INTRODUCTION TO RAPID PROTOTYPING

Rapid prototyping (RP) is a new manufacturing technique that allows for fast fabrication of computer models designed with three-dimension (3D) computer aided design (CAD) software. RP is used in a wide variety of industries, from shoe to car manufacturers. This technique allows for fast realizations of ideas into functioning prototypes, shortening the design time, leading towards successful final products.

RP technique comprise of two general types: additive and subtractive, each of which has its own pros and cons. Subtractive type RP or traditional tooling manufacturing process is a technique in which material is removed from a solid piece of material until the desired design remains. Examples of this type of RP includes traditional milling, turning/lathing or drilling to more advanced versions - computer numerical control (CNC), electric discharge machining (EDM). Additive type RP is the opposite of subtractive type RP. Instead of removing material, material is added layer upon layer to build up the desired design such as stereolithography, fused deposition modeling (FDM), and 3D printing.

This tutorial will introduce additive type RP techniques: Selective Laser Sintering (SLS), Stereolithography Apparatus (SLA), FDM, Inkjet based printing. It will also cover how to properly prepare 3D CAD models for fabrication with RP techniques.

Rapid Prototyping (RP) can be defined as a group of techniques used to quickly fabricate a scale model of a part or assembly using three-dimensional computer aided design (CAD) data. What is commonly considered to be the first RP technique, Stereolithography, was developed by 3D Systems of Valencia, CA, USA. The company was founded in 1986, and since then, a number of different RP techniques have become available.

Rapid Prototyping has also been referred to as solid free-form manufacturing, computer automated manufacturing, and layered manufacturing. RP has obvious use as a vehicle for visualization. In addition, RP models can be used for testing, such as when an air foil shape is put into a wind tunnel. RP models can be used to create male models for tooling, such as silicone rubber molds and investment casts. In some cases, the RP part can be the final part, but typically the RP material is not strong or accurate enough. When the RP material is suitable, highly convoluted shapes (including parts nested within parts) can be produced because of the nature of RP.

Definition:

Rapid Prototyping is basically a additive manufacturing process used to quickly fabricate a model of a part using 3-D CAM data. It can be defined as layer by layer fabrication of 3D physical models directly from CAD.

What is Rapid Prototyping?

Rapid Prototyping is the "process of quickly building and evaluating a series of prototypes" early and often throughout the design process. Prototypes are usually incomplete examples of what a final product may look like. Each time a prototype is used, a formative evaluation gathers information for the next, revised prototype. This cycle continues to refine the product until the final needs and objectives are met. The following diagram demonstrates the non-linear nature of Rapid Prototyping.

Why Rapid Prototyping?

The reasons of Rapid Prototyping are

- To increase effective communication.
- To decrease development time.
- To decrease costly mistakes.
- To minimize sustaining engineering changes.
- To extend product lifetime by adding necessary features and eliminating redundant features early in the design.

Rapid Prototyping decreases development time by allowing corrections to a product to be made early in the process. By giving engineering, manufacturing, marketing, and purchasing a look at the product early in the design process, mistakes can be corrected and changes can be made while they are still inexpensive. The trends in manufacturing industries continue to emphasize the following:

- Increasing number of variants of products.
- Increasing product complexity.
- Decreasing product lifetime before obsolescence.
- Decreasing delivery time.

Rapid Prototyping improves product development by enabling better communication in a concurrent engineering environment.

How does Rapid Prototyping Work?

Rapid Prototyping, also known as 3D printing, is an additive manufacturing technology. The process begins with taking a virtual design from modeling or computer aided design (CAD) software. The 3D printing machine reads the data from the CAD drawing and lays down successive layers of liquid, powder, or sheet material — building up the physical model from a series of cross sections. These layers, which correspond to the virtual cross section from the CAD model, are automatically joined together to create the final shape.

Rapid Prototyping uses a standard data interface, implemented as the STL file format, to translate from the CAD software to the 3D prototyping machine. The STL file approximates the shape of a part or assembly using triangular facets.

Typically, Rapid Prototyping systems can produce 3D models within a few hours. Yet, this can vary widely, depending on the type of machine being used and the size and number of models being produced.

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TRENDS IN MANUFACTURING INDUSTRIES EMPHASIS THE FOLLOWING

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- Increase in product complexity
- Decrease in product lifetime before obsolescence
- Decrease in delivery time
- Product development by Rapid Prototyping by enabling better communication

HISTORICAL DEVELOPMENT

The development of Rapid Prototyping is closely tied in with the development of applications of computers in the industry. The declining cost of computers, especially of personal and mini computers, has changed the way a factory works. The increase in the use of computers has spurred the advancement in many computer-related areas including Computer-Aided Design (CAD), Computer-Aided

Manufacturing (CAM) and Computer Numerical Control (CNC) machine tools. In particular, the emergence of RP systems could not have been possible without the existence of CAD. However, from careful examinations of the numerous RP systems in existence today, it can be easily deduced that other than CAD, many other technologies and advancements in other fields such as manufacturing systems and materials have also been crucial in the development of RP systems. Table 1.1 traces the historical development of relevant technologies related to RP from the estimated date of inception.

Table: 1.1 Historical development of Rapid Prototyping and related technologies

Year of Inception	Technology
1770	Mechanization
1946	First Computer
1952	First Numerical Control (NC) Machine Tool
1960	First commercial Laser
1961	First commercial Robot
1963	First Interactive Graphics System
1988	First commercial Rapid Prototyping System

First Phase: Manual Prototyping

Prototyping had begun as early as humans began to develop tools to help them live. However, prototyping as applied to products in what is considered to be the first phase of prototype development began several centuries ago. In this early phase, prototypes typically are not very sophisticated and fabrication of prototypes takes on average about four weeks, depending on the level of complexity and representativeness. The techniques used in making these prototypes tend to be craft-based and are usually extremely labour intensive.

Second Phase: Soft or Virtual Prototyping

As application of CAD/CAE/CAM become more widespread, the early 1980s saw the evolution of the second phase of prototyping — *Soft or Virtual Prototyping*. Virtual prototyping takes on a new meaning