



**International Conference**  
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## **Integration of Rapid Prototyping in Manufacturing Process for Mechatronic Systems**

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### **Generalities**

In present goods manufacturing is in a continuing process of deep changes due to a bitter competition caused by opening of the borders and markets and also because of the globalization of production and consumption which implies continuous updating of production means and also rethinking the designing, production planning, control of the produced goods and certificating the quality.

Main requirements to follow at this moment for a producer are:

- to produce good quality;
- to produce at low costs;
- to produce in short time;
- to produce at the right moment;
- to produce without damaging the environment.

All this requirements have to be meet in conditions of a decreasing using time of a product. Present context of economy and industry with a great offer of products, of a wide range of types and models for the same product, leads to a reduction of lots and fabrication series for identical products continuously manufactured. A productive company is under triple pressure: terms/costs/performance, beside quality and price requirements it have to deliver also a great flexibility in manufacturing at low costs when the configuration of products is changed.

Computer usage in fabrication process offers a unique flexibility in what concern acquiring an stocking the data, processing those data or for operations of dynamic modification of references, combinations, analyzing variations of parameters and passing them over threshold of significant values, assuring thus support elements for taking the right decision at the right time.

By computer assistance not only a good automation of some activities carried out by trained personal is acquired but also all the technical knowledge available on production line at a moment is introduced in research-design-planning-fabrication-control process.

In case of modern fabrication systems, computers have the role to assure logical connectivity between designing(CAD-Computer Aided Design), setting the fabrication (CAM-Computer Aided Manufacturing), simulations (CAE- Computer Aided Engineering), production (CAP Computer Aided Production), Quality control (CAQC – Computer Aided Quality Control).

Computers are used in fabrication process, including production planning activities, designing and ordering new tools and materials, running CN programs, quality control and

packaging, so these computerized activities may be also classified as CAM.

In developing and renewing the products an substantial support is offered by models and scale models as intermediate phases of developing new products and designing production technologies. CAD/CAM technologies offer basically the possibility of creating such models using directly designing data, from electronic format, already being known as Rapid Prototyping (RP).

The rapid manufacturing of the designed product creates the opportunity to capitalize the project while negotiating the selling of the product and for researches regarding assembling and thus opening to the designer a whole new ways to improve the product unknown until now. The designer will be able to have the physical part he designed in a few days, for which, on conventional manufacturing it would have taken weeks, and thus he may take rapidly the right decisions. Analyzing life cycle of a product, fig 1, it is shown that in preliminary phases I and II there is often necessary to intervene over future product.

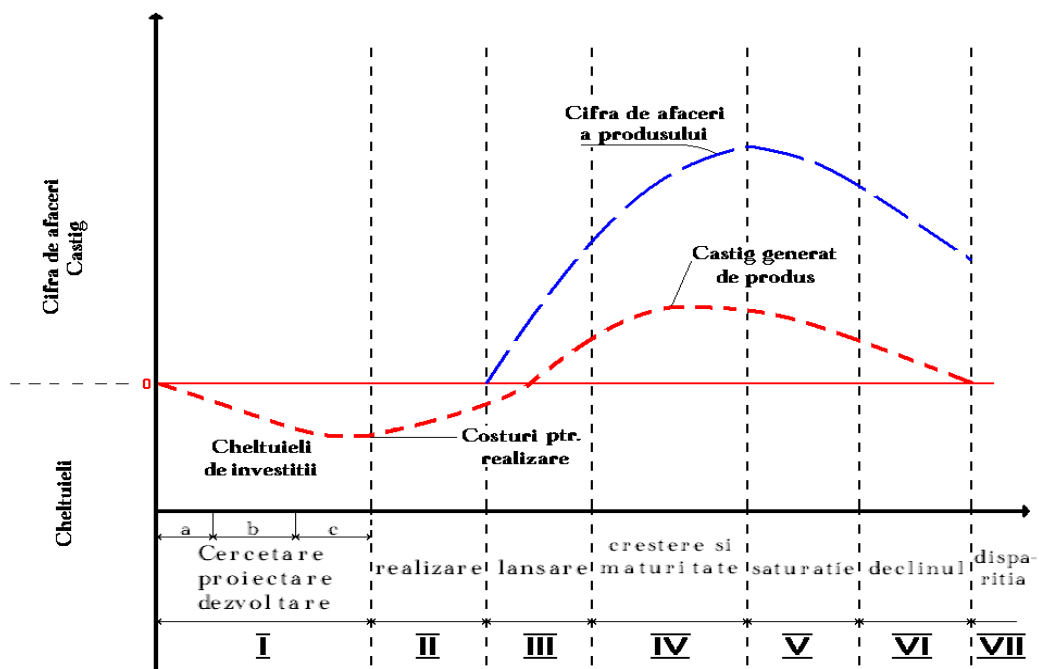


Figure 1

In preliminary phase of development there are many interventions, first on design models and geometrical prototypes which generally are manufactured as unique. Design models have to partially respect the dimensions; those are used for design and ergonomic studies and also for first marketing analysis. On the other hand they are submissive to some thoroughly optical and tactile requirements because functionality requirements have less importance in this phase, so models are often made out of specific materials for scale models which are less expensive.



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Unlike design models, on geometrical models, the optical, tactile but also functional properties are subordinate to main requirements in this phase concerning dimensional and shape precision, shape tolerances and reciprocal positioning. The material for geometrical prototypes doesn't match necessarily the material of series part, usually it is used in this models same materials for mock-up models. Those types of prototypes find their use especially in designing the technological process, for example to elaborate a conception of the production, to check technological process and mounting capabilities. In this phase prototypes are used also as testing means and also as communicational means between various compartments and services.

In functional model phase are used mostly up to five models and functional prototypes to verify and to optimize product idea, and also working process and functionality. In this stage of development, the stress is on analyzing the functions of individual components and subassemblies. In designing fabrication process these functional models are used to design equipments, technological process of manufacturing and assembling and all the auxiliary systems. Exterior aspect and dimensional tolerances at this moment are secondary in importance as long as it doesn't affect the functionality of the product.

Starting from requirements of model-prototypes for different phases of development there will be shown the capabilities and limitations for the methods available to obtain prototypes. Duration and costs of development stage for a product depends on great extent on how fast are available the models and product mock-ups. These serve to check product structure and to create the fabrication technologies for future mass production, building information carriers and connections which integrate activities of conception and fabrication technologies. Studies proved that usually over 25% of the time affected to develop a new product is used to build mock-ups and functional models. In this way rapid prototyping offers a great potential to shorten development time for a new product. Manual labor used to produce complex components is significant in increasing the time of building a prototype by manufacturing model-parts; this determines high cost for personnel and supplementary expenses, which may reach 50% from total development costs. Rapid Prototyping opens new possibilities that companies may use to shorten designing phases and/or to improve products characteristics.

In the next development phase, prototype phase, technical prototypes are manufactured in greater series (accordingly to application between 3 and 20) which must be as close as possible to final product in what concerns the used material and fabrication process. When manufacturing, for example, pressed parts, molded or poured under pressure tools used are the ones that will be used for zero series or the ones used for try-outs in order to further analyze product functionality, capacity of extended loads, technology and customer acceptance. In isolated cases products are delivered to some selected customers to test the products in order to optimize the design. Before launching the product, in zero series phase are built up to 500 products depending on the branch and product, then individual parts are fabricated using production series material, using series tools, as for the rest of the processes of the series.

Zero series require designing the product for extensive testing of product and market, in this phase starting the mass production, being carried out in order to determine and optimize technological parameters of the process. At last there are some changes made to improve final product. Profound modifications at this moment to the product or to it's parts may end in very high costs.

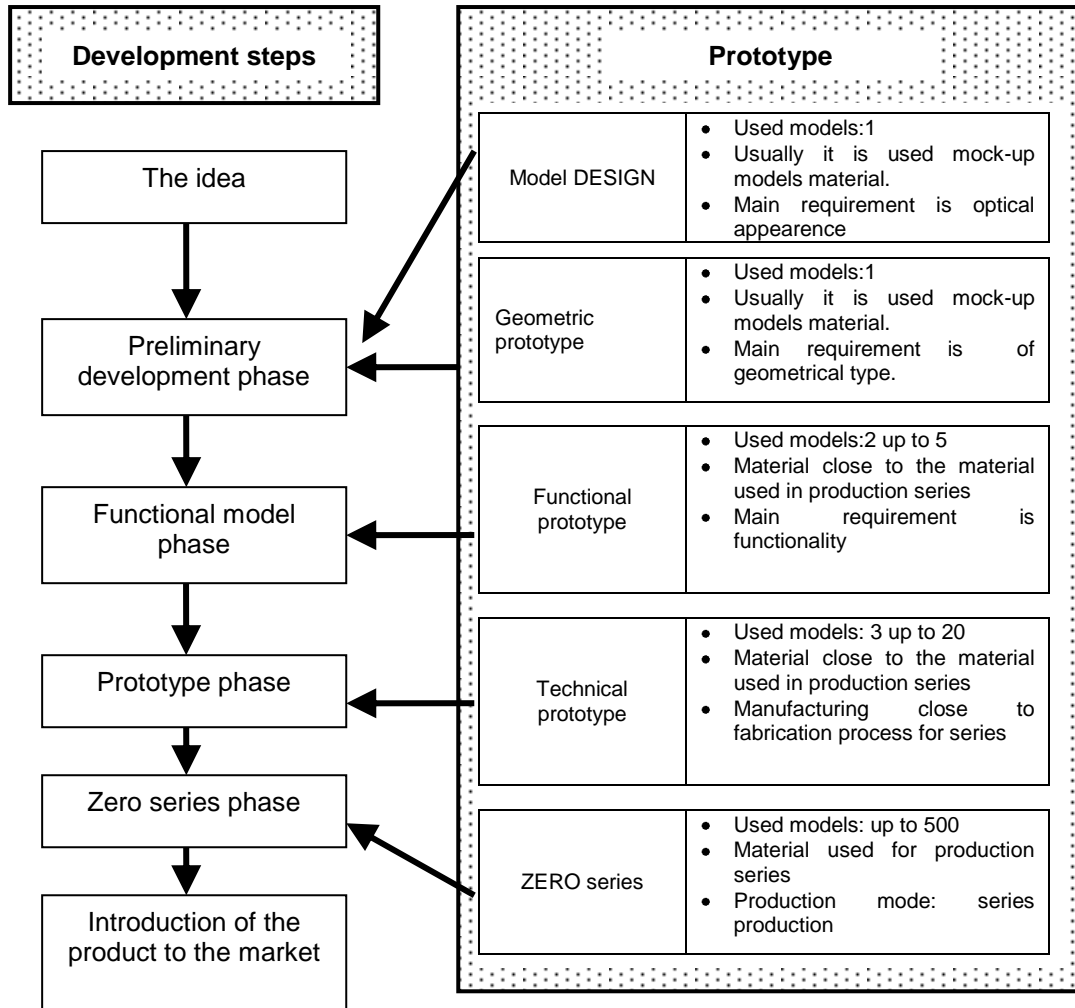


Figure 2

Models and prototypes for development of the products are today still conventionally manufactured, in combination with processes from the molding category. Especially here are used numeric command milling, copy milling, turning, and grinding as also manual techniques of assembling and mounting. Thus prototypes and models building is characterized by a high fabrication cost and, due to small series and frequent modifications in product configuration, becomes a significant component the share of high costs and fabrication time of prototypes in the development of a product. At last, on this basis, often producers are forced to give up on building models and prototypes. By using CAD/CAM technology main capability offered is to build models and testing parts directly using designing data and also parts ready to sell.

New fabrication processes, which lately are known as RP, Desktop Manufacturing, Solid Freeform Manufacturing and Layer Manufacturing frequently use this capability. Main characteristic of those technologies is obtaining the shape of the part not by removing material as in conventional manufacturing but rather adding material or by phase transformation of a material, passing it from liquid state or powder state to solid state.

Another particularity is that model is built layer by layer (Layeretechnik).

Giving up to casting mold or plastic deformation or to milling tools significantly decrease the manufacturing time and costs.

Rapid prototyping has a series of technique to build prototypes, which may be concepts, functional or technical; the process may be used to check the costs, building time and marketing research.

Rapid prototyping is a relatively new, but knows a unique dynamic. Every company which builds rapid prototyping machines developed it's own technique to shape materials. At this moment powder technique is growing because changing the powder user may obtain a wide range of products having various physical and mechanical properties. Gluing stages of rapid prototyping.

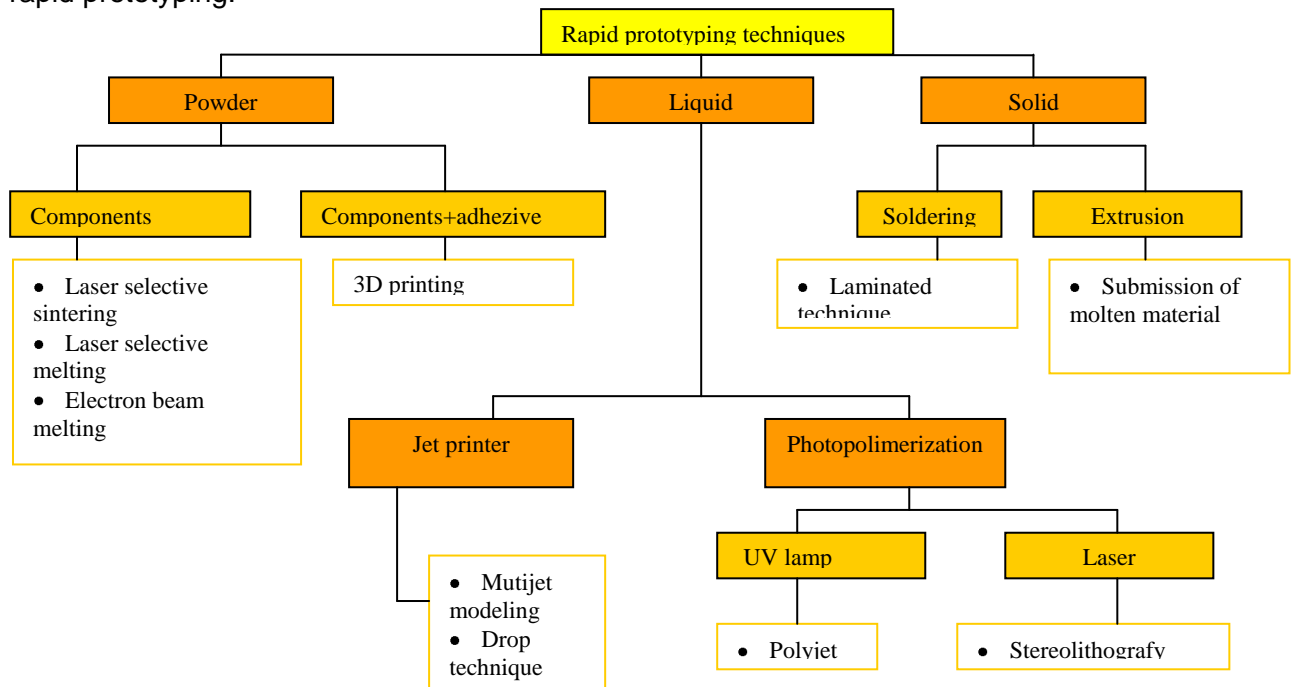


Figure 3



Figure 4. Creating a 3D CAD part.

Steps to build a model by rapid prototyping are:

- creating a STL file starting from a CAD model;
- Managing STL file;

- Building the prototype layer by layer;
- Post processing operations.

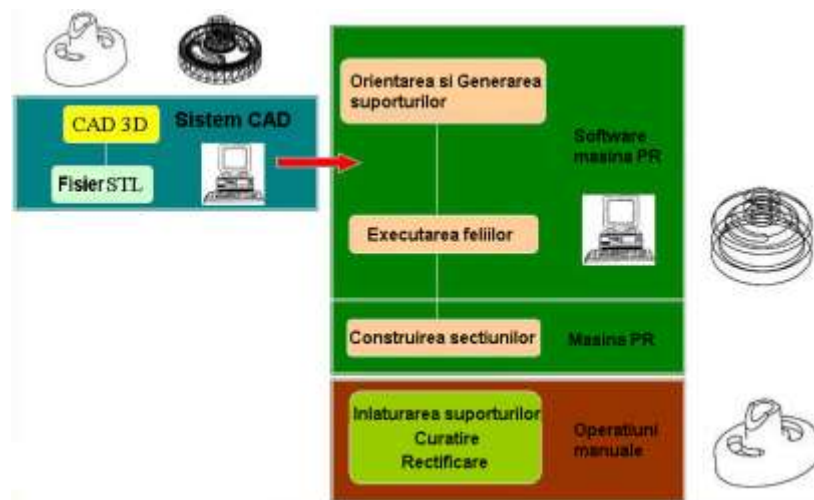


Figure 5.

Thanks to a high demand of products built in a shorter time and to a high quality level, rapid prototyping industry had a spectacular development in the last few years.

Multijet rapid prototyping technique is similar to a jet printer. In the nozzle there is an epoxidic resin which is placed on the working platform in a manner that builds a layer. Successively the platform is lowered and the resin adheres to precedent layer. By this technique a model of a vehicle body (fig. 6.) was made using a THERMOJET 3D SYSTEMS printer. With this printer rapid prototyping services are offered by building 3D models out of wax, using Multi-Jet Modelling – MJM. Molten wax is pushed out of the nozzle to the working area. Material is placed layer over layer in a few hours, accordingly to model dimensions and the orientation on platform. The software creates automatically a fine sustaining mech for the printed object. Also the cavities of the body will be filled with the same type of mech.

Thermojet printer uses as material for building the parts a thermopolymer in solid state which contains hydrocarbures, uretan, amide and esters, which anre not soluble in water, 0.975g/dm<sup>3</sup> density, melting point 80<sup>o</sup>-90<sup>o</sup> C.



Figure 6. Body outline of a car built by thermojet technique.



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## Conclusions

Producing models in a few hours instead of a few days or weeks increases the competitiveness by building a larger series of parts and delivering urgent demands.

Against the successes in development of rapid prototyping methods, applying those techniques confront with a variety of technological problems, of information and organization and is held back by the lack of experience for integration in what concerns technical information of a company.

On mechanical, thermal and chemical limited properties of the working materials (polymers, wax, plastic, paper etc.) with current technologies applied in industry, parts build are unfortunately only models, model parts or primarily models for further operations. A thoroughly check over part functionality, as most of the time user demands, is possible with those prototypes only in a limited series.

Regarding a closer match between prototype and final mass production part, it should be used materials in prototype building as close as possible to the materials used in mass production. On this basis there is an intensive work to develop further processes of RP which can make possible obtaining tools and metallic parts. By this accelerated building of prototypes and by the rapid availability of models and parts, the mock-ups are available in early stages of the development, a high grade of maturity of the product and thus a high quality of designing/planning data for production. To develop future RP is to be expected to extend the capabilities of methods through new materials, perfected installations and an informational technique capable of superior performances. RP processes will may be used in manufacturing the prototypes and to individual production and small scale series of complex functional parts.

These techniques opened to designers, thanks to almost unlimited geometrical capabilities that can be materialized, whole new ways in designing and building parts that in other way will be impossible to manufacture. Thus rapid prototyping proved that can be not only an application used in development of the products but also an application stand alone in fabrication technologies.

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