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## MULTIVARIANT PROCESS PLANNING THEORY AND ITS APPLICATION FOR SPECIAL PURPOSE VEHICLE PRODUCING

The article deals with the characteristics of input and output data, which are necessary for manufacturing of machine parts of special purpose vehicles. It shows the relations between the individual manufacturing objects by means of information flow analysis within CAPP. It is possible to create several process plans for every engineering part and consequently use one of them in specific manufacturing conditions that are optimal according to the selected criterion. The analysis of information flow can considerably help with the process plan selection and, in result, with effectiveness or quality increasing.

**Keywords:** computer aided process planning, process plan design, production information system

### 1. Introduction

While making decisions about production software, manufacturing companies can select an information system as a variation of two border zones: one extreme is to obtain a complex system and the opposite extreme is an independent solution for each enterprise action. The first one is difficult to get by small enterprises to due to expensive price. The second one generally dispose only possibility of interconnection to related information systems. Within the area of these diametric options lay the requirements of the majority of production companies. The creation of a new theory to approach manufacturing information system deals by authors involves: arrangement to obtain advantages of both extremes; integration of IS in specialized systems environs (CAD/CAM ...) and the possibility of sharing data by every ring in the supplier chain. One of first steps was detection of typical demands on the European market from the view of a representative enterpriser.

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## 2. Relations between enterprises

The statistical studies [1] pointed that European micro companies constitute a substantial part of the European market – they form the basis – over 92% (17.82 million business units) – of the overall number of companies and employ over 39 per cent of the employees at the EU market (Fig. 1). Small and medium size companies together comprise 7.5% of the overall number and employ 30.3 per cent of the employees. The rest – 0.2% of production unites and 30.2% of employees – is covered by large companies. From the same study it can be seen that micro companies have at their disposal the potential of 20% of the productivity and 15% of profitability. These are very important characteristics which describe a distinct ability of dynamic growth in production and the possibility of effective evaluation of micro company instruments, basically ‘over a night‘.

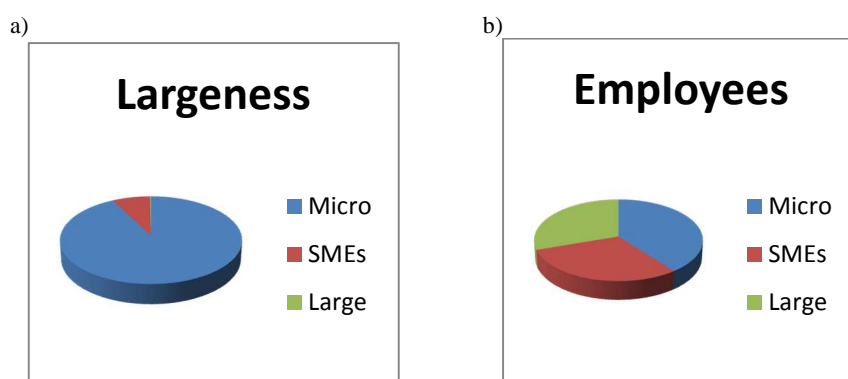


Fig. 1. Statistical analysis of European market: a) Numbers of enterprise units on the European market in conformity with the size of enterprises, b) Fraction of employees in European enterprises

On the basis of the analysis of potential system users securing the computer support of the computer aided process planning, it can be said that it is the micro companies that constitute the significant part of the enterprise subjects [2]. The specifications of this type of enterprise units imply diametrically different demands regarding information systems from the normal setting of IS, appropriate for large and medium size companies. This part of companies requires mainly very simple implementation, the possibility of modular concept for covering all necessary areas [3], reliable and secure data formats and structures, possibility of flexible data sharing among partners in the supply chain, the possibility of trouble-free extension to the needed modules, securing the possibility of a relatively fast transfer to higher IS levels when necessary and, last but not least, a reasonable price. From the point of view of demand variety of individual companies, the conditions were assessed while designing the IS:

- the system must be able to work with the possibility of user view on the production process from several angles,
- the enterprise subject should be limited when launching new products to the production process as little as possible,
- it should be applicable for a wide range of business,
- it should be modular.

The simplified structure production system design, divided into parts according to [4] can be applied, to advantage, to design of the information system composition. The layout of this simplified structure is shown in Tab. 1. Thus, the system was built for wide product definitions and their parts from the point of view of three technological approaches. The approaches of Individual, Type, and Group must be accessible in the information system because every producer applies production design with own style and also different conditions of the same product can be used in different approaches.

Table 1. Simplified structure of the production system design

Production system design		
1. Product design	2. Manufacturing design	3. Studies of labour and production costs
1.1. Design procedures 1.2. Design methods 1.3. Value analysis	2.1. Technological structure planning 2.2. Process planning 2.3. NC programming	3.1. Work analyses 3.2. Work measurement 3.3. Wage schemes

### 3. Development of the CAPP system

Computer Aided Process Planning (CAPP) represents activities leading to creation of production documentation and the details of equipment for the production process. The cost structure analyses for small and medium series production indicate a significant ratio of CAPP in the production costs composition. From the point of view of these analyses it is very important to pay considerable attention to the CAPP area which can, in result, influence the output costs of a product and its quality in a great measure [5]. When designing a new product the aim is to secure or increase its technical value, not only by systematization of the production process, but also by increasing the level of the supporting tools for the rational processing of the production documentation and data needed for planning [6].

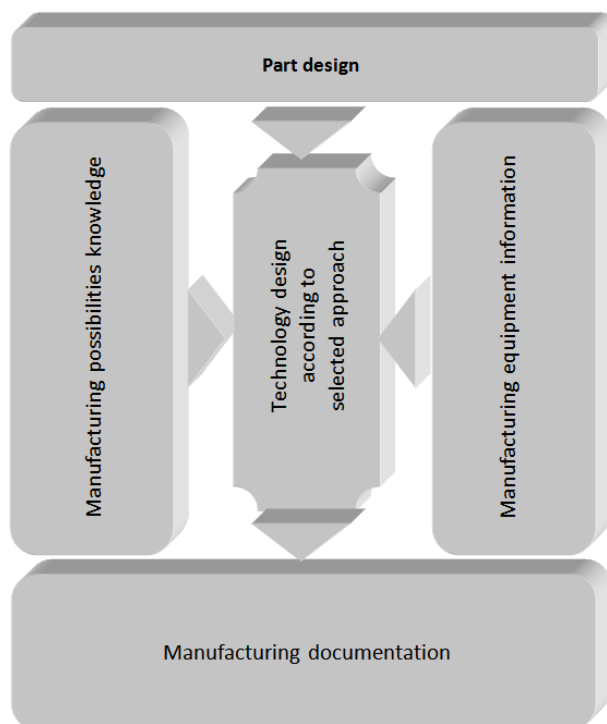


Fig. 2. Simplified scheme of multi-variant process planning

The theory of multi-variant process planning deals with the production process (during its project phase, also during the production) as a homogenous whole, including technological and labour processes organised via various possible parallel phases in the way the final product could be processed in the optimized way for the set conditions, whilst fulfilling all the demands required by a consumer. On the basis of this theory it is possible to create combination of possibilities of various techniques used in an individual process planning based on the strategy aimed at achieving the specific goal of the production unit (Fig. 2). The main objective of this theory is [3]:

- creation of the unified definition environment for all the factors immediately influencing the result of the production process,
- flexible interface which enables bidirectional exchange of the required information with all the surrounding systems.

Thanks to the unified definition environment the philosophical and conceptual unity is secured within the whole issue falling into the formation area of multi-variable process planning, a distinct classification product constituent and the laws of production sequence for operation projection, which enable the use of several possibilities designed by an information system based on this theory. Flexible interface of the system must enable effective work in the production environment,

so that all the individual relevant systems creating heterogeneous information system (CAD/CAM application, wage records, accounting, material management,...) have the inter-connection secured via the suitable interfaces, in order to prevent the errors caused by data redundancy, human factor, but also to reduce the response time to minimum. A truly tested Multi-Variant Process Planning system was originated by interconnections for a wide variety of CAD/CAM systems (models, CL data & NC programs etc.) and various methods of technological approaches to multi-variant process plan design correspondent to requirements of European plants [7].

#### **4. Information system real application**

On the basis of the aforementioned theory, the characteristics of the information system were created and applied into real production conditions in the computer aided process planning, consisting of approximately 6,000 components. The given product was a result of the co-operation between a German company, providing investments and co-operation of the activities, and Slovak companies providing the technical process planning and the production of the final product.

From the very beginning of the project the established IS served for the purpose of suitable analysing individual real database objects (components, substructures, structures, finished product), i.e. new analytical tools were created when required. Established solution serves the purpose of easier and faster assigning of process parameters, shortening of the computer aided process planning documentation time in real production conditions, and it also supports effective utilization of the production plant based on the model mathematisation of object variation of the computer aided process planning, fulfilling the combination of the required characteristics within the given production conditions. Output system data can be used for processing the details of the warehouse, economic and wage records as well as for their control and optimization.

The main contributions to assigning IS, elaborated on the basis of the multi-variable process planning in the real manufacturing conditions, can be summarized as follows [8]:

- reduction of the variability of warehouse stock (at the first application by nearly 30%),
- immediate information about product description,
- fast acquisition of the details via interfaces for wage records and accounting,
- elastic analytical tools enabling the adoption of better decisions.

The software tool is created in such a way that it is easily implemented to the already existing information company structure via flexibly adjustable interfaces. It is also user-friendly, developed with the characteristics of GUI, typical for OS MS Windows, so that the basic grasp of its functioning does not require expensive trainings (Fig. 3). Of course, if the maintenance of this system is to be productive,

it must be familiarized with the given philosophy and possibilities of tactic and strategy planning, through which the production can be optimized.

The presented manufacturing information system is unique in terms of the possibility of cooperation with CAD/CAM systems (practically with any from known) and connectivity to other systems (accounting, stock, wages etc.). This concept brings advantages mainly to micro companies:

- modular conception,
- flexible interconnections to partners,
- possibility of cooperation with a wide variety of external software,
- convenient price level.

The ground tasks for near future in the focus area of authors are:

- research for general format of process plan data,
- investigation of production environs in other European countries,
- study of graphical features used for process planning.

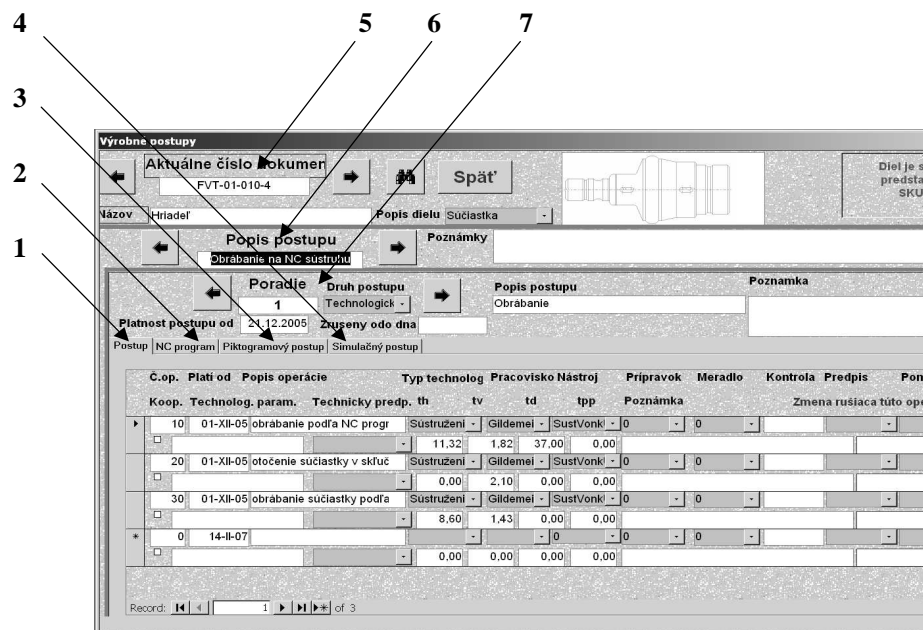


Fig. 3. Definition of manufacturing characteristics; 1 – manual entry of technological operation cycles, 2 – technological operation cycles as NC program – directly entered by the operator or established for a group of fixtures in the framework of Group Technology or automatically generated within CAD/CAM systems environment, 3 – technological operation cycles in the form of the sequence of operation pictograms, 4 – technological operation cycles in form of the simulation sequence (video, animation, ...), 5 – identification of the segment for which is process plan designing, 6 – identification of Process plan, 7 – identification of Phase

## 5. Conclusion

From the very beginning of the project activities, the prepared CAPP system served the purpose of suitable analysing of individual real database objects (components, substructures, structures, finished product), i.e. the new analytical tools were created as required. On the basis of the aforementioned multi-variant theory characteristics new software application were created and established into the real production conditions. The main benefits of the above mentioned software application, elaborated on the basis of the multi-variable process planning in the real manufacturing conditions, can be summarized as follows:

- reduction of the warehouse stock variability (at the first application by nearly 30 per cent),
- immediate information about the product elaboration,
- fast acquisition of the details via interfaces for the wage records and accounting,
- analytical tools enabling adoption of better decisions,
- acquisition of statistical values of parameters applicable to plan production in the future.

The system tool was created so as to be easily implemented to the already existing information company structure via flexibly adjustable interfaces. It is also user-friendly, developed with the characteristics of GUI, typical for OS MS Windows, so that the basic grasp of its functions does not require expensive trainings. Of course, to make maintenance of this system productive, it has to be familiarized with the given philosophy and possibilities of tactic and strategy planning, through which the production can be optimized. The presented manufacturing information system is a unique one in terms of cooperation with CAD/CAM systems (practically with every known) and its connectivity to other systems (accounting, stock, wages, etc.). This concept brings following advantages, mainly for micro companies:

- modular conception,
- flexible interconnections to partners,
- convenient price level.

The established solution serves the purpose of easier and faster assigning process parameters, shortening the computer aided process planning documentation time in real production conditions, and it also supports the effective utilization of the production plant based on the mathematical model of object variation. Output system data can be used for processing the details of the warehouse, economic and wage records as well as for their control and optimization. All know-how used in the described system shows the new tasks for future research within this scope:

- investigation of a system for comparison of 3D data for finding objects similarity,
- study of graphical features used in process planning,

- finding better interfaces for CL data creation, NC program sharing, alerts about 3D model changing etc.,
- seeking certain data formats for communications between cooperating plants,
- research into general format of process plan data,
- investigation of production environs in other European countries.

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## WIELOWARIANTOWY PROCES PLANOWANIA PROCESÓW W ZASTOSOWANIU DO PRODUKCJI POJAZDU SPECJALNEGO

### Streszczenie

Artykuł dotyczy charakterystyki danych wejściowych i wyjściowych, które są niezbędne do produkcji części maszyn do pojazdów specjalnego przeznaczenia. Pokazuje zależności między poszczególnymi obiektami produkcyjnymi za pomocą analizy przepływu informacji w ramach CAPP. Możliwe jest stworzenie kilku planów procesów dla każdej części inżynierskiej i w konsekwencji użycie jednego z nich w konkretnych warunkach produkcji, które są optymalne zgodnie z wybranym kryterium. Analiza przepływu informacji może znacznie pomóc w wyborze planu procesu, a tym samym zwiększyć jego efektywność lub jakość.

**Słowa kluczowe:** wspomagane komputerowo planowanie procesu, projektowanie procesu, system informacji o produkcji

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