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FRAMEWORK FOR EXTENDED USE OF TECHNOLOGICAL RESOURCES IN THE NETWORK OF ENTERPRISES

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Abstract: *Manufacturing companies are currently under strong pressure to supply goods, related services, and information that more faithfully answer to their customers' requirements. In this paper, development of a framework and system enabling integrated use of technological resources in the network of companies is described.*
Key words: e-Manufacturing, system ontology, technological resources, optimal utilization, database.

1. INTRODUCTION

Main part of the value created to the customer is created by production system. Therefore, production system plays central part in every manufacturing company. At the same time, production system is one of the systems having the most complicated configuration and functionality in the company. In knowledge-based economy and production, which is characterized by continuously shortening product life-cycles, but continuously increasing demands towards products' functionality, quality and other customers' requirements, the orientation towards development and improvement of production system and its efficient use is extremely important.
Technological resources constitute one important part of the production system. Technological capabilities, nomenclature and complexity of manufactured products depend on the essence of technological resources (see Fig.1). Inefficient use of technological resources brings along more expenses to the company. To guarantee company's strategic position in the market and competitive net value of the product, technological possibilities and technological capabilities of the company have to be determined and managed carefully and efficiently.

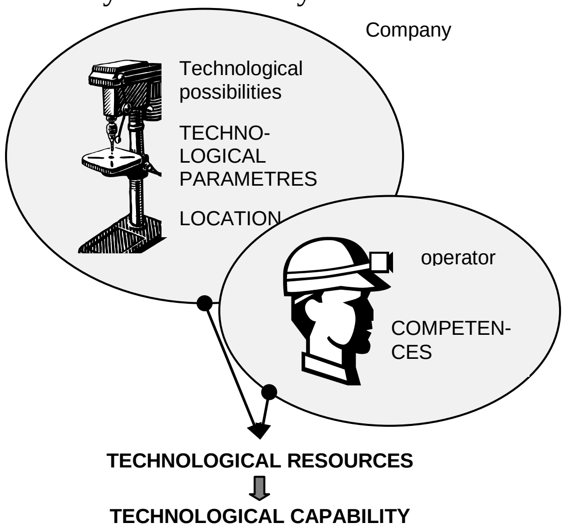


Fig.1. Connections between technological possibilities, resources and capability

Most companies in Estonia are small and medium sized enterprises (SMEs) that often lack necessary techniques, tools and technological resources to be able to correspond quickly to customers' larger and/or more complicated orders. Here sharing of technological resources would be one possibility to respond more quickly and effectively to market need.
In the current paper is analysed how production system influences company's competitiveness and developed framework. Impact of technological resources in fulfilling production tasks and possibilities to broaden technological capabilities in cooperation are analysed. Information system for technological resources

management enables to determine companies its technological capabilities and manage them, determining and fixating its existing resources, their unemployment in real time and exchange unemployed resources with other companies in the network.

2. ONTOLOGY OF A PRODUCTION SYSTEM

A company is entire system that operates in certain location and in certain (customer-oriented) field of activity. A company may belong to group (network), whereby its belonging to the group (network) may be abstract (undetermined) or the company may have some certain connections or functions with the group (network). One example of determined belonging to the network is cluster structure [1].

The increasing product complexity and emerging manufacturing globalization require the cooperation and coordination of manufacturing enterprises [2]. The resource sharing and reuse among these enterprises are essential for achieving efficiency and competitiveness.

Manufacturing companies may operate in networks, complementing each other via technological resources. With an aim to make collaboration more effective and efficient, information systems are developed that enable describe technological resources of a company, determine expediency of their use, analyse the rate of use of the resources and if needed, make exchange transactions, offering its unemployed resources and buying needed resources with an aim of mutual benefit. This information system requires unified ontology and semantics from the viewpoint of system development as well as system use.

A standardized terminology needs to be semantically consistent across organization boundaries, since the communication aspects of information require that communicating parties have the same understanding of the meaning of the exchanged information [3-5]. An approach for defining manufacturing taxonomy and axioms, based on a manufacturing system engineering (MSE) ontology is presented in Fig.2.

Production system has certain resources, processes and strategies (Fig.2). Production system is characterized by physical environment (number, type, model of machine tools, their layout and location) and functional environment that is expressed by technological possibilities of machine tools. Machine tools have mutual logistical relations inside the system as well as with external environment.

Technological possibilities of company's production system evolve mainly on the basis of technological possibilities of machinery (machine tools, presses, welding equipment etc). Technological possibilities can be defined as a set of characteristics of the current device (machine tool, industrial robot, manufacturing cell) for producing a specified work piece or performing certain technological task.

Manufacturing a product needs using a certain amount of technological possibilities. When parameters needed for manufacturing a product exceed technological possibilities of a machine tool, then use of different machine tools is needed. Meanwhile, manufacturing simple and similar products, usually it is not economically reasonable to use too complicated equipment.

Technological possibilities of equipment belonging to the production system determine greatly essence of processes taking place in this system and also are basis for forming possible strategies.

In addition to technological environment (machine tool with its technological possibilities), also machine tool operator with its competences belongs to the workstation.

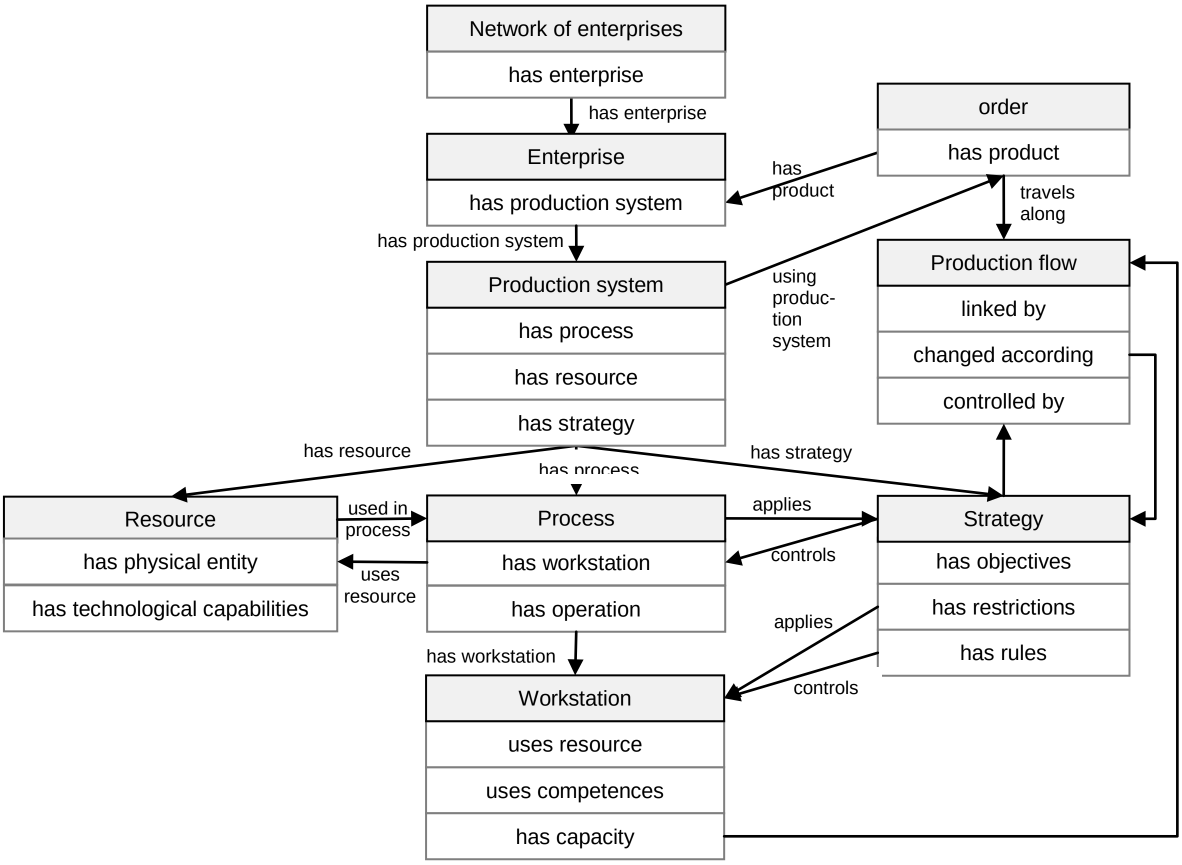


Fig.2. Production system ontology model

The human's skills, knowledge, experiences, motivation and desire to apply them in a team influence how many pieces he/she could produce during a certain time period using a certain machine with certain technological possibilities. Therefore, using the same machine and applying the same organizational methods, one employee could produce much more details than another during the same time. Influence of human factor to productivity is larger when the process is less automated. This combination (machine tool with its technological possibilities and machine tool operator with its competences) expresses technological capability of workstation and forms basis when determining company strategy, order portfolio and planning production flows. Raising effectiveness and efficiency of production flow begins from raising workstations' productivity through development of technological capabilities and competences.

3. OPTIMAL USE OF TECHNOLOGICAL RESOURCES IN PRODUCTION FLOW ORGANIZATION

Manufacturing system performance realizes via completing technological tasks. The result depends on how production system is organized, tasks formed and given to workstations in a company. Input to this activity is production volume and product mix.

Main parameters describing expediency of the use of technological resources are:

- Extent of using technological resource;
- Extent of using machine tool;
- Extent of flexibility – exchangeability of technological resources.

How suitable are company's technological resources and how efficiently they are used for production task fulfilment, is one factor determining how well production system is realized.

The optimal manufacturing planning is traditionally based on use of mathematical programming approach by optimizing the objectives that represent the results we want to achieve and considering possible constraints existing in production. This approach could be used in determining optimal number of machining tools.

Choices about how much and what type of machine tools to use have a strong direct influence on a company's efficiency. Capacity decisions have a major impact on all other production planning issues (e.g. aggregate planning, demand management, sequencing and scheduling, shop floor control). To estimate the need for using additional resources and to estimate the optimal level of inventory both product-mix planning and aggregate planning models could be used. In both models decisions are related with the corresponding constraints. For the need to increase (decrease) the accessible capacity, different tools of sensitivity analysis or post-optimality analysis could be used.

The most essential tasks in addition to determining number of resources needed, is optimizing technological routes and dividing production operations among workstations.

Model for determining numerically technological resources is following (Eq 1).

Parameters: X_j, Y_{ikj}

Function:

$$\sum_{j=1}^{J}(X_j P_j + C_j \sum_{i=1}^{I}\sum_{k=1}^{k_i} Y_i k_j t_{ikj}) \qquad (1)$$

Subject to constraints:

$$\sum_{i=1}^{I}\sum_{k=1}^{k_i} Y_{ikj} t_{ikj} \le X_j F_j \eta_j \text{, j = 1, 2, ... J}$$

$$\sum_{j=1}^{J} Y_{ikj} = N_i \text{, k = 1, 2, ... K, i = 1, 2, ... I}$$

$X \geq 0$, X_i = int

$Y_{ikj} \geq 0$, Y_{ikj} = int

Where

i – type of processed workpieces (from the product mix);

N – production amount of workpieces per certain time-period;

j – model of machine tool among this types of machine tools;

t – processing time of workpiece i using machine tool j;

I – number of types of workpieces that are possible to process using machine tool j;

k – number of processing types;

J – number of types of machine tools which enable perform processing type k;

t – time of realisation of process ik using machine tool j;

F – effective work time front of machine tool j;

η_j – planned loading coefficient of machine tool j;

P_j – price of machine tool j;

C_j – cost of working hour of machine tool j;

X_j – number of machine tools type j;

Y_{ikj} – number of workpieces of type i that operation k is processed using machine tool type j.

Exploitation of machine tools has to be as unvaried as possible. Bottleneck can't be brought about to some machine tool having more technological possibilities. Hence the need for making choice of processing methods in the phase of composing manufacturing routes and alternative routes planned, if needed. Therefore, an expert system should belong to the information system of technological resources management.

4. INFORMATION SYSTEM FOR MANAGEMENT OF TECHNOLOGICAL RESOURCES IN NETWORK OF COMPANIES

As follows, we propose web-based technological resources management system to share and use technological resources in the network of companies. Management system of technological resources includes information regarding companies' technological resources (see Fig.3) and enables to use this information in real-time inside the company or also externally according to agreed rules.

Management system of technological resources is realised in Internet environment and its objective is to enable efficient use of technological possibilities of production equipment and therefore reduce production costs and achieve competitive net value of products.

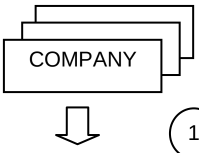
Using previously described model (Eq 1), it would be useful to use a certain hierarchy for classifying technological resources. In classification four levels can be distinguished: [6]

1. Group (e.g. machining);
2. Type (e.g. drilling);
3. Class (e.g. CNC vertical drilling);
4. Parameters.

Group, type and class specify machine tool model for realizing a certain operation.

In the proposed database model technological possibilities can be described by using characteristic data (see Fig.3):

- D – max diameter of workpiece;
- d – max diameter of spindle;
- L – max length of workpiece;
- B – max with of workpiece;
- H – max height of processing;
- Ra – surface roughness parameter;
- IT – positioning accuracy;
- c – number of axes.



Company data (name, location, address, contact persons, homepage etc)

(1) Basic description of a company's manufacturing equipment (physical entity) (to be fulfilled for every machine tool in the company)

Model	ID number	Produc-tion year	Location	Power consumption, kW	Weight, kg	Cost of working hour, EUR	Availability (occupied, unoccupied – dates)	Willingness to sell out the resource hour	Technolo-gical parametres, see part 2
1	2	3	4	5	6	7	8	9	10
1K62	123	1982	Tallinn						
2P135F2	456	1984	Tartu						

(2) Technological possibilities and paramentres describing the manufacturing equipment

Determination of technological possibility			Desciption of parametres, max									
Group	Type	Class	D	L	d	B	H	IT	Rz	kg	c	...
Machining	Lathing	With centers	400	1000	40							
Machining	Drilling	CNC				400	400					

Fig.3. Model of web-based management system of technological resources

The list presented here is not definite, but depends on the group and type of processing method.

Technological possibilities are determined for each machine separately and on the basis of technological possibilities of separate machines belonging into system are formed possibilities of the whole system.

Web-based technological resources management system enables solving problems in three levels:

1. Company level

- Statistical analysis of utilization of machinery;
- Dynamical planning of utilization of machinery depending on orders;
- Informing other members of the network about the company's technological resources and technological possibilities;
- Determining need for and/or surplus of technological resources in real time and making agreements with other members of the network about

purchasing or selling technological resources for certain time-period.

2. Level of the company's technological possibilities:
- Analysis about expediency of use of the company's technological resources regarding production subsystems as well as groups and types of machine tools;
- Determining the company's technological capabilities concerning essence of workstations and comparing it with the company's strategic objectives;
- Determining nonexistent technological capabilities from the viewpoint of raising productivity or broadening product nomenclature.

3. Product level:
- Determine optimal technological possibilities to manufacture a certain product family;
- Define in planning phase nonexistent technological resources, determine their essence and find possibilities to cooperate with other network members and buy in the use of the resource;
- Divide order between companies belonging to the network, taking into consideration principle of optimal use of technological capabilities.

5. CONCLUSIONS

The main key factors that influence the company's production capability were investigated. Technological possibilities play important role in designing operational and route technologies but also in management of whole production process. Framework and model of web-based technological resources management system for optimizing use of technological capabilities and increasing efficiency through extended use and exchange of technological resources were presented. Results of this phase are used for further development of database and system for controlling, managing and exchanging company's technological resources in the network of companies.

6. ACKNOWLEDGEMENT

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