

# **Computer Aided Process Plan and Its Application System**

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**ABSTRACT :** Process planning knowledge is one of the most important knowledge in mechanical manufacturing field. Traditional process planning systems requires human input into interface between CAD and CAM systems. The bridge to join this CAD/CAM is called and achieved by Computer Aided Process Planning (CAPP). The benefits of CAPP in the real industrial field are still to be achieved. Due to different manufacturing applications, many different CAPP systems have been developed. The development of CAPP techniques needs to a summarized and classified in a descriptive analysis. This paper deals with the suggestion of new software for the small and medium sized industry. The software enables to prepare the manufacturing process plans with multi variant approach and to process the information in several versions. The internal mathematical structure was generated and a new code system was suggested for manufacturing objects inside a new software application.

**KEYWORDS :** Computer Aided process planning, manufacturing system, coding, multi variant information system.

## **I. INTRODUCTION**

Process planning can be defined as the function which establishes the sequence of the manufacturing processes to use, to convert a part from an initial to a final form, where the process sequence incorporates process description, the parameters for the process and possibly equipment and machine tool selection. This will allow the process planning function to be performed either totally or partially by a computer, providing the user with optimum process plans in a quick consistent fashion.

First of all, this description should contain:

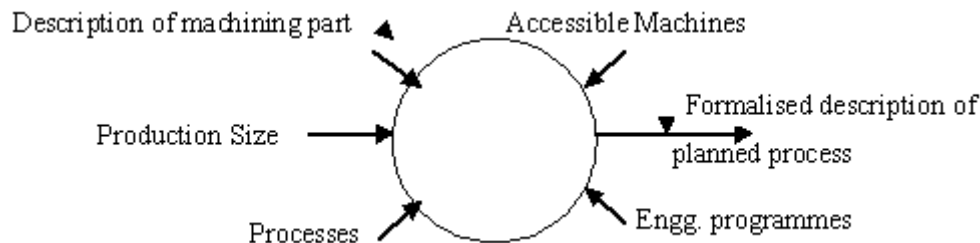
- a) General information about part name, part class, drawing of part and its number,
- b) Technological process structure including its elements like operations, set-ups, positions, cuts, etc.,
- c) Information for every operation; operation name (string description), operation number (code symbol), production department name, work (machining) station name and type (code symbol of work station), part drawing before and after carrying of operation, specification of part fixtures, specification of tool fixtures, kinds and sequence of technological cuts, technical standard operation time, control program, etc.
- d) Information for every technological cut, word description of cut, its number, kind and type of tool and its characteristic, machining parameters like cutting speed, rotational speed, feeding rate, main time of cut.

Components taken consideration in CAPP are shown below:

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**Fig.1. Resources of Production plant**

Characteristics of methods to CAPP : CAPP is carried out with utilization of two major methods:

- 1) Variant Method : This method of CAPP is comparable with the traditional manual method where a process plan for a new part is created by identifying and retrieving an existing plan for a similar part and making the necessary modifications for the new part. The following versions of CAPP are used:
  - A. Planning on the basis of a set of individual processes.
  - B. Planning on the basis of typical process model
  - C. Planning on the basis of a group process model.
- 2) Generative Method : The generative method process plans are used to automate planning and designing processes. CAPP systems are supporting computer programs for planning technology of the elements of given class. The generative method process plans are generated by means of decision logic, formulae, technology algorithms and geometry based data.

Some alternative approaches to generative process planning are used are:

1. Decision Trees: It is a graph-tree which comprised of a root and a set of branches originating from the root.
2. Decision Tables: These tables organize conditions, actions and decision rules in tabular form.
3. Axiomatic approach: Its intention is to provide a logical framework for designing products and processes.
4. Artificial intelligence technique and expert systems: These techniques like formal logic, describing components and expert systems for codifying human processing knowledge are also applicable to process planning problems.

The present software uses a multi-variant approach to the preparation of the process plan according to the selected criteria. It enables the creation of technological documentation and NC programs on the basis of hybrid approach. It compendious storage time and it economizes the manufacturing costs, too. This system is called Application system because of a possibility to accommodate to the individual requirements of the industry.

## II. RELATED WORK (LITERATURE SURVEY)

To present the ongoing work of Computer Aided Process Plan is mainly referred from the “Analysis of computer aided process planning techniques”, [1], from which it is thought to use different techniques for the said planning activity. In which, Dr.Salim Saleh, explains that, two major techniques are there to resolve the problems related to process plans. They are Variant method and Generative method. But, the second one is having very good scope of open mindedness and can be used to any kind of job and anywhere.

Where as, “Computerized Manufacturing Process System” [1], says that, to plan the process plan, different following versions are used. They are: (a)Planning on the basis of a set of individual processes, (b) planning on the basis of a typical process model, and (c) planning on the basis of a group process model.

While developing the application of the subject, Individual Application System for Computer Aided Process Planning [4], published by Peter Monka, Katarina Monkova has been referred. Then for further details of applications, the theory proposed as “Mathematical model of technological processes with prediction of operating & determining value [5], by Krehel R., Dobransky J., Krenicky T. as been studied. Finally, while defining the system of application,

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the paper , Process planning knowledge discovery based on CAPP database for mechanical manufacturing enterprise [6], published Jia X, Zhang Z, Tian X has been referred.

### III. THEORY OF MULTI-VAROANT PROCESS PLANNING

The theory of this paper deals with the production process which includes technological, labor, processes organized via various possible parallel phases so that the final product is processed in the optimized way for the set purposes for the demands of the customer.

On the basis of this theory it is useful to create a combination of potentialities of various techniques used in individual process plans based on the strategy aimed at achieving the specific goal of the production unit. The various objectives are considered: a) the creation of the unified definition environment for all factors, which directly affect the result of production process. b) The flexible interface which enables bidirectional exchange of the required information with all surrounding systems.

- A. Mathematical basis: The objects in machine engineering such as the parts, machines, equipments and others are possible to be modeled at the various stages with various goals. These objects can be regarded as various types of models (physical, simulation, computer, mathematical). Each of these objects may be considered a system which consists of some features or, on the other hand, as a feature being the part of some system.

The smallest unit of system model is “feature”, which is in suggested theory indicated by a small cursive letter (with or without index), for example  $a_1, a_2, \dots, a_j, \dots, a_n$ . Features with the same characteristics can be grouped into a set. The set is defined if all of its features have the same specific property. In such case it can be said that the features belong into the set. The sets are indicated by capital letters  $A_1, A_2, \dots, A_i, \dots, A_n$ .

The manufacturing system can be expressed by the relation,

$$MS = E \cup S \cup O \quad (1)$$

Where, MS - manufacturing system E - Equipment S - Segment O – Operation.

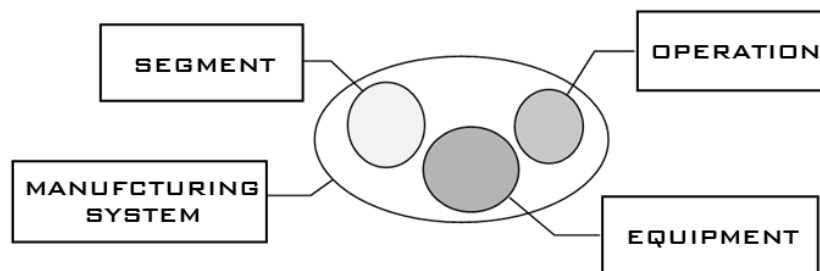


Fig.2. Graphical presentation of manufacturing system

On the basis of this structure it is possible to consider the manufacturing system to be a set, which is unification of subsets marked as subsystems.

- B. The subsystem “Equipment”: In this theory the term “Equipment” is used for a wide range of various production equipments, such as: premises (the manufacturing halls, workshops, offices, ...), equipments for the energy production and energy distribution, machines, tools, jigs and fixtures, equipments for the manual operations, equipments for assembly, measuring and testing equipments, equipments for storage, other devices (for example computer techniques, ...).

The set Equipment can be mathematically expressed as follows,

$$E = P \cup EP \cup ME \cup MTE \cup TE \cup SE \cup OE \quad (2)$$

Where, E – Equipment,

P - Premises (manufacturing halls, workshops ...),

EP - Equipment for Power production and distribution,

MTE - Measuring and Testing Equipment,

ME - Manufacturing Equipment,

TE - Transport Equipment,

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SE - Storage Equipment,

OE - Other Equipment (e.g. computer techniques ...).

All of these sets are the unions of subsets. For example the set ME can be written down as follows,

$$ME = M \cup T \cup F \cup AME \cup EMO \cup AE \quad (3)$$

Where, M - Machines,

T - Tools, F - Fixtures,

AME - Auxiliary Manufacturing Equipment,

EMO - Equipments of workshops for Manual Operation,

AE - Assembly plants Equipment.

In next structuring the subset Machines can be divided according to the technology type as follows,

$$M = MM \cup CM \cup WM \cup AM \cup MoM \quad (4)$$

Where, M - set of all Machines in the plant,

MM - Machining Machines,

CM - Casting Machines,

WM - Welding Machines,

AM - Assembly Machines,

MoM - Moulding Machines.

The following features come under the MM subset,

$$MM = M01 \cup M02 \cup M03 \cup M04 \cup M05 \quad (5)$$

Where, MM - Machining Machines,

M01 - turning machines,

M02 - milling machines,

M03 - drilling and boring machines,

M04 - machining centre,

M05 - grinding machines.

Production plant has a certain number of turning machines, which are the features of the set M01,

$$M01 = \{m1, m2, m3, m4, \dots\} \quad (6)$$

or

$$\sum_{i=1}^n m_i \in M01 \quad (7)$$

Where,  $m_i$  - is  $i$ -th machining machine,

$n$  - is total number of machining machines in the plant.

Individual turning machines are characterized by properties, which define the machine selection for turning of a specific part, for example: the centre lathes are suitable for the machining of too long shafts, for very small parts is necessary to select different, etc. The relationship between turning machines and their properties can be written down by the functional dependency,

$$M01 = f(p1, p2, p3, p4, p5, p6, p7, p8, p9, \dots) \quad (8)$$

Where, M01 - set of all plant turning machines,  $p_i$  -  $i$ -th property of turning machine,

$p1$  - lathe type,

$p2$  - control system,

$p3$  - tool equipment,

$p4$  - dimensions,

$p5$  - energy and precision,

$p6$  - turret head type,

$p7$  - speeds,

$p8$  - feeds,

$p9$  - postprocessors

C. The subsystem "Segment": The basis of subsystem "Segment" is the classification code for the segment description, which represents the start point of the entire system. The suggested coding system keeps the space for creation of process plans not only for cutting technology but also for other technologies.

The codes cover the following characteristics:

- Geometrical shape,
- Class of part,
- Manufacturing characteristics,
- Class of dimensions.

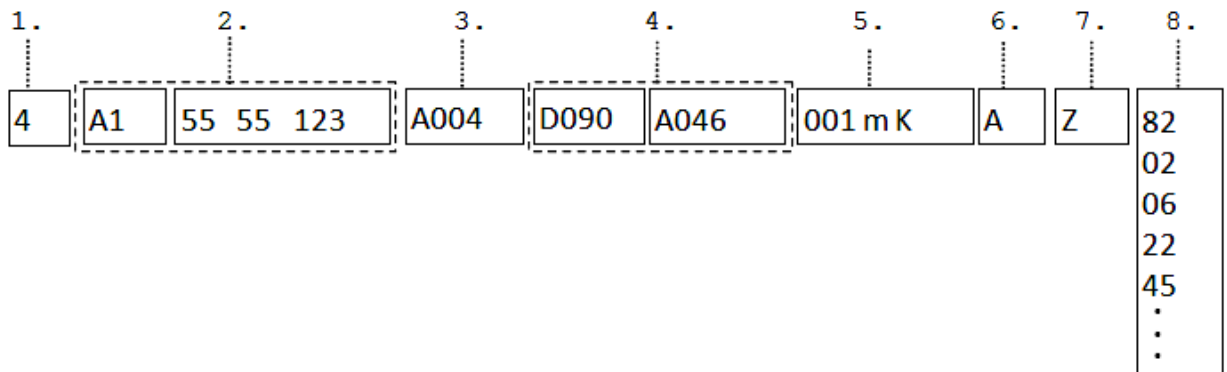
The coding of segment in this software application is based on the assumption that the data registered in this module will be used later at the creation of technological or drawing documentation and the parameters already once defined will be possible to be recorded by another database module.

During the creation of software application several methods of the segment classification were suggested. Regard to a large number of parameters variable in consequence of the varied manufacturing process conditions, the most suitable was to use the type of code at which the starting positions are reserved for the characteristic properties of the object. Other positions are attached to the attribute part of code according to the need to define the classification of the object. Definitive version of the generated code with its structure is shown in Fig. 3.

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**Fig. 3. Structure of individual code parts in subsystem**

Segment In this code, for example, its 4-th part describes the raw product size. This sequence of code is created by 4 positions. The first position is defined by alphabet letter, which determines the type of raw product (for example the group “A” includes the sheets, steel strips...). The second, third, and fourth position give the standard sequence for specific type of raw product in database module. It is possible for the plant to register up to 1000 standards for one type of raw product. Segment code may appear to be too difficult at the first sight, but its creation is very simple when working with user interface and it is supported by the partially completed databank. A new code is formed by 8 parts. Basic characteristics of all individual parts are shown in Table.

Table.I. The importance of individual parts of the code in subsystem segment

Sequence	characteristics	code format	code meaning
1.	Segment type	0	1. segment type
2.	Shape of part	A0	1. basic shape 2. specification of shape
	Segment dimensions	000x000x000	
3.	Material (STN - include additional digits)	A000	1. kind of material 2. } material sequence 3. } inside material kind
4.	Row product size (e.g.: L 25x25x4)	A000	1. kind of raw product 2. } dimension sequence 3. } in specific kind 4. of row product
	Row product standard (STN - include additional digits)	A000	1. kind of material 2. } dimension 3. } sequence in specific 4. kind of material
5.	General tolerances of geometry and dimensions (e.g.: ISO 2768)	000aA	1. } order of general 2. } tolerances, size and 3. } geometry sign 4. general size tolerance 5. general geometry tolerance
6.	Heat treatment	A	1. mode of part heat treatment
7.	Surface treatment	A	1. mode of surface treatment
8.	Type of surface	00	Surfaces complex segment forming

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D. Subsystem “Structure of operation”: The specific machining operation may be specified by means of three stages: • class of the machining, • type of the machining, • process of the machining. The example of the Structure of operation coding is shown in Fig. 4, which represents the code meaning.

	1. digit Class of the machining	2. digit Type of the machining	3. digit Type of the machining
0	<i>rotary machining</i>	<i>autom. lathe work without thread</i>	<i>Thread cutting internal</i>
1	<i>facing</i>	<i>lathe work without thread-cutting</i>	<i>Thread cutting external</i>
2	<i>drilling and boring</i>	<i>grinding</i>	<i>Thread milling internal</i>
3	<i>manual work, generally</i>	<i>threading</i>	<i>Thread milling external</i>
4	<i>surface treatment</i>	<i>autom. lathe work with thread</i>	<i>Thread rolling internal</i>
5	<i>inspection, checking</i>	<i>lathe work with thread</i>	<i>Thread rolling external</i>
6	<i>heat treatment</i>	<i>gear cutting</i>	<i>Thread grinding internal</i>
8	<i>metal joining</i>	<i>vacant</i>	<i>vacant</i>

**Fig. 4. The example of structure of operation coding**

### IV. DATABASE STRUCTURE DEFINING AND USER

CAPP Computer Aided Process Planning represents the activities leading to preparation of manufacturing documentation and the details of material equipment for the production process. The database logically divided into the following:

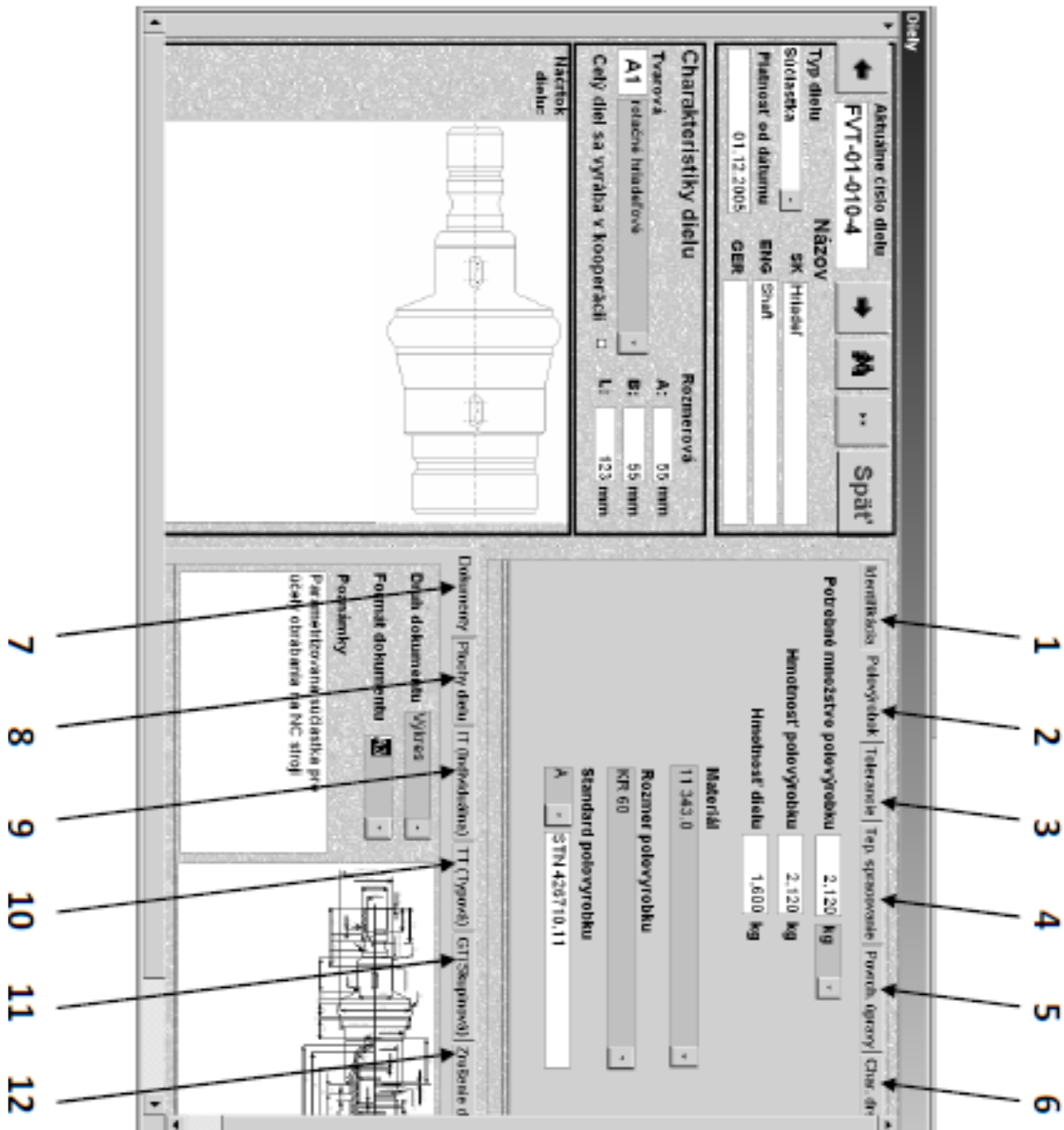
1. Product design involving design procedures, design methods and their value analysis.
2. Manufacturing design involving technological structure planning, process planning and NC programming.
3. Studies of labor and production costs involving work analysis, work measurements and wage schemes.

All necessary data were arranged by means of relation database which is difficult, but data tables and their relations used in reality for developing software . To develop this, some principles were defined and followed as,

- |   |  |
|---|--|
| 1. User rules for definitions of rights | 2. Queries for selecting required data     |
| 3. Forms for data editing by operators  | 3. Reports for exploring the relevant data |
| 5. Procedures for operation with data   |  |

For correct database working it is required to fill in all relevant information to the interface designed for storing and characteristics of production segment.

After entering all relevant information – production segment data and classification – the information system is ready for a definition of manufacturing characteristics as is displayed below.



**Fig. 5. Interface for of properties and characteristics of production segment (part, subassembly ... final product)**

- 1- Identifications of segment,
- 2 - Raw product identification,
- 3 -Tolerances,
- 4- Heat treatment information,
- 5 - Surface treatment information,
- 6 - Surface roughness information,
- 7-Document definitions,
- 8 - Surfaces generating volume of segment,
- 9 - Individual technology,
- 10 - Type technology,
- 11 - Group technology,
- 12 - Cancelling of production segment

The application interface provides the facility to create several alternatives of process plans, which are suitable for actual segment production. Basic varieties of prepared process plans can be worked out for the following objectives:

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1. Maximum efficiency
2. Minimum costs
3. Change of goods flow

Every phase represents a relatively independent line of operations. In each work phase the operator may generate individual manufacturing sequences as:

1. Manual entry of technological operation cycles,
2. As NC program – directly entered by the operator or established for a group of fixtures
3. In form of the sequence of operation pictograms
4. In form of the simulation sequence.

## V. CONCLUSION

A set of typical advantages are achieved when the systems are carried through CAPP. They are reduced clerical effort, fewer calculations, immediate access to up-to-date information, faster response to engineering production changes etc. While the variant method has the advantage of mixing each of individual process and typical process with group operations, it still depends on the knowledge of process planner.

Presented manufacturing information system is a unique one in cooperation with CAD/CAM system and its connectivity to other systems. Such concept brings many advantages like flexible interconnections to different segments, convenient price level, etc.

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