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INTEGRATED SYSTEM FOR PLASTIC MASS FABRICATION

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Abstract: this paper shows general notions about plastic mass, along with design and realization of moulds using CAD/CAM/CAE systems, for both classical and nonconventional working; also, an integrated system for plastic mass parts production is presented, starting from raw material, design and realization of the mould active parts, automatic setting and adjustment of machines, robotic exchange of moulds, effective processing of parts, ending with automated parts storage.

1. BASIC NOTIONS ABOUT PLASTIC MASS

The technology for thermoplastic parts production has continuously developed, with several reference points in its evolution, such as:

- attainment of new thermoplastic materials;
- mechanical improvement of the injection machines;
- appearance of the heated injection networks;
- simulation of the thermoplastic mass flow by means of CAE software suites (*Computer Aided Engineering*);
- introduction of expert systems for the setting of the injection machine.

Massive transformations have occurred in the machine construction domain after year 1990, the last century brought unprecedented development and many of the technological improvements have been achieved by means of production automation. The transfer lines, the improvement and realization of new materials (metals, ceramics and polymers), the appearance and development of calculus technique and informatics and their implications in industrial activities can be mentioned here [1, 2, 5, 6, 9, 11].

The volume of polymeric materials in the industry of the last decades is increasing in this millennium also. The geometrical shape of the parts becomes more and more complex, and their quality have definitely established the plastic mass in various industry branches and in consumer goods production.

The world production of plastic mass increases by 15% each year and doubles each 5 years [14]; fig.1 shows a conclusive image concerning the evolution of world plastic mass production.

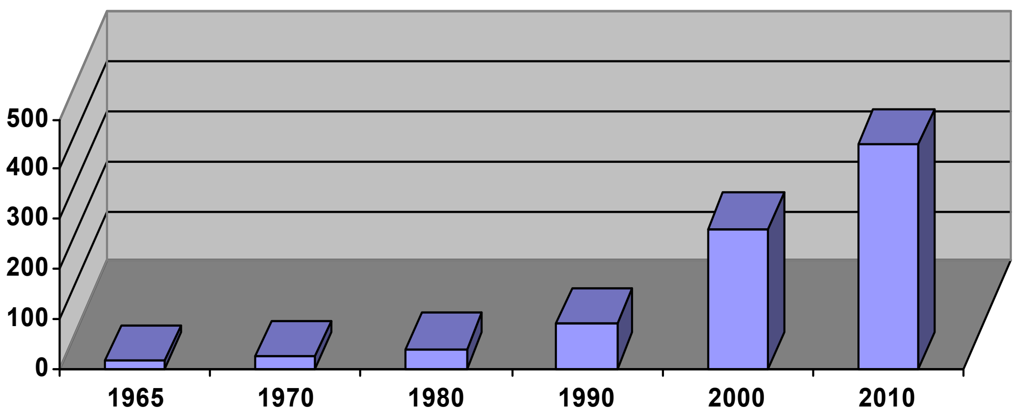

Fig.1. Evolution of world plastic mass production (millions of tons / year).

In comparison with other materials, we must observe the following qualities and advantages of plastic mass:

- ✓ wide variety of polymers;
- ✓ ease and diversity of working procedures;
- ✓ low energy costs for synthesis and turning into products;
- ✓ low polymer density, which gives superior quality for parts which are required to be lighter and economic;
- ✓ pleasant color and aspect;
- ✓ corrosion resistance and chemical passivity.

The disadvantages of the plastic mass parts, which limit their applications, are:

- o relatively low mechanical strength;
- o they are not biodegradable;
- o they produce toxic fumes when burnt.

The injected plastic parts are widely used nowadays, from automotive board parts to cellular phone cases. In the industrialized countries, the plastic mass domain is primordial.

The production of a plastic mass part implies the following of certain steps as:

- ♦ design of the part;
- ♦ selection of the injection process;
- ♦ selection of the optimal material;
- ♦ design and realization of the injection tools;
- ♦ study of the mould filling;
- ♦ ensuring of the complete mould filling;
- ♦ testing of the injected part;
- ♦ optimization of production.

Most plastic parts are made in large quantities, so it is obvious that a small decrease in the part price has spectacular effects at she scale of the entire production. From the economical point of view, there are three possible ways to save costs:

- ❖ use of a cheaper material;
- ❖ reduction of part thickness;
- ❖ shortening of the injection cycle.

2. FLEXIBLE INTEGRATION OF THE PLASTIC PARTS FABRICATION SYSTEMS

Lately, we assist more and more to the implementation of the computer assisted fabrication in the plastic parts production, with tendencies to automation of the entire production cycle and realization of flexible systems. Automatic feeding with raw material, programming of the machines for using of the closed-loop systems driven by microprocessors (CAM), robotic downstream functions and real-time production administration (CAPS) led to important improvements of the productivity and equipment reliability [6, 7, 11]. So gradually we get to the definition of the future factory, where the starting point of the working program consists of the task specifications translated into machine-code language, and the ending point consists of billing in the conditions of the real-time administration of the entire production. Fig.2 [6] shows a draft of the automation, materialized in a flexible fabrication system in the plastic mass domain. All processes (design of parts, design and realization of moulds, leading and administration of fabrication) are integrated by means of computers [1, 6, 9, 12].

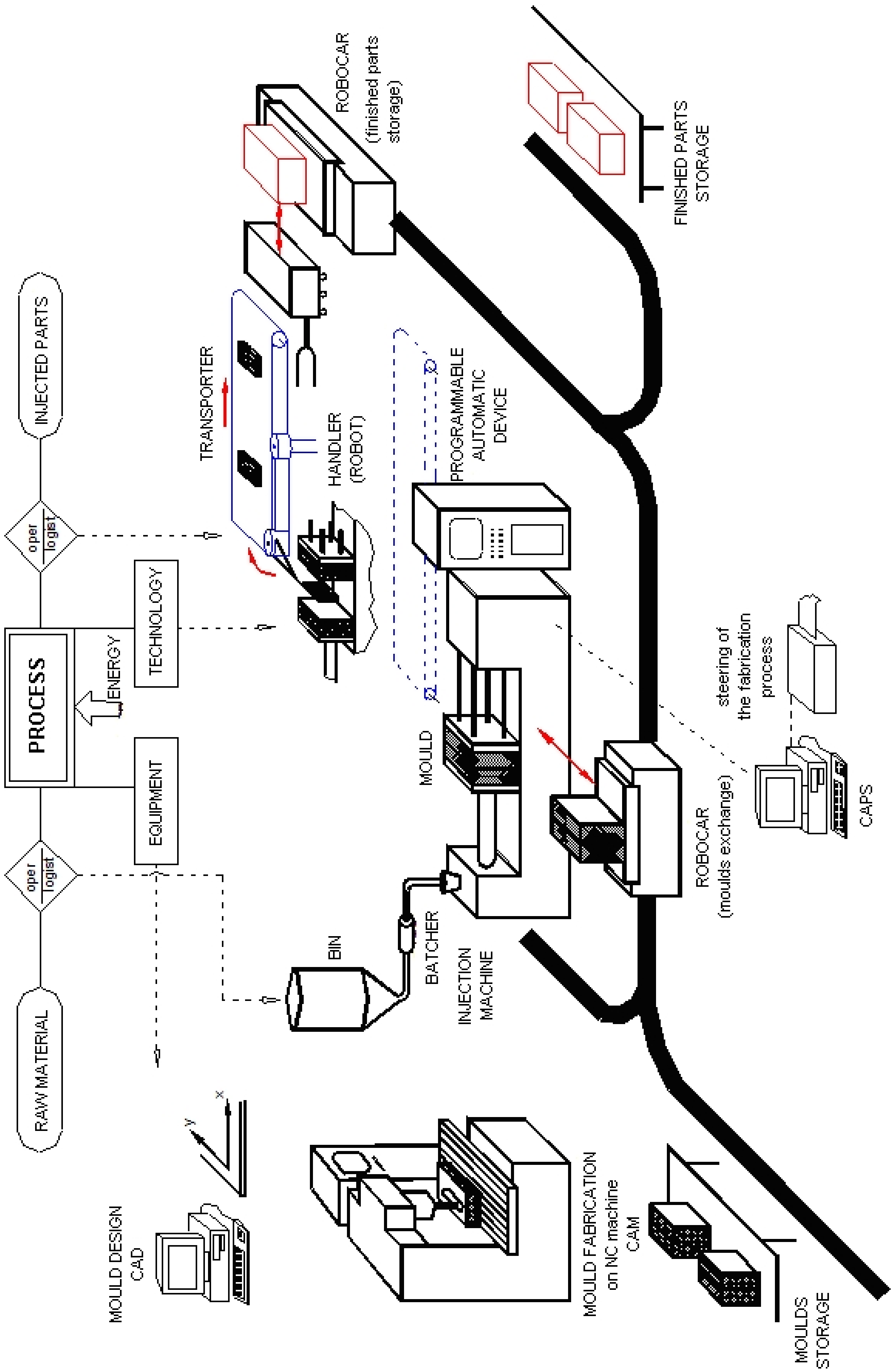

Fig.2. Flexible fabrication system for injection (example).

The flexibility of the system is determined also by the flexibility of the CNC electric discharge machines, which are equipped with modular tool storage devices of a large typo-dimensional variety. Fig.3 [13] shows two vertical tool storage devices filled with tool-electrodes, which are arranged in the proper order according to the machine program for each processing of the technological itinerary of the part. Fig.4 [13] shows a horizontal tool storage device.

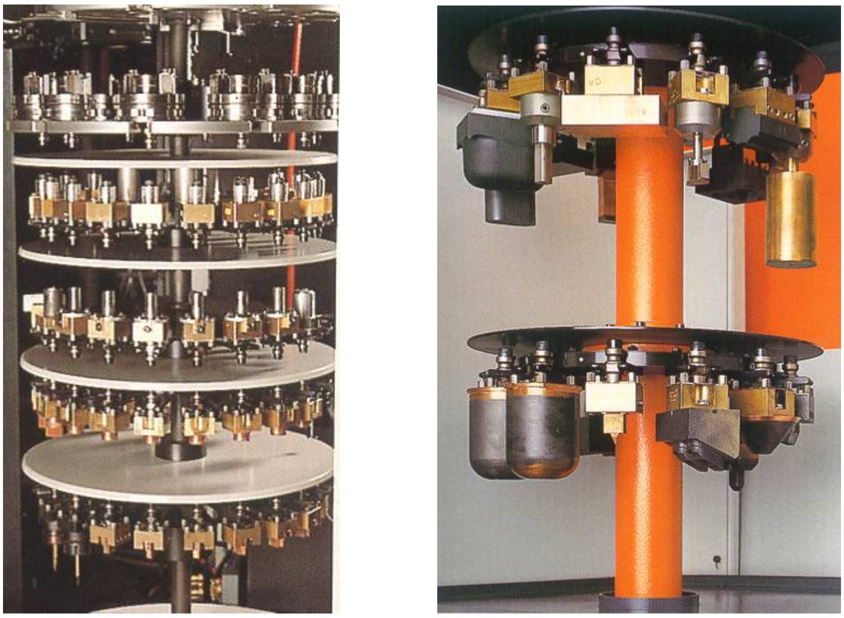

Fig.3. Vertical tool storage devices, for CNC machines.

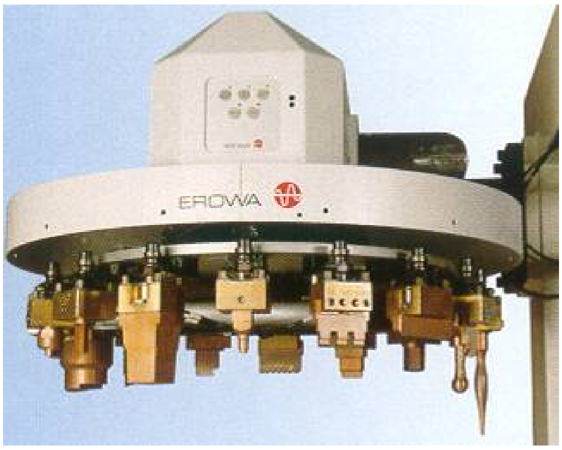

Fig.4. Horizontal rotary tool storage device EROWA.

3. CAD/CAM SYSTEMS FOR MOULD REALIZATION

In order to use the CAD/CAM system, the following purposes must be established:

- time must be saved during the development of the part from idea to construction;
- during mould construction, the routine work is abandoned and the rationalized construction system is adopted;
- optimal moulds and injected parts are attained by means of the CAE system, so that the product quality increases [1, 4, 12].

The CAD/CAM systems have evolved, and nowadays we have integrated systems (fig.5). Such an integrated system is a multi-modular system based on NC-type numerical calculation systems, which link the mould construction, fabrication programming and fabrication on mould-making modern numerical machines [9, 10, 12].

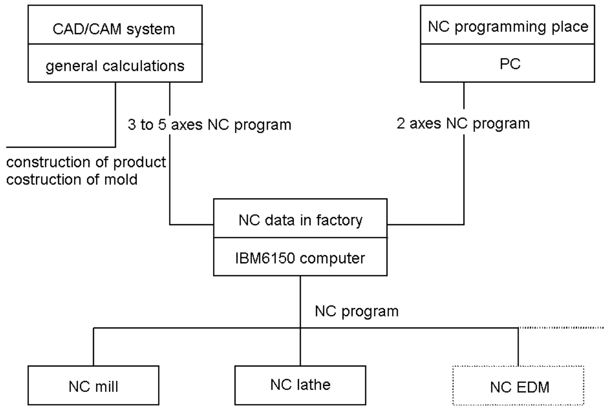

Fig.5. CAD/CAM integrated systems for mould making.

The CAM system includes all activities about the execution and supervision of the mould fabrication system. The CAD system for mould fabrication refers to:

- ✓ automation and control of fabrication;
- ✓ handling and moving of tools and materials;
- ✓ supervision of fabrication.

Along with the CAD/CAM systems there are a series of standalone NC programming systems. They allow the attainment of new part geometries and the processing of the geometrical data of CAD systems. For simple uses, these systems may generate a NC processing program by means of graphical assisted dialogue.

The fabrication of thermoplastic materials injection moulds is achieved with CAD/CAE systems by means of mould rheological exposure programs. Optimization is always used in mould fabrication, due to the infusion of new technologies. An example consists of 5 axes milling. Along with the shorter mould processing time, this allows the attainment of higher precision. In comparison with the 3 axes NC milling, 5 axes milling of the irregular surfaces is achieved by means of fewer milling passes, with better surface quality, as shown in fig.6 [9]. Because of the complex mathematical apparatus, the 5 axes NC programs require a large volume of calculations at an adequate processing speed.

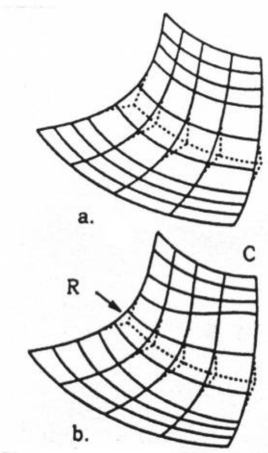

Fig.6.a. Law of free surfaces: a - constant; b - variable; R - radius.

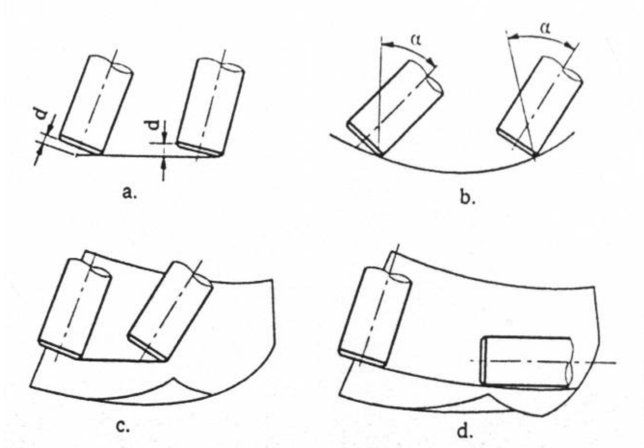

Fig.6.b. Milling geometry for 5-axes milling with frontal mill: a – constant d distance; b – constant α angle; c – maximum tool-part contact; d – NC rolling (flank processing).

The 5 axes NC milling has the following advantages:

- better processing, compared to the model copying mills;
- better surface quality (reduces the finishing duration);
- shorter milling time by reduction of the milling passes and higher efficiency of the NC machines.

4. AUTOMATIC MOULDS EXCHANGE

Tools and moulds exchange and adjusting are operations that require a great part of the processing time. In the general schedule, these operations are marked to the so-called “dead-times”, which might have great impact upon the costs of the finalized parts if they become too frequent. Often, a good management of these operations lightens their economical and organizing impact. So, the rational storage of tools and moulds, the standardization of the mould construction and of the fixing elements in correlation with the usable machines, preparation of mounting accessories and mostly the constructive modifications in coordination with some required facilities may have a benefic effect.
An automatic mould exchange system, as shown in fig.7 [6], may prove itself very useful when moulds are frequently changed. The moulds must have identical formats and must be fitted with the required elements that make them easy to install. Robocars are used to transport moulds, which take the mould from the storage device or from the intermediate storage frame and bring it to the injection machine. The robocars ensure the mould transportation for mounting and dismounting.

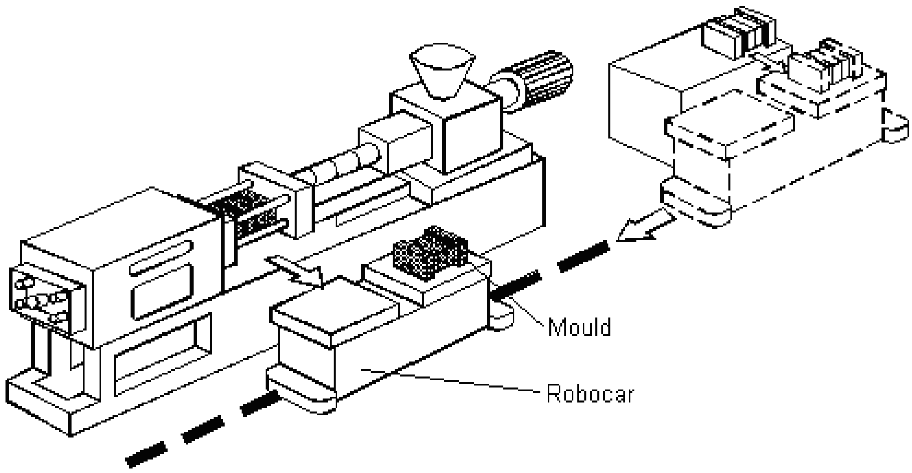

Fig.7. Automatic mould exchange systems with robocars.

The feeding system (fig.8) [10] plays an important part in plastic products elaboration.

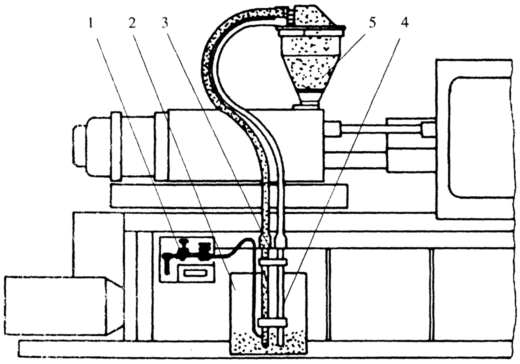

Fig.8. Pneumatic feeding system: 1 – air preparation assembly; 2 - bunker; 3 – feed pipe; 4 – evacuation pipe; 5 – feed hopper.

Robots are often components of complex factories, with high automation degree. Besides robots there are other automatic systems and equipment: transport systems, measuring and control devices, automatic storage devices etc. In order to ensure a continuous and efficient production, without any jamming, each component must operate in coordination with all others. The robots must synchronize with the machines that they assist or depend upon. This coordination is taken over by the controller of the robot, which must communicate with higher, lower or equal control units within the chain of command. The actual systems and technologies used for the coordination of a highly automated factory consist of:

- programmable automatic devices;
- Fieldbus communication systems;
- controller of a fabrication cell;
- controller of stocks;
- production planning system (PPS).

5. AUTOMATIC STORAGE OF FINITE PLASTIC PARTS

Nowadays automatic controller/computer-driven storage devices are used. Any raw materials or semi-finite parts storage action is carried out automatically, along with the registration of stocks in a database. The system controller will always consult the database in order to allow certain production feed actions or to signalize the lack of raw materials. Because the database is very important for the factory, it is memorized on redundant systems, so that data will not be lost even if one computer crashes.

The system controller is directly subordinate to the production planning system, which decides the circulation of the items in the storage, according to the developing production plan.

6. PRODUCTION PLANNING SYSTEM

The industrial production units must have a *medium-term* production plan (guide) and a *short-term* production plan (detailed). These plans determine the allocation mode of the resources in the production process (which raw material for which products). The production plan is closely correlated to the company sales plan and it is subordinate to this plan, because the sales dictate the adjustment and modification of the production plan.

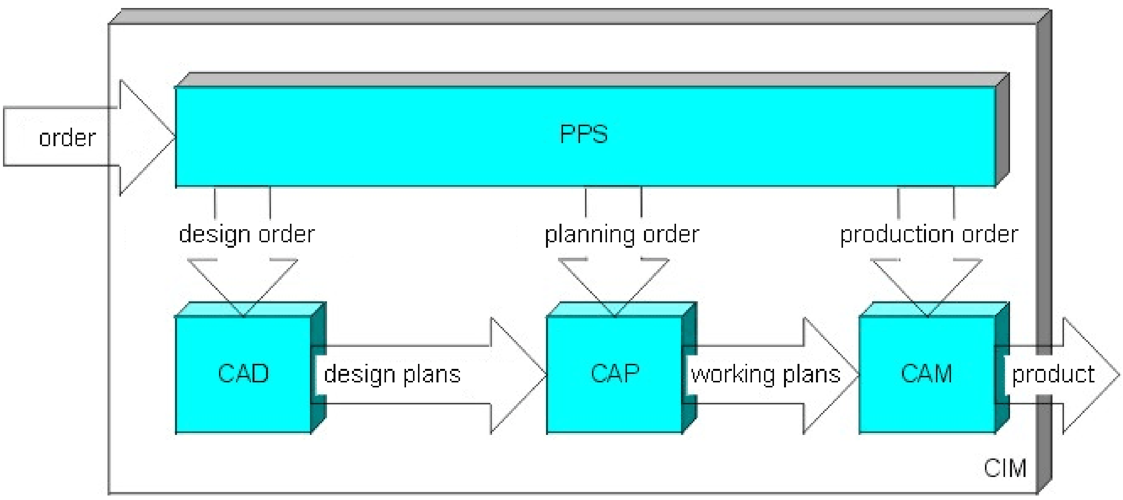

Fig.9. Logical diagram of the processing of an order into an automated factory (CIM); CAD: Computer Aided Design; CAP: Computer Aided Planning; CAM: Computer Aided Manufacturing; CIM: Computer Integrated Manufacturing.

According to the minimal stocks principle, the "on-demand" production strategy is practiced. An accepted order is introduced into the production planning system (fig.9) [15]. This system allocates resources and plans the fabrication of certain products, for certain clients, in a certain time interval. Then, it starts production at a given time and sends the raw material through the transportation system to the fabrication lines or to the fabrication cells for the elaboration of the product.

8. CONCLUSIONS

The world production of thermoplastic injected parts increases rapidly. Well-known plastic parts mass-production companies from Japan, USA, Germany, Italy, France etc. use integrated systems and highly-automated.

Nowadays, the routine work is abandoned and the rational construction system is used in the construction of moulds and of the electrodes required for the processing of their active parts. So, the CAD/CAM systems have evolved, turning into integrated systems based on numerical computers which link the mould construction, the production planning and the effective fabrication on modern NC machines.

The use of integrated systems for plastic parts fabrication leads to the reduction of the injected parts production price, shortening of the execution time and more efficient control over the stocks.

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