Computer Integrated Manufacturing – CIM - in Stamping and Moulding Tool Production

IOAN BONDREA, CARMEN SIMION,
Manufacturing Engineering Department, "Lucian Blaga" University of Sibiu, Faculty of Engineering "Hermann Oberth", 4 Emil Cioran St., 550025 Sibiu, ROMANIA
ioan.bondrea@ulbsibiu.ro, carmen.simion@ulbsibiu.ro
HARALD HERRMANN
BRANDL Maschinenbau from Pfeffenhausen, 73 Rottenburger str. 84076, GERMANY
harald.herrmann@brandl-hb.com

Abstract: - In the automotive industry, the growth of the productivity means, first, the reduction of the manufacturing preparing time as much as possible. This way, the design and the manufacturing of the stamps and moulds must be carried out in effective quality conditions, and, especially, the time allotted for these activities should be as short as possible. One way of reducing the design-manufacturing time is to integrate all the CAD/CAE/CAM activities by the help of the computer into a computer integrated manufacturing system/CIM. This integration is carried out by the soft and hard interfacing of the different departments which contribute to the design and manufacturing of the stamps and moulds for the automotive industry. This interfacing takes into account the handling of the files as data going out of each department; these files contain graphic data (assembly and execution design), as well as alphanumerical data (technological data from the process). The paper presents the way the link between CAD/CAE/CAM was made, with a view to increasing the flexibility and the productivity of the stamping tool design and manufacturing for the automotive industry.
Key-Words: - PLM, CAD, CAE, CAM, PP&C, CIM

1 General issues

Computer Integrated Manufacturing, known as CIM, is the phrase used to describe the complete automation of a manufacturing plant, with all the processes functioning under computer control and digital information tying them together.

The heart of computer integrated manufacturing is CAD/CAM. Computer-aided design (CAD) and computer-aided manufacturing(CAM) systems are essential to reducing cycle times in the organization. CAD/CAM is a high technology integrating tool between design and manufacturing. CAD techniques make use of group technology to create similar geometries for quick retrieval. Electronic files replace drawing rooms. CAD/CAM integrated systems provide design/drafting, planning and scheduling, and manufacturing capabilities. CAD provides the electronic part images, and CAM provides the facility for toolpath cutters to take on the raw piece.

Manufacturing strategies that provide a large variety of different products with high quality and attractive prices have become crucial competitive factors. Customers expect short delivery times and state-of-the-art products; corporations have to manage a constant flow of innovations with reduced time-to-market and time-to-volume. All this requires the ability of firms to adjust rapidly to changing market conditions. Many industrial corporations have responded to these challenges- and still do-by implementing computer based tools and sophisticated systems for Production Planning and Control. The basic concept of CIM focuses on the integration of the technical and business oriented branches of Electronic Data Interchange on the one hand, and the production systems to improve information and material flows between different operations, on the other hand. Figure 1 shows the components of the Computer Integrated Manufacturing - CIM concept and their relations.

Computer Integrated Manufacturing is achieved when the engineering based Computer Aided-..-Tools (CAD, CAP, CAM, CAQ) are bound up with the different stages of the managerial Production Planning and Control (PPC) system to allow the effective use of relevant information sources. Reliable, high quality, fast, flexible, and cost efficient production processes are the expected results. Representative empirical investigations to find out whether these high objectives are actually achieved are rare at least. Experts in the field express their opinions about the potentials of CIM. Case studies describe how individual firms behaved or performed in specific situations, many of these descriptions are from providers of CIM equipment, but the academic literature provides little evidence with convincing validity about the benefits or the shortcomings of CIM. Considering the costly, complicated and lengthy processes of CIM implementation, this is an unsatisfactory situation.

product, having consequences on costs, quality and the delivery terms.

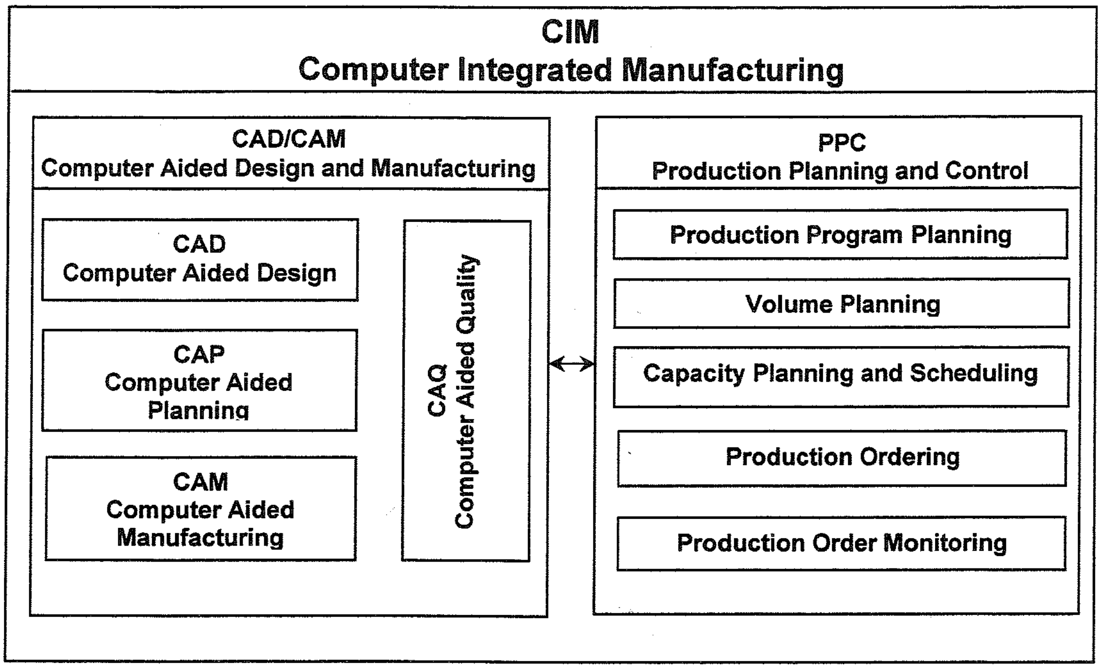

Fig.1

2 Product Lifecycle Management

All companies wish to satisfy their customers as well as they can. The working analysis is an effectual way of defining the products that meet the customers' expectations. So, it has to consent to the definition of "the good product", the one expected by the final customer, but it has to integrate the intermediary users that will interfere in order to give life to the product as well - starting with the conception. Organising a company (factory) depends essentially on its importance and on the types of the manufactured products. It is believed that the resources of a factory are organised on a structure determined by its functions. The main four elements of the factory are the following (fig.2):

- The ***product*** – the end result of the manufacturing process can be a tangible good or service;
- The ***customers*** - a person, company, or other entity which buys goods and services produced by another person, company, or other entity;
- The ***supply*** - total amount of a good or service available for purchase;
- The ***resources*** - a person, asset, material, or capital which can be used to accomplish a goal, equipment, people, assets (money).

The necessity of the analysing and developing stage has great importance in the lifecycle of a product, having consequences on costs, quality and the delivery terms.

From the point of view of expenses, reporting to the sequential approach, the curve of the simultaneous approach is getting considerably close to the expected costs, which allows the pursuit in real time of the financial consequences for the decisions made during the project.

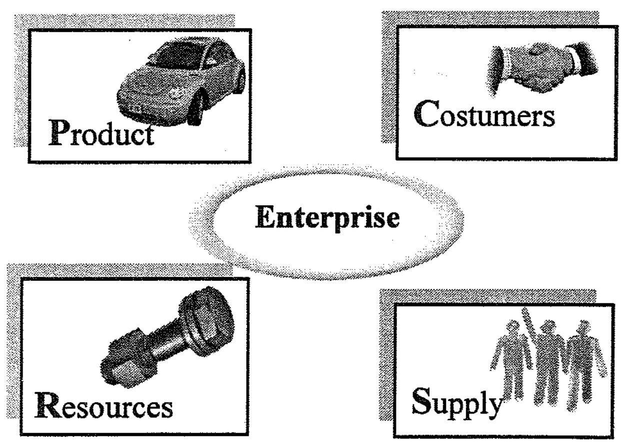

Fig.2

Using a parallel structure of work does not solve all the possible aspects. One of the difficulties that may appear is related to human issues. In order to make this reorganisation easier, a physical regrouping of the participants in the project who are in the same room might be a solution, even though is not easy to accomplish it because of the communication problems between the different professions. So, an automobile wing will be seen:

- depending on the way light reflects, by the designer;
- from the point of view of the maximum plastic deformation endured by the sheet during the deformation, by the mechanic;
- from the point of view of the trajectory made by the tool in order to get the shape of the mould, at the recommended tolerances, by the processor. But all these cases are about the same figure, which can be geometrically defined by Bezier's squares. Finding a common language to allow everyone to pursue the evolution of the project in real time represents an impossible bet.

Product Lifecycle Management - PLM is a strategic business approach that applies a consistent set of business solutions to manage product definition data for a product throughout its lifecycle (fig.3). Through PLM, automotive industries can improve the product, support the customer, reduce the cost, minimize the downtime, beat the competition, increase the profit, etc., and know how and when to pull the plug of a product.

In our research we focused on the following activities:

Planning - configuring, scheduling;
Design - conceptualizing, detailing, analyzing, prototyping, testing, solid modeling, simulation;
Manufacturing - process planning, part producing, CNC machining, virtual NC.

2 Product Design

The conception process is regarded as an activity based on induction, deduction, intuition, experience and creativity. Through information technology systems, we can progressively transfer the experience, deduction and induction from the conception engineer to the CAD system, the latter becoming thus an intelligent system. A CAD system requires a permanent dialogue between the technical database and the general database, on the one hand, and the algorithms base, on the other hand, through a conception monitor. Taking into consideration that the conception process has to offer optimal solutions to the problem, there is no general methodology, which can guarantee the global optimization of the conception. That is why CAD system has to allow the user to make a product with cost and time reduction and also with a high degree of flexibility. In CAD, stamping and moulds tools for automotive company use CATIA v5. CATIA provides the users with structure editing facilities, inspection, cinematic simulations, databases, modules and possibilities of definition, storing and reusing of engineering knowledge. CATIA offers a unique technological environment of design and preparation for manufacturing using the PLM concept (Product Lifecycle Management).

The premises in creating a stamping and mould tools in the CAD module are:

- its integration into the integrated system of production
- connection with the other two modules through informational system, the definition of the types of information used and the compatibility of information

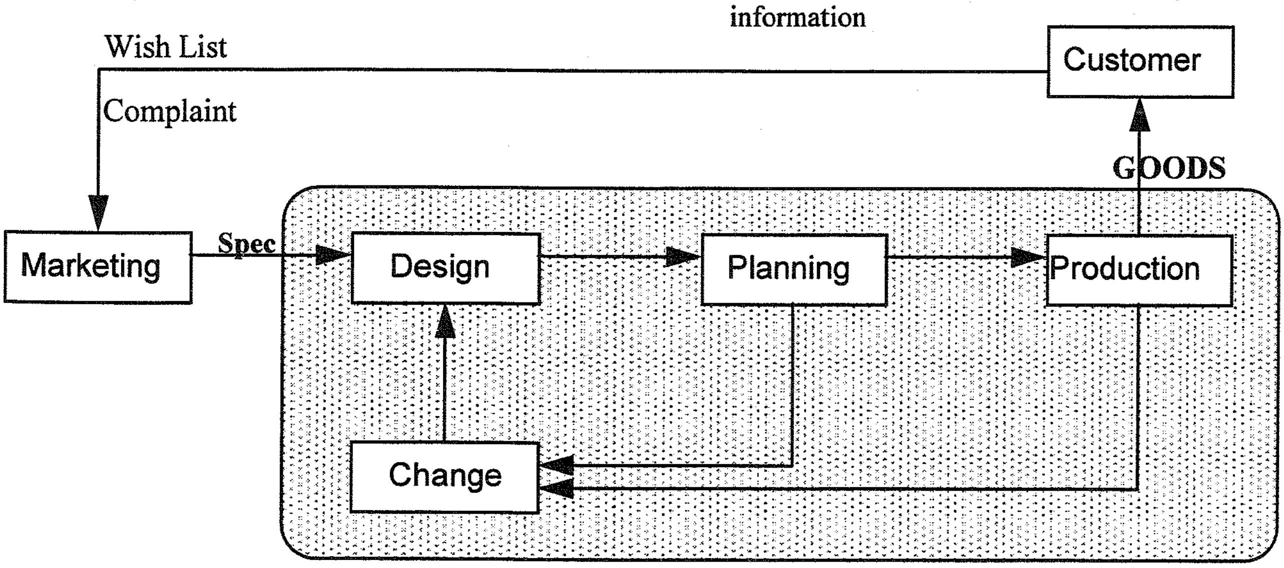

Fig.3

- the possibility of recognition of geometrical data (the geometrical attributes of the product) by the CAPP module (the module which uses the data from CAD as in-data. Punctual attempts have shown particular interest on form features in the preparation for the manufacturing stage. Instead of using a product molding starting from conception, at the end of this stage, form characteristics extraction algorithms can be applied to the supplied model. With the help of calculated data this model can be expanded so it would come close to a product molding to a high level structure, containing not only the structural description of the piece but also complementary data regarding certain areas, profitable especially for manufacturing.

the more possibilities of automatism, faster production, so the more advantageous it is. In our specific case, form characteristics that, in particular, must be detected before the manufacturing stage, lead to:

- reducing, even canceling human intervention, till absolute necessity, to interpret the conceptual models and plates provided, and so decreasing the risk of errors;
- automatic selection of the tool;
- calculation of the trajectory of the tool;
- feature based parameterization of the manufacturing process;
- analysis of the possibility of manufacturing;
- classification of tools and comparison of objects.

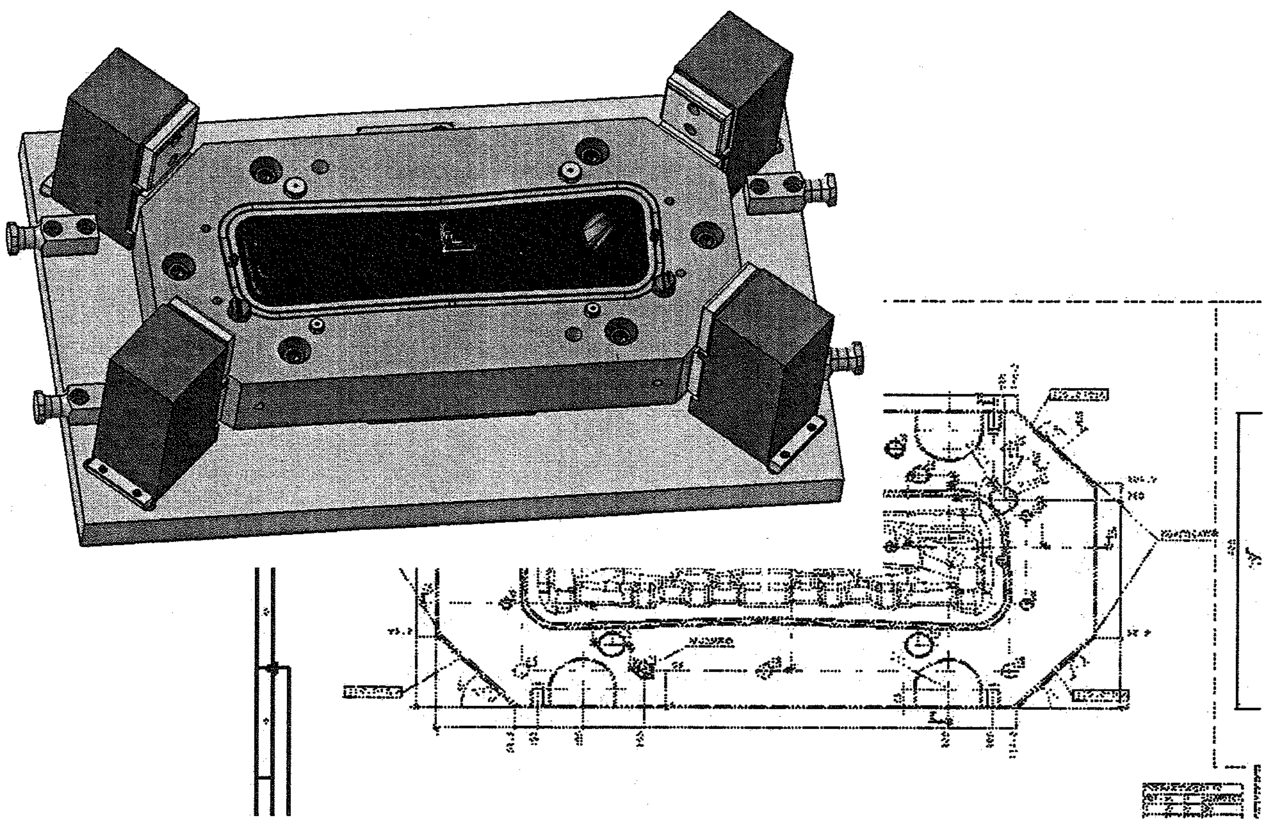

Fig.4

The description of a form characteristic is tied to two aspects:

- its form (geometry, typology, category)
- complementary data on its meaning or functioning, even if these last do not intervene in algorithms yet

The study of form characteristic extracting subscribes to a larger picture of automatic understanding of a piece. The interest is so immediate because the better this understanding is,

The graphic databases of standardized and normalized products which communicate through CATIA v5, in the stages of design of moulds, is an important facility which leads to an increase of productivity and of design precision. Parameterized design of stamping and moulding tools that is possible thanks to some facilities of CATIA v5 program leads to the increase of both the design productivity and its quality.

Databases with normalized and standardized marks are used in the design stage; these have as support "xls" files with numerical values of the parameters used in design. Figure 4 shows 3D and 2D for a stamping tool. During the design stage, the technological engineer team carries out simultaneously the computer aided design of the technological process, so that the overlapping of the design times reduces the preparing total time of the manufacturing and consequently the reduction of costs. Once the 3D and 2D drawings are made, the technological data necessary for the manufacturing process are realized too, the work pieces of component elements, materials, costs etc. being established through the Bill of Material.

3 Analysis and simulation

The product consists of the description of an object, not just geometrically, but also depending on a certain number of features, functional features, manufacturing features etc. So the model of the product contains:

- geometrical information, which can correspond to that which is being manipulated in solid models
- technological data, for example manufacturing operations (drilling, threading, milling, lathering) which give more explicit data regarding the whole geometrical feature or just a part of it;
- precise data, which explain the manufacturing tolerances in order with the ideal feature;
- material data, which specify the type of material and its properties;
- administrative data, which make the maintenance of the material easier (references, providers, supply).

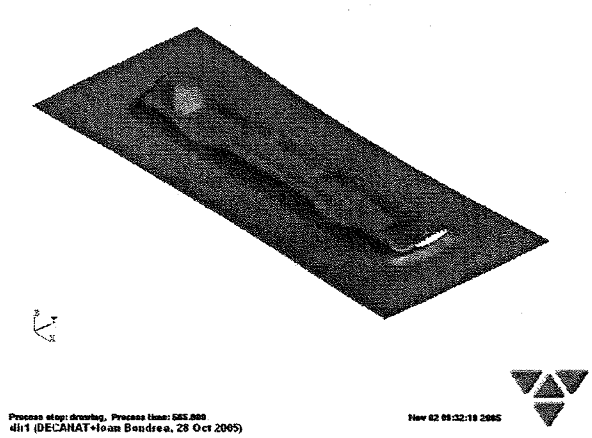

Fig.5

After the model was made, one passes on to the engineering calculations using methods and means of Computer Aided Engineering – CAE. The constructive-functional optimization of the product allows its verification from the point of view of the dynamical stress during working, as well as the simulation of the stamping-moulding operation. By this simulation (fig. 5), the product is subjected to the real working conditions and the obtained results (fig. 6) offer the necessary data through which the product and technology designer can decide on the correctness of the project.

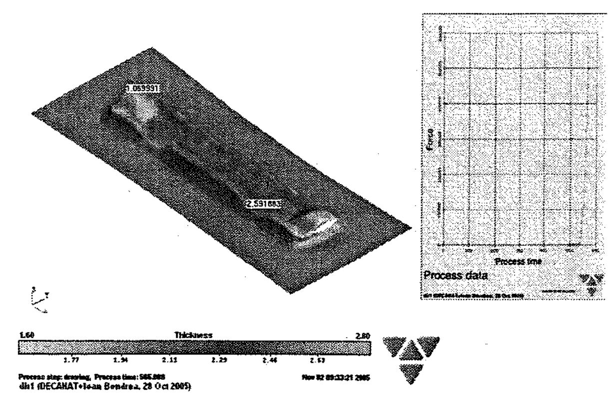

Fig.6

At the end of the analysis and optimization operations, the geometrical data of the model (product) are transferred to the manufacturing department for the physical realization of the product.

4 Manufacturing

Computer Aided Process Planning (CAPP) makes the connection between constructive computer aided conception and aided manufacturing. In this module, the technological processes of manufacturing are conceived, and then the data is transmitted to be processed with the purpose of product manufacturing. Computer aided manufacturing (CAM) is the most complex module of the production system, its integration affecting directly the quality and manufacturing flexibility. The CAM module includes procedures of automatic generation of numerically controlled machine-tools running instructions, based on the geometrical model of the executed piece. CATIA v5 is the program that allows the making of NC manufacturing programs needed for numerically controlled machine-tools, using the NC Manufacturing module, as shown in fig.7. The results of the CAM department, the NC program in APT or NC-Code language are transmitted to the CNC machines and the brand of the product is manufactured.

5 Production Planning & Control

Production Planning & Control - PPC&C is a classical area of application for the electronically processed data about the entire production process. The term PP&C is used to describe the way the informational systems are used for planning, supervising and controlling the life cycle processes of the product, starting with the collection of the data (the order) and ending with product delivery, while considering the quality aspects given by placement and capacity.

the building of the components (especially of those made of sheet metal) for car production.

The increase in the productivity and quality of design, at the same time with the decrease of costs, can be achieved by using CAD/CAE/CAM methods and means by running CATIA v5 and by using the CIM concept.

The present paper shows the research and results regarding the development of a manufacturing integrated system in the mould area for automotive industry, in BRANDL RO firm. In this company we have integrated all the processes necessary in order to manufacture a product through the use of computer technology. In its fullest implementation, CIM integrates all manufacturing information, not just the manufacturing data for products, but also the business procedures, corporate goals and

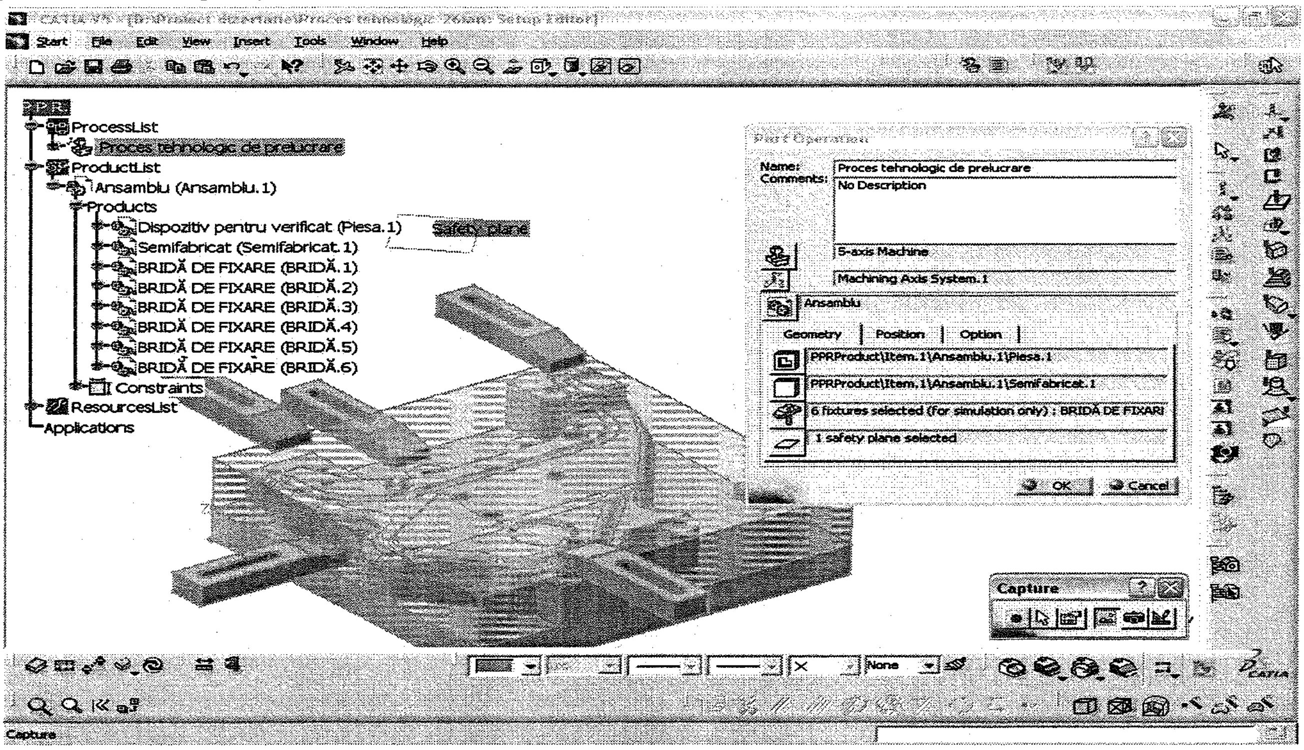

Fig.7

The link between the graphic databases, the technological databases, customers and delivery terms are realized through the use of the SAP/R3 program.

6 The impact of integration in the automotive industry

One of the most dynamic fields of industry is that of car manufacturing. The preparation of manufacturing requires the design in the shortest possible time and with low costs of dies used for

management structure of a manufacturing company The teams are shown in figure 8.

The conception, manufacture and integration of these modules into an integrated manufacturing system has lead to the creation of a CIM system, with production application in mould manufacturing for the automotive industry, a solution which can ameliorate the company's competitiveness. We can say that informational flow is a decisive factor in describing the CIM concept, quality, intensity, and speed, having an important role for the manufactured products. Informational technologies are a set of disciplines that are interrelated in order to build the integrated enterprises, having as a basis distributed connected and standardized database systems.

Further elements can be added on a step by step basis, as production facilities require or financial and human resources permit the investment.

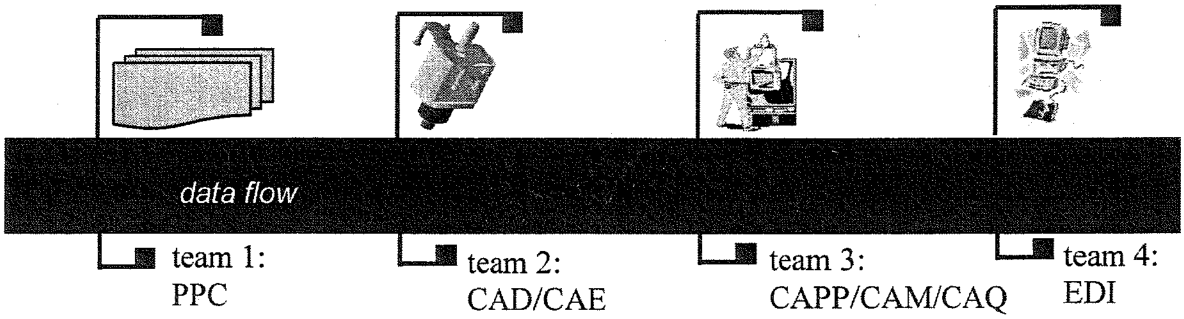

Fig. 8

6 Conclusions

The paper presents a part of the research and preoccupation of the team of the "Manufacturing Science" department regarding the design and manufacturing of stamping and mould tools in the auto field in the context of a modern production system.

Using the CIM and PLM concepts it was possible to build stamping and moulding tools, under the circumstances of high quality and low costs.

The design and manufacturing teams, the technological and quality engineers were linked to the Internet, being able to overlap the activities and thus reduce the preparing time of the manufacturing and the delivery terms. All of these led to increase in the company profit.

The integration by computer of the conception activities and of the design and manufacture into a Computer Integrated Manufacturing system – CIM determines the increase of company flexibility and low production costs, as in figure 12.

Integrated Engineering is defined as a methodology that allows the integrated and simultaneous design of products, and the manufacturing and maintenance processes associated, taking in consideration from the beginning all phases of the product life cycle, integrating quality aspects, delays, costs, custom requirements etc.

Figure 9 provides an overview of the different types of components used by the firm.

Considering the major cost of CIM components, the empirical confirmation of the sequential implementation strategy is an important finding. Investment in CIM can be - or perhaps evens should be - started with one or only a few components at a time.

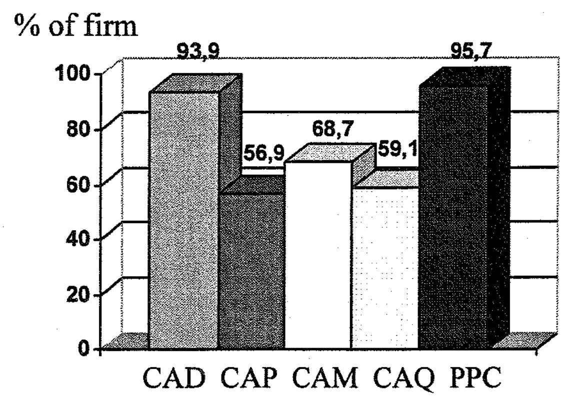

Fig. 9

This makes CIM both attractive and feasible for smaller or medium sized firms. Due to this implementation option, the utilization of CIM advantages is not restricted to large, capital-intensive corporations.

Contributions to the conception and achievement of CIM modules with a view to implementing a manufacturing integrated system for stamping and mould tools are presented.

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