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ABOUT INFORMATION MANAGEMENT IN CAD/CAM INTEGRATION

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Abstract: *The present paper aims the technology of CAD/CAM Systems, the accent being put on CAD/CAM integration and optimization of some elements specific to technological processes. As it is known, the importance of tool durability and its impact upon the technical economical efficiency of the related cutting process are both very important. The present paper approaches a new possibility of determining the mathematical models for a rapid determination of the cutting parameters in case of drilling. In the same time it is also presented a possibility of integrating CAD and CAM phases, based on the new concept of constructive – technological entity.*

Key words: *CAD/CAM, engineering integration, process planning, cutting parameters.*

1. INTRODUCTION

The companies from all over the world are facing today a tough competition into the market place. As a result they are concerned of decreasing the conception and manufacturing cycles, but also the decreasing the production costs, under the condition of ensuring the quality requested by customers. These preoccupations led to finding some new concepts and engineering strategies, such as [1, 9, 8, 6]: the technique of CAD/CAPP/CAM Systems; Concurrent Engineering; Rapid Prototyping; Reverse Engineering; Knowledge Engineering; Virtual Engineering.

Within the product life cycle manufacturing plays a decisive role resulting the great importance that must be paid on process planning. The way in which the technological aspects are also influencing the proportion of manufacturing costs within the total cost of the product. But, the constructive design also plays an important role. From here, in accordance with the actual trends, the necessity of CAD/CAM integration appears.

2. CAD/CAM INTEGRATION, A FACILITY OF ACTUAL COMPUTERIZED TECHNOLOGIES

2.1. CAD/CAM Integration through a Common Data Base

No doubt, the integration of the processes related to the product life cycle is the sure way towards ensuring the rapid introduction of products to the market place. But, for the products to have market success, the integrated processes must be optimal.

The idea of process integration is logically leading to annulment of the traditional engineering mechanism because the actual computerized technologies, based on the computer network principle and the exploitation of a data base / common knowledge (Fig. 1) [9, 6], allow another way of approaching the processes, which is different from the serial approach, such as simultaneous approach, virtual and convergent approach, towards a supreme goal: producing better products, sooner and cheaper.

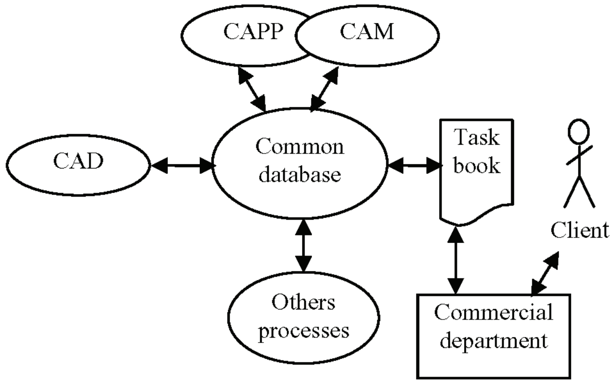

Fig. 1. Integration of CAD and CAM.

2.2. Concept of Constructive-Technological Entity a Facility for CAD / CAM Integration

With a view to an easier integration of CAD and CAM phases, we propose that product design and process planning to be made on the basis of some predefined constructive – technological entities [4, 6, 7]. A constructive – technological entity, in the authors' acceptation, means a predefined complex of surfaces (meaning even a

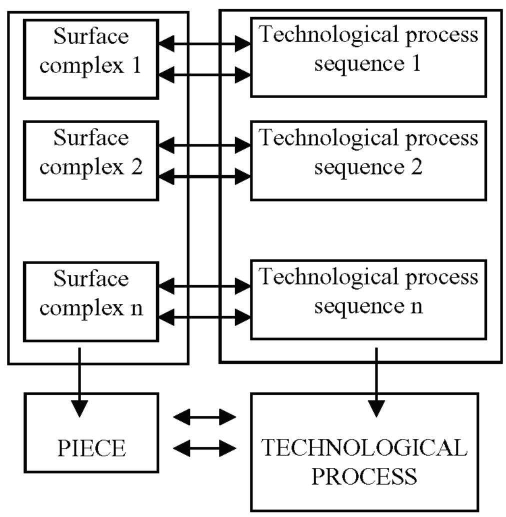

Fig. 2. Connections between Entities and Technologies.

simple surface) to which a certain sequence corresponds, which is also predefined by technological process.

The roles of these constructive – technological entities are: the facilitation of rapid conceiving of products through assembling the sequences of technological processes related to the entities used in product construction; the facilitation of rapid conceiving of the technological processes related to the conceived products, through assembling the sequences of technological processes related to the entities used in product construction (Fig. 2); ensuring the integration of the phase of product conceiving (CAD) and the phase of conceiving the related technological process (CAPP / CAM). From computerization point of view, the constructive-technological entities proposed are 3D virtual models, organized into an entity library.

2.3. Application Regarding the Use of Constructive-Technological Entities

In case when the part family had in mind refers to some adaptive pieces (Fig. 3), then the constructive-technological entities are in accordance with Figs. 4 and 5. Using these entities any part from the family of adaptive parts can be obtained (Fig. 6).

3. REGARDING THE PROCESS INFORMATION MANAGEMENT

3.1. Tool Life an Important Element in Manufacturing Process Management

As an example, we will present a very important aspect regarding the management of information of technological nature. The tool life affects the manufacturing costs and the productivity of manufacturing processes through both tool consumption and costs and times related to maintaining/exploiting the tools.

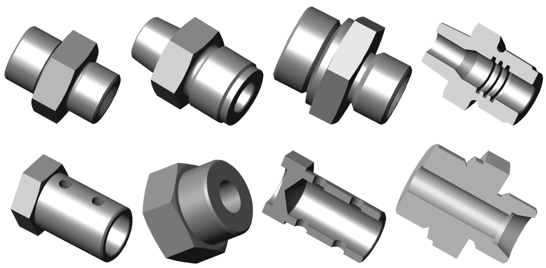

Fig. 3. Fitting Part family.

Fig. 4. Exterior Constructive-Technological Entities.

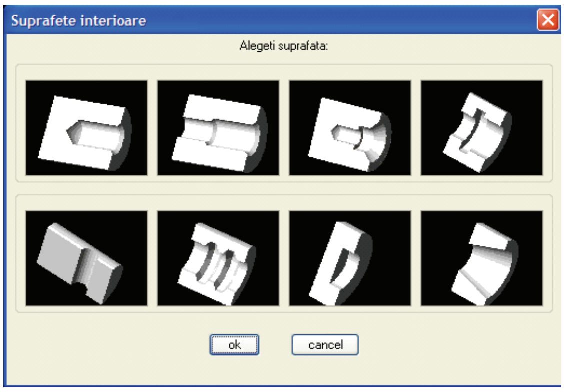

Fig. 5. Interior Constructive-Technological Entities.

Thus, it is necessary that some correct and objective information regarding the cutting tool life must exist within the data base. This information allows the companies to correctly plan their tool consumption and also to ensure an optimal technological management regarding the regime of changing and maintaining the tools (although the consequences upon organizing the activities for the tool store room and maintaining workshops). Of course, the information regarding the cutting tool life must be viewed in correlation with cutting parameters The CAD/CAM technique requires the existence of some objective models regarding the tool life. Thus, it is needed to know the correct mathematical models of the following type:

$$T = f(v, s, t), \tag{1}$$

where: T is the tool life; v – cutting speed; s – cutting feed.

These models must be objective because the parameters related to them are overtaken from the common data base and automatically handled without the human experience intervention (contrary, the efficiency is badly affected). Within specialized literature many of such models are presented [8, 1, 3, 6, 10] and the space does not allow us to present a detailed analysis of the problem. However, we remind that many researchers have been preoccupied by this problem: Taylor (1901), Sofonov (1933), Temcin (1957), Colding (1958), Wu, Granovski (1963), Koniasov, Ksiunina (1964), Metcilen (1965), Horvath (1967), Depiereux-Köning (1969), Kronenberg (1970), Palmal (1978) [3]. One of the most frequent tool life models has the following form (for twist drill made rapid steel) [10, 11]:

$$T^m = \frac{C_v \cdot D^{z_v}}{v \cdot s^{y_v}}, \tag{2}$$

where D is the drill diameter. The practice of using this formula confirms the fact that the results obtained must always be verified with a view to avoiding some absurd values. Then it is necessary a model of calculation the drill life and control it, too, based on experimental data and data collected from industrial practice. Thus, it was established a model controlled by the diameter D of the drill (with diameters till 10 millimeters) for processing OLC 45 and similar steels:

$$T = 6{,}07 \cdot D^{0{,}6}. \tag{3}$$

The formula from above considers the economical drill life. In addition, it is necessary the determination of some control formulas for the feed and cutting speed, too, with a view to including them within the validity area of formula (2). In the same time the tool durability must inferiorly limited to, in the following way:

$$T \geq (1-1,5)\cdot D\,. \tag{4}$$

As regards the feed, this can be correctly determined in the following manner:

$$s \leq 0,018\cdot P^{0,64}\cdot R^{0,56}\cdot D^{0,6}\cdot k_s\,, \tag{5}$$

for *L/D* ≤ 3, $k_s = 1$. The parameter *P* has the following values: *P* = 3, for drills with high tolerances; *P* = 2, for drills with medium tolerances; *P* = 1, for drills with low tolerances; Parameter *R* has the following values: *R* = 4, for a material with a low hardness/rupture strengths; *R* = 3, for a material with low/medium hardness/rupture strengths; *R* = 2, for a material with medium/high hardness/rupture strengths; *R* = 1, for a material with high hardness/rupture strengths.

Regarding the cutting speed it is also good to have a control upon it through the diameter *D*. In this way on the basis on the formulas (2), (3) and (5) the formula $v = f(D)$ is obtained in the following manner:

$$v \leq \frac{32,5}{D^{0,14}}\,, \tag{6}$$

formula that also considers ensuring a normal thermal regime on the cutting area.

3.2. Optimization of Information Having a Technologic Nature

In an ideal way, having in mind the CAD/CAM integration, designing a product in CAD phase using the constructive-technological entities must lead to an immediate display of the technological information related to the entities involved. The part from the data base related to processing an entity through drilling must contain information regarding an efficient mathematical model of the following type:

$$\begin{cases} v = f(D) \\ s = f(D) \\ T = f(D) \end{cases}. \tag{7}$$

The model given by formula (7) must be determined, previously solving a series of as many mathematical models as possible (three dimensional linear programming model). The computerized processing of the solutions of this series of models leads then to obtaining a model given by formula (7). In addition, the approach from this paper brings some improvements taking into consideration the previous results of the authors [5]. The mathematical model, that being solved by n times (as n is greater) leads to the solution (7), is:

$$\begin{cases} \min C/\max Q = f(v,s,T) \\ r_i(v,s,T) <= a_i \quad (i = 1,2,\ldots,m)\,, \\ v,s,T > 0 \end{cases} \tag{8}$$

where *C* and *Q* are the cost and productivity of processing a hole through drilling and m is the number of constraints of the mathematical model. *C* or *Q*, depending on the case, refers to the objective function of the model. We mention that in using mathematical linear programming in optimizing the cutting parameters some significant results were obtained by Goranschi (1962), Drăghici and Chiriacescu (1971) [2]. Through replacing the cutting speed with the rotation speed, formulas (4), (5) and (6) become:

$$\begin{cases} n\cdot s^{0,7} \leq 1467,58\cdot D^{-0,8} \\ s \leq 0,018\cdot P^{0,64}\cdot R^{0,56}\cdot D^{0,6} \\ n \leq 10345,07\cdot D^{-1,14} \end{cases}. \tag{9}$$

The constraints (9) are important because they allow the control of work the tool life formula through some results that are compatible with the industrial practice, ensuring the maintenance of a normal thermal regime. With the constraints (9) the mathematical model (8) becomes:

$$\begin{cases} \max Q = \min \tau = \min(L\cdot n^{-1}\cdot s^{-1}\cdot a\cdot T^{b}) \\ n\cdot s^{0,8} \leq 23053,254\cdot P_{mu}\cdot D^{-1,9} \\ s^{0,8} \leq 0,029\cdot D^{1,1} \\ s^{0,85} \leq 1,84\cdot D^{2,91}\cdot L_f^{-2} \\ T^{0,2}\cdot n\cdot s^{0,7} = 1591,55\cdot D^{-0,6} \\ s^{0,85} \leq 0,0114\cdot F_{amu}\cdot D^{-1,09} \\ s \leq 0,018\cdot P^{0,64}\cdot R^{0,56}\cdot D^{0,6} \\ v \leq 32,5\cdot D^{-0,14} \\ n\cdot s^{0,7} \leq 1467,58\cdot D^{-0,8} \\ n \leq 4500 \\ n \leq 400 \\ n,\ s,\ T > 0. \end{cases} \tag{10}$$

For determining a solution of formula (7) type, which to facilitate the CAD/CAM integration, the model (10) must be solved more times, having as entering data a certain machine-tool, a range of drill diameters, the accuracy of the hole to be processed and the type of material to be processed.

3.3. Application

Having in mind that a hole having *D* = 8 mm must be processed, having the roughness $R_a = 12,5$ and the dimensional accuracy being in accordance with H11 in a part from OLC 45 using a drilling machine G10/Mecanica Plopeni the following solution was obtained through solving the model (10), using the Simplex algorithm:

$$\begin{cases} v = 24\ \text{m/min} \\ s = 0.14\ \text{mm/rot} \\ T = 21\ \text{min} \end{cases}. \tag{11}$$

For making the model (11) linear the following substitutions were used:

$$x_1 = \log n\,;\quad x_2 = \log(100\cdot s)\,;\quad x_3 = \log T. \tag{12}$$

3.4. Solution Generation

For the range of drill diameters between 5–10 mm (rapid steel), for processing with a medium accuracy some medium-high hardness/rupture strengths materials (similar to steel OLC 45) using the machine tool G10/ Mecanica Plopeni and using the computerized mathematical processing of the range of discrete solutions obtained through solving some models of (10) type, the following solution was found:

$$\begin{cases} v = 0,09 \cdot D^2 - 1,74 \cdot D + 32,43 \text{ m/min} \\ s = -0,00045 \cdot D^2 + 0,02013 \cdot D + 0,01214 \text{ mm/rot} \\ T = 0,1786 \cdot D^2 - 1,42143 \cdot D + 20,43 \text{ min} \end{cases} \quad (13)$$

With a view to implementing the principles of CAD/CAPP/CAM integration within industrial practice, the models of (13) type must be determined for all the combinations of machines, tool characteristics, tool materials, materials to be processed and accuracy required.

4. APPLICATION REGARDING CAD/CAPPCAM INTEGRATION

It is supposed that the processes for developing a product of fitting type must be started. As entering data a client's sketch is available. Through an approach that is in accordance with concurrent engineering, CAD and CAPP phases are integrated resulting the desired design in accordance with Fig. 6.

5. CONCLUSIONS

Based on the authors' experience, the present paper is an original strategy that suitably allows the integration of the processes related to product engineering. First of all, we have in mind the CAD/CAPP/CAM integration.

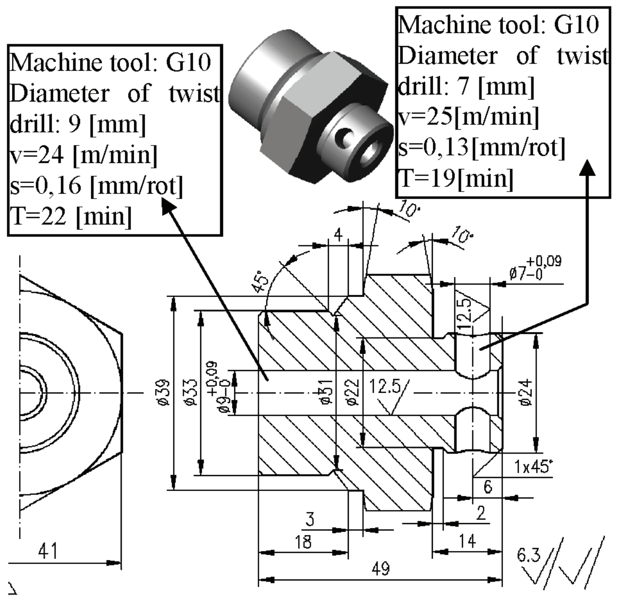

Fig. 6. CAD/CAPP Application.

This strategy considers the concepts of constructive-technological entity, concurrent engineering and group technology. The system is also based on programming-designing environments AutoCAD, AutoLISP and Turbo Pascal.

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