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THE ASPECTS ABOUT RAPID PROTOTYPING SYSTEM

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ABSTRACT: This paper has presented some aspects about rapid prototyping system, which stay at the base of product design by using CAD/CAM and advanced methods and technology. In addition, this work presents some main techniques of rapid prototyping such as: stereolithography, solid ground curing, laminated object manufacturing, fused deposition modelling, selective laser sintering, etc. These techniques has known a large using in manufacturing by shorting time process at hours versus days and weeks as classical fabrication, in special in dynamic sectors as computers, automotive, aerospace, medical device.

1. INTRODUCTION

Computer-aided design/Computer-aided manufacturing (CAD/CAM) has become an important factor in design and manufacturing. Three-dimensional (3-D) modeling has given a full and complete CAD/CAM representation. 3-D CAD system consists of wireframe, surface and solid modeling systems. Their capability is necessary to describe all but the simplest of mechanical parts and provide multi-axis CNC of machine tools.

Rapid prototyping represents a general term, which describes a variety of systems that can construct three-dimensional models directly from electronic data. This technology, first developed in the mid 1980's, is based on the solid modeling portion of computer-aided design, or CAD. Solid modeling uses CAD data to fully describe not only the parts overall shape, but also its interior volume and outside surfaces.

Rapid prototyping systems use this data to build fabrications layer by layer in very thin cross sections. Each layer is stacked upon a previous layer until the model is complete. Rapid prototyping systems build intricate and complex shape much fast and more simply than by conventional modeling methods. Additionally, these systems can also produce models from data generated from the 3-dimensional digitizing of existing parts, and medical imaging devices.

Materials used to fabricate prototype models have broadly classified as liquid, powder, filament, or foil. Prototyping systems typically operate untended, and upon completion, the fabricated models can require some post operations. These post-processing operations include surface finishing and support removal. In total, however, the cost of prototype modeling has greatly reduced from more conventional model shop fabrications.

2. RAPID PROTOTYPING SYSTEM

Rapid prototyping has used a modern technology to build up a physical prototype form by a CAD file data during a few hours versus days or weeks with classical technology. The primary rapid prototyping systems include [3]:

- Stereolithography;
- Selective Laser Sintering;
- Fused Deposition Modeling;
- Ultrasonic Consolidation;
- Solid Ground Curing;
- Ballistic Particle Manufacturing;

- The Pro-Metal System;
- The Thermojet Modeler;
- The 612 Modeler;
- The Z810 Modeler;
- The Eden 330;
- Room Temperature Vulcanizing Tooling;

Fig.1. Installation for rapid prototyping.

The rapid prototyping presents certain advantages such as:

- Accelerate prototype production;
- Produce 3-D parts within hours;
- Create masters and patterns;
- Increase manufacturing capabilities with low-volume production runs;
- Achieves major savings in production of soft and hard tooling;
- Improve the accuracy of vendor bid response;
- Add impact to marketing concept presentations with hands-on models.

Also, rapid prototyping are some disadvantages such as:

- Equipment is expensive;
- Parts have surface finish quality and tolerance limitations;
- Special techniques and materials are required of some systems;
- Parts typically can’t be used for physical testing.

3. TECHNIQUES OF RAPID PROTOTYPING

This chapter presents some of principal methods or techniques used to created parts with rapid prototyping systems.

Stereolithography

Stereolithography is a liquid based RP system, which builds models in layers within a reservoir of a liquid, thermosetting, epoxy-based, photosensitive polymer. Curing of each successive layer is accomplished by a focused low power laser beam following, or tracing, a path dictated by the part’s CAD file. It builds the physical models one layer at a time. An ultraviolet laser traces a thin cross section of object onto a liquid resin surface, selected hardening polymer. After that the layer is lowered in a polymer vat and its surface is recoated for build up the next layer. The operation is gone with successive layers until is completed the object. Models as large as 1000 X 800 X 600 mm can be fabricated.

Selective Laser Sintering

Selective Laser Sintering is similar to stereolithography except that a powder is used to fabricate the model. Sintering, or fusing, has done with a more powerful carbon dioxide laser. In operation, a layer of powder has spread evenly over the sintered powder layer, and then the laser beam scans the model design to the CAD file and selectively sinters the powder particles together.

At start process, a very thin layer of heat fusible powder has deposited in a container and heated just below its melting points. An initial cross section of part under manufacturing has traced on layer of powder by a laser. The temperature of powder impacted by laser beam is growing to the point of sintering, formed a solid mass. The process is repeated, each layer fused to underlying layer and successive layers of powder are deposited and sintering until part is complete.

The principal advantage of this process is the wide variety of powder materials that can be used. Models fabricated are as large as 400 X 320 X 450 mm.

Fused Deposition Modeling

Fused Deposition Modeling involves feeding a thermoplastic filament through a heated extrusion head, which moves in the "X" and "Y" axes, depositing model material on a table that operates in the "Z" axis, building the model.

The thermoplastic material has deposited in the form of a fine bead, which has flattened for the next bead layer. The thermoplastic material has heated just above its melting point so that the bead solidifies almost upon application thus cold welding itself to the previous bead.

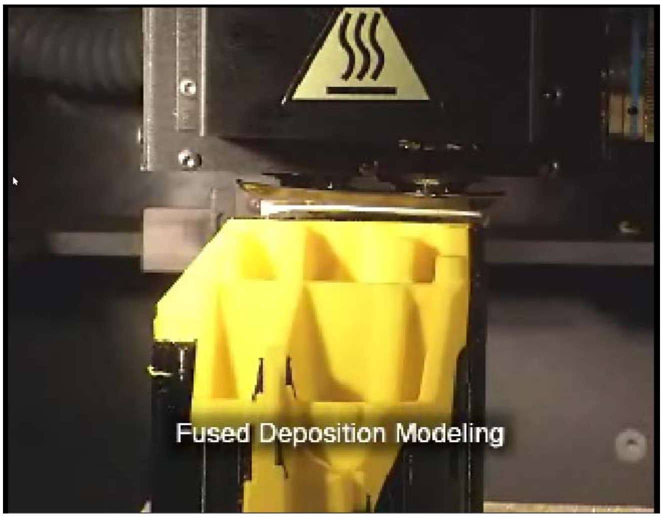

Fig.2. Fused deposition modeling.

Laminated Object modeling

Laminated object modeling realized 3-D parts of various complexities directly from CAD data by successive deposition, bounding and laser cutting of sheet or film materials. A laser is guided over an X-Y axis table by the data from CAD files and cuts a 2D cross section in the sheet material. A platform positioned under the table drops an increment equal to thickness of a single material layer.

After that, material has advanced from a supply roller to a pickup roller over the top of previous cut cross section and a heated roller presses and bounds the material against previous layer. The laser beam cuts the next layer and the process is continuing until the 3-D object is completed.

Solid Ground Curing

Solid grounding curing builds up 3-D object layer by layer in a solid environment. A photocurable resin is spread across the work area of workpiece, following by the exposed of resin with ultraviolet light through a mask. Each un-solidified liquid resin has removed carefully by an aerodynamic wiper. It is going with water soluble wax, serving as support material, is than spread over all polymer-free area. After cooling, each layer has milled an exact thickness. In final, the model is cleaning from wax support material by using heat to melt wax or dissolving the wax in an acidic solution.

Ballistic Particle Manufacturing

Ballistic particle manufacturing system deposits material in an organized pattern to build a part. The material has attached to a robotics system and driven by data generated from CAD files. Wax droplets are delivering by an ink-jet mechanism and polypropylene glycol has used for support material. When all layers are been deposited, the part is placed in a warm water bath, which dissolved the support material, results a cleaning finished part.

Ultrasonic Consolidation

Ultrasonic Consolidation produces direct metal parts by ultrasonically welding layers of aluminum foil strips to a prepared metal substrate. Once welded, the layer has milled to its cross-sectional shape as dictated by the CAD data. Like other rapid prototyping systems, this process allows the building of parts with complex geometries, overhangs, and internal enclosures. Additionally, ultrasonic consolidation is capable of joining a variety of similar and dissimilar metals, along with certain ceramic-metal combinations.

Pro-Metal System

The Pro-Metal System is also used to create metal models by using inkjets to apply a liquid polymeric binder onto a powder media. Models had built from steel-based powder from the bottom up. When the model is finished, they are sintered to remove the binder, then infiltrated with bronze to either eliminate or significantly reduce porosity. Models are of high strength with no support structures needed. Tooling for plastic molding is a common application.

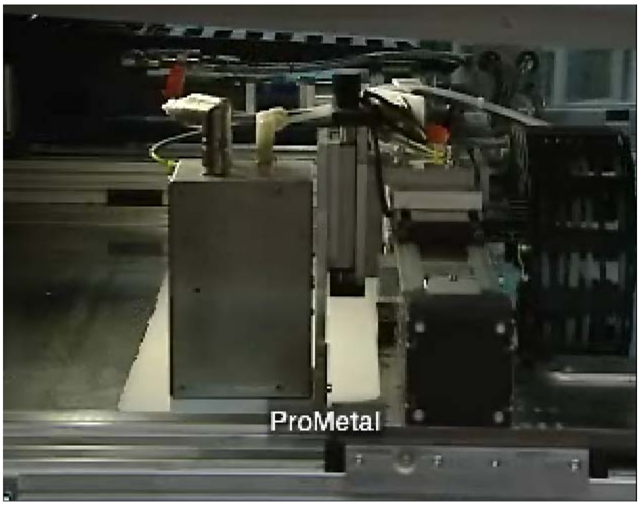

Fig.3. Pro-Metal System.

Of the smaller rapid prototyping systems the Thermojet, the 612 modeler, the Z810 modeler, and the Eden 330 modelers are all inkjet based.

Thermojet Modeler

The ThermoJet Modeler uses an array of over 300 jets to produce wax models. It's a self-contained, compact unit producing models up to 250 X 200 X 180mm in size. The system is cartridge loaded and post finishing operations are minimal.

The 612 Modeler

Two print heads are used on the 612 Modeler. One to build the model using a proprietary thermoplastic and the other to build the necessary supports using a proprietary wax. The supports are designed to dissolve in solvents without affecting the model itself. A milling operation is performed after each layer to provide extreme accuracy and detail. The system is widely used in the medical and jewelry industries.

The Z810 Modeler

The Z810 Modeler is the fastest modeling system, building up parts at rates of one to two inches per hour. The Z810 uses one of two materials. The first combines starch and cellulose while the second is plaster based. Either material can be infiltrated with wax or resins to enhance the model's mechanical properties. The Z810 uses a wiper blade to smooth powder in the build area. Once level, the printer head dispenses a binder only in areas dictated by the CAD file. Then the building platform lowers and the existing layer is leveled over with powder to repeat the process. Models produced by the Z810 have rough surfaces but operating costs are low, including the cost of modeling materials.

The Eden 330 Modeler

The Eden 330 Modeler has eight heads containing a total of over 1,500 nozzles. Half the nozzles dispense fine droplets of a proprietary model photopolymer material while the other half dispenses droplets of proprietary photopolymer support material. The system produces very thin layers of modeling material increasing accuracy and surface quality. Each layer is cured immediately by exposure to ultra-violet light. When the model is complete the gel-like support material is easily removed.

Room Temperature Vulcanizing Tooling

Room Temperature Vulcanizing Tooling produces soft tooling for low-pressure injection molding. Silicone materials are used to produce tooling since they do not require special curing equipment.

Fig.4. Room temperature vulcanizing tooling.

The method uses a prepared prototyped model as a pattern. The mold halves are typically prepared and pour one half at a time. Once the pattern is secured in a box, the silicone material is poured around the pattern and allowed to cure. Once cured, the first mold half and the patterns are prepared for the pouring of the second half of the mold.

Once prepared the mold half is poured, and again allowed to cure. Once cured, the mold is separated at the parting line and prepared for use. This process can mold a number of parts before replacement tooling is required.

3. CONCLUSIONS

Rapid prototyping represents a tool for design, engineering, and manufacturing. As with any tool, there are barriers and obstacles that impede its growth, and there are strengths and weaknesses that limit its use. It is amazing that prototypes can rise from a vat of resin or chamber of powder.

Rapid prototyping system is powerful to produce parts without machining, molding, or casting. However, rapid prototyping is just a tool: an alternative solution to design and manufacturing challenges. The benefits and value of the technology are realized only when it is applied to suitable applications.

Rapid prototyping may be the tool for change. New methods, processes, and procedures are required in the highly competitive business environment. Rapid prototyping can be a catalyst to powerful and lasting change for progress.

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