SYSTEMS ADVANCED PROCESSING THROUGH RAPID PROTOTYPING

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Rezumat: *Prototipajul rapid este un pas esential în proiectarea produsului şi procesului de dezvoltare, fie pentru a demonstra forma, funcţia sau fabricarea, se va asigura clienţilor, proiectanţilor şi la toţi partenerii de dezvoltare ca au o înţelegere clară a intenţiei de proiectare şi pot contribui în mod eficient în validarea proiectării. Prototipajul rapid este unul dintre cele mai convingătoare şi eficente căi pentru a comunica, arăta şi "simţi" pentru un produs proiectat pentru alţii. Dacă o poză valorează o mie de cuvinte... imaginaţi-vă un prototip în mâna dvs. cât valorează?*

Abstract: *Rapid prototyping is an essential step in the product design and development process, whether to demonstrate form, function or manufacturability, it will ensure clients, designers and all development partners have a clear understanding of the design intent and can effectively contribute in design validation. Rapid prototyping is one of the most compelling and effective ways to communicate the look and "feel" of a new product design to others. If a picture is worth a thousand words … imagine what a prototype in your hand is worth?*

Keywords: Rapid prototyping, stereolithoraphy, selective laser sintering, three dimensional printing, fused deposition modeling.

1. Introduction

Rapid prototyping is a technology of producing a three dimensional visual prototype or model direct from a CAD file. Rapid prototyping is based on CAD (Computer Aided Design).

Available since the 1980, the technology was initially used to produce models and prototypes. Currently there is a larger number of fields of application of RP technology being used including manufacturing in small series of components designed on computer.

Most applications of RP parts made by depositing successive and strengthening layers of liquid plastic, or by fusion of layers of microparticles polymer powders.

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Fig. 1 Rapid prototyping system

Before transmitting to a PR system CAD file, it is converted to STL file type, which approximates the shape of the piece with veneers triangle. The veneers were even smaller surface quality is better, but the file sizes are higher and higher processing time.

Depending on the method chosen, the PR machine, the size and complexity of CAD models, time "Printing" can vary between several hours and several days.

2. Rapid Prototyping Techniques

Rapid prototyping techniques is the name given to the class of manufacturing processes that allow objects to be constructed by building up a structure from individual layers.

The layered construction method allows complex structure to be built that would be prohibitive or impractical using more traditional methods, and in a fraction of time.

At present time, there many different processes that fall under this umbrella term, using a variety of materials and methods. What they have in common is that they may each be given as input a three dimensional model (described by a computer file), along with a set of perimeters particular to the process. The computer model is automatically sliced into layers by calculating its intersection with a set of parallel planes, spaced according to the resolution of the process. Each of the processes then constructs the object by building up reproductions of these layers in physical material.

Most commercially available rapid prototyping machines used:

- Sterolithography
- Selective Laser Sintering
- Fused Deposition Modeling
- Three Dimensional Printing

Rapid prototyping is widely used in automotive aerospace, medical and consumer products. Although the possible applications are virtually limitless, nearly all full into one of the following categories. Prototyping, rapid tooling or rapid manufacturing.

2.1. Stereolithography

Stereolithoraphy is one of the several available methods of predicting rapid prototype models. The process allows complex shapes to be reproduction in polymer resin, going from computer data to finished product within a period of 24 hours. Rapid prototyping techniques are increasingly being used by industry to produce models in a fraction of time required for more conventional methods. Stereolithogphy is widely used through all manufacturing industries to accelerate the design product development process by addressing three application areas: models patterns and masters.

The main component of a Stereolithography system a vat containing liquid photopolymer, galvanometer controlled mirrors, directing a UV laser on the surface of liquid and just below the surface, vertical elevator tray. The Stereolithography process is basically comprised of 4 major steps: CAD Process, Part Preparation, Setup and Build, Post Processing.

The CAD process involves the utilization of a CAD system to structure object/part date for use on the Stereolithography apparatus (SLA). The process being with a design created on a solid modeling CAD system. Pro/Engineer and Auto CAD 13 with 3D modeling extension are 2 examples available 3D modeling software packages.

Part preparation, this process is performed utilizing the SLA manufactures proprietary software. Typically, 3 part orientation tasks are performed. These include : placing the parts in positive space, orienting the parts in such a way as to minimize support structure and positioning the parts to optimize the total number of parts to be made during the build process. At this stage of the part preparation process, if required, the parts can easily be scaled up or down in size. One orientated, the parts are then supported. Support structure is required to hold a part in place on the elevator tray and support any overhanging surfaces that are greater then 1/8” at any angle less than fifty degree from horizontal. Support structures are basically thin vertical webs.

Setup & Build the third step of the Stereolithography process involves the initialization & setup to build parts on the SLA. Prior to initializing the build process, the laser is warmed up for 15 min. The time required allows the laser to stabilize and reaches maximum output capacity. During the warm up period three tasks are performed: transfer of slices and operational data files from slice workstation to SLA control computer, lowering of platform into vat and resin level adjustment. The process of SLA software is now activated by the operator, which begins building the part by moving a focused laser beam across the surface of the vat of resin. The laser draws the first support cross-section, which adheres to the platform. Typically 3 inches of base support structure of built up before initiating the part build itself and whatever additional support are needed for over hanging surfaces.

Post Processing, the final step post processing involves cleaning UV curing & final finishing of the part. First the part is raised out of the vat and as much liquid resin as possible is allowed to drain off the part.The part and the platform are then removed from the process chamber and the remaining excess liquid resin is removed by rinsing in a solvent with the aid of an ultrasonic cleaner. The part is then removed from the platform and support structure is removed from the part. Ultraviolet light to solidify any remaining trapped liquid and increase strength of part. Post curing is required, since a part is only about to go percent cured by SLA’S ultraviolet laser when it is built. The final cured part can be finished in a number of ways. Finishing techniques such as sanding, sand blasting, painting, polished can be applied. The steriolithoraphy lab is equipped with majority of items required for finishing which include a sand blaster.

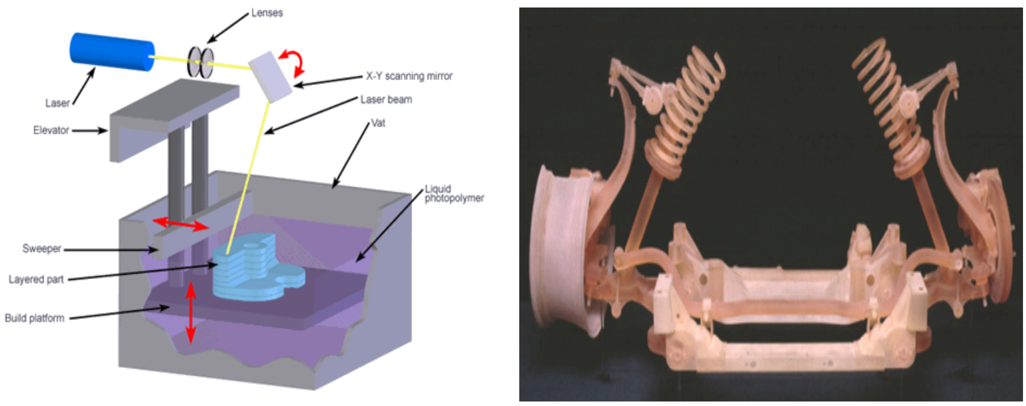

Fig. 2 Schematic of the SLA process and Car deck (components - made by stereolithography)

2.2. Selective Laser Sintering

Selective laser sintering (SLS) is a process that was patented in 1989 by Carl Deckard, University of Texas. A layer of powder (particle size approximately 50 µm) is spread over a platform and heated to a temperature just below the melting temperature. A carbon dioxide laser needs to raise the temperature only slightly and selectively to melt the powder particles. As the layer is finished, the platform moves down by the thickness of one layer (approximately 0.10–0.15 mm), and new powder is spread. When the laser exposes the new layer, it melts and bonds to the previous layer. The process repeats until the part is complete.

On completion, the built volume has to cool down to room temperature after which the processed objects can be removed from the powder bed by brushing away excess powder. Sandblasting the objects removes all unsintered particles. Surrounding powder particles act as supporting material for the objects, so no additional structures are needed. Furthermore, more objects can be built at the same time because they can be meshed above/in each other. Excess powder can be reused. However, it needs to be mixed with virgin powder to guarantee good part quality. Commonly used materials for SLS are nylon (polyamide-12), glassfilled nylon, and polystyrene. The method has also been extended to direct fabrication of metal and ceramic objects and tooling inserts.

Characteristics:

- Key advantage of making functional parts in essentially final materials.
- Good mechanical properties, though depends on building orientation.
- Powdery surface
- Many variables to control
- No support required

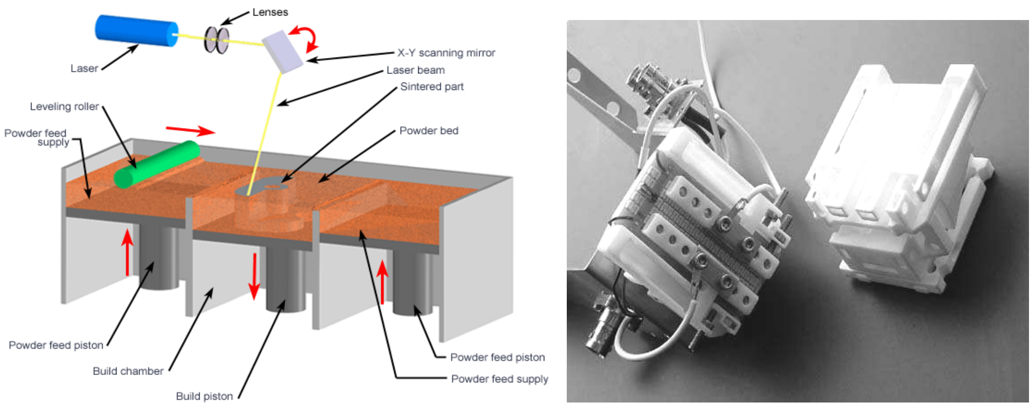

Fig. 3 Schematic of the SLS process and accurate positioning elements with internal hinges produced by SLS

2.3. Fused Deposition Modeling

Fused deposition modeling (FDM), developed by Stratasys, is the second most widely used rapid prototyping process. A filament thread of plastic is unwound from a coil and fed into an extrusion head, where it is heated and extruded through a small nozzle. Because the extrusion head is mounted on a mechanical stage, the required geometry can be described, one layer at a time. The molten plastic solidifies immediately after being deposited and bonds to the layer below.

Support material is laid down similarly through another extrusion head. The platform on which the object is built steps down by the thickness of a single layer.

The entire system is contained within a heated oven chamber which is held at a moderate temperature above the glass transition temperature of the polymer.This provides much better control of the process because stresses can relax.

As in the SLA process, overhanging features need to be supported. This support material needs to be removed in secondary operations. Commercially available water-soluble support materials facilitate this final step. ABS, polycarbonate, and poly(phenyl)sulfone are commonly used materials in the FDM process.

Characteristics:

- Office-friendly and quiet.
- FDM is fairly fast for small parts.
- Good mechanical properties, so suitable for producing functional parts.
- Wide range of materials.

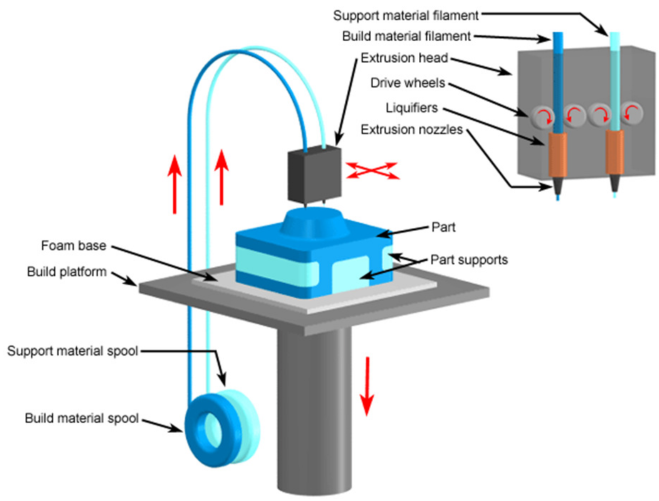

Fig. 4 Fused deposition modeling technology

2.4. Three dimensional printing

In some textbooks, the term “three-dimensional printing” (3-DP) is used for all rapid prototyping processes. In this process, a layer of powder is spread over a platform. The particles are bonded together selectively by a liquid adhesive (binder solution). This liquid is deposited in a two-dimensional pattern by a multichannel jetting head. As the current layer is completed, the platform moves down by the thickness of a layer, so that a new layer can be spread. This process is repeated until the entire object is formed within the powder bed. On completion, the object is elevated and the extra powder is brushed away, leaving a fragile “green” object. It is necessary to infiltrate the part with another material to improve mechanical characteristics.

No support structures are required because the surrounding powder particles support overhanging features. By adding color to the binder solution, objects can be produced in every desired color. Starch, plaster, medicines (for producing controlled-dosage pharmaceuticals), ceramics, and metals are commonly used materials (powders) for 3-DP.

Characteristics:

- Limitations on resolution and surface finish.
- Fragile objects need to be infiltrated.

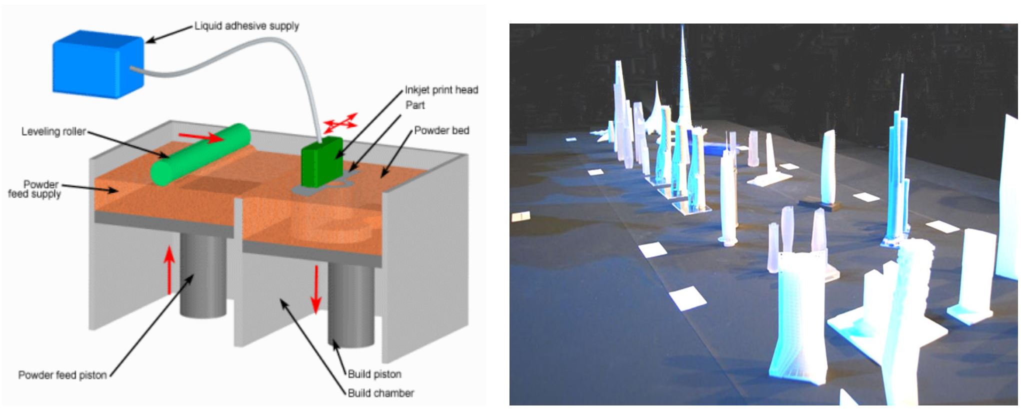

Fig. 5 Schematic of the 3DP process and 3D printed landscape

3. Application

As stated before, RP models were primarily used as visual aids (for engineering, tool-making, quote requests, and proposals). Due to the use of other more durable materials, the field of application has enlarged substantially. Companies are increasingly applying additive RP processes to produce tools for various industrial production processes (rapid tooling). The quality of RP models (durability, accuracy, reproducibility) makes them suitable for end uses (rapid manufacturing).

Conclusions

New technologies not only improve and replace conventional methods but also offer the chance for new types of products and developing procedures and in this process it needs the knowledge on the potentials of these evolving in many fields of applications such as engineering product development, medical and surgical applications.

RP systems offer the opportunities to make products faster and usually at lower costs than using conventional methods. Since RP can substantially reduce the product development cycle time, it can be used to develop the accurate models directly from designs generated from computers. The bottlenecking in pattern development by conventional methodscan be overcome by using the RP technology. To stay ahead in competition, the updated technology demands development of fast and accurate castings of high standards from foundries.

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