \dots$
2			
⋮			

Fig. 5. Characteristic of the relation R_N

system. This links are described in a following way:

R_{TR} - the relation containing the possibilities of execution of the transformers in the manufacturing system.

This relation is described by the following set of parameters:

A t_v - defining the model of the change of the workpiece shape and its technological properties,

B t_v - defining the way of shape change,

$YO^{(O)} \in U_O^{(O)}$ - the parameter identifying unequivocally the machine tool on which the transformer is executed,

$YO^{(ZNS)} \in U_O^{(ZNS)}$ - the parameter identifying unequivocally the permanent tool instrumentation,

$YO^{(ZNW)} \in U_o^{(ZNW)}$ - the parameter identifying unequivocally the exchangeable tool instrumentation.

In a similar way further relations can be defined:

R_{OP} - the relation containing the possibilities of execution of the operators in the manufacturing system,

R_{ID} - the relation containing the possibilities of execution of the identifiers in the manufacturing system.

The relations R_{TR} , R_{OP} , and R_{ID} give the characteristics of the event for the particular configuration of the stand performing the operation.

The connection parameters U_p which are the characteristics of the machine tool by the ZPS, ZNS, ZPW and ZNW give the possibility of combining the relations. The parameters determine permissible alterations of the manufacturing stand structure, giving also the possibilities of the realization of events in the manufacturing system. By defining the relations creating the database (fig. 6) and defining the keys for combining the relations K_1 , K_2 and K_3 a scheme of the data base (which is also its logical illustration) can be created.

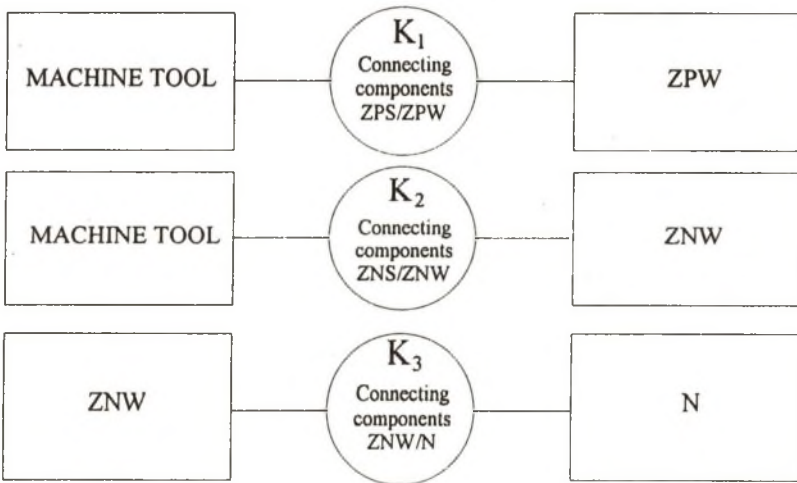


Fig. 6. The principle of combining relations by means of keys.

4. CONCLUSIONS.

The usefulness of the presented model of the data base for solution of the problem of computer aided design of the manufacturing processes were checked while building an advisory experimental system [5]. In the designed data base the information concerning:

- machine tool characteristics and their technological equipment,
- possibilities of realization of events which take part in the manufacturing system, are presented in the form of relations which define dependencies between elements of manufacturing system and events. "n" element symbols of relations are used here.

Resuming it should be stressed, that the assumed form of the data description of the manufacturing system gives an easy way of determining feasible solutions and effectiveness in forming the structure of the technological process, and the same time in selection of machine tools and in tool and part instrumentation.

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