

Rapid Prototyping

Training Objective

After watching the program and reviewing this printed material, the viewer will understand the principles and practical applications of Rapid Prototyping.

- Basic concepts are explained
- Layer-by-layer modeling is demonstrated
- Pattern-based prototyping is shown
- The primary rapid prototyping technologies and systems are detailed

Rapid Prototyping

Rapid prototyping is 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 it's 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 shapes much quicker 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 are broadly classified as either 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 includes surface finishing and support removal. In total, however, the cost of prototype modeling is greatly reduced from more conventional model shop fabrications.

Rapid Prototyping Systems

Rapid prototyping systems range from large modeling units suitable for shop and laboratory use to smaller 'desk top' systems. The primary rapid prototyping systems include:

- Stereolithography
- Selective Laser Sintering
- Fused Deposition Modeling
- Ultrasonic Consolidation
- The Pro-Metal System
- The Thermojet Modeler
- The 612 Modeler
- The Z810 Modeler
- The Eden 330
- Room Temperature Vulcanizing Tooling

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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. Upon completion supporting ribs are removed in secondary operations. Models as large as 40" X 32" X 23" 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, is done with a more powerful carbon dioxide laser. In operation, a layer of powder is 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. The principal advantage of this process is the wide variety of powder materials that can be used. Models fabricated are as large as 14.5" X 12.5" X 17.5".

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

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 is 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 are 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.

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

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Thermojet Modeler

The ThermoJet Modeler uses an array of over 300 jets to produce wax models. It is a self-contained, compact unit producing models up to 10" X 7.5" X 8" 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. 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 pattern 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.

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Review Questions

1. The essential element from which Rapid Prototyping technology is based is:
 - a. computer aided manufacturing
 - b. computer aided design
 - c. laser beams
 - d. numerical control

2. Most rapid prototyping modeling systems build models by:
 - a. injection
 - b. fusion
 - c. layering
 - d. molding

3. Building material in stereolithography is:
 - a. a powder
 - b. a foil
 - c. solid stock
 - d. a liquid

4. A process which can build models of dissimilar materials is the:
 - a. ultrasonic consolidation system
 - b. pro-metal system
 - c. the 612 modeler
 - d. the Eden 330 modeler

5. The Z810 modeler is known for it's:
 - a. low initial cost
 - b. extreme accuracy
 - c. speed
 - d. smooth finished surfaces

6. The Eden 330 system uses:
 - a. two print heads
 - b. wax modeling material
 - c. photopolymer material
 - d. powder-metal material

7. Room temperature vulcanizing is used primarily for:
 - a. jewelry models
 - b. tooling for low pressure injection molding
 - c. medical tool models
 - d. rubber products

8. Materials used to produce RTV tooling are:
 - a. silicone
 - b. metal powders
 - c. polymers
 - d. carbon based

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Answer Key

1. b
2. c
3. d
4. a
5. c
6. c
7. b
8. a