

RAPID PROTOTYPING TECHNOLOGY: APPLICATIONS, ADVANTAGES AND LIMITS - A REVIEW

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ABSTRACT: *Rapid Prototyping is an additive manufacturing technology which is used to produce prototypes, models, patterns, machine parts etc. using 3D CAD model which is designed by using CAD software. The prototype is used to check for the flaws in the design before the production and we can use the parts built by this process as patterns. It is also possible to build scale models by using Rapid Prototyping. This paper gives an overview of Rapid Prototyping, various techniques used in Rapid Prototyping like Stereo lithography, Fused Deposition Modeling, Selective laser Sintering etc., areas of applications, advantages and limitations of Rapid Prototyping.*

Keywords: *Rapid Prototyping, additive manufacturing, 3D CAD model, CAD software*

I. INTRODUCTION:

Most of the machining processes like facing, turning, drilling etc. are subtractive processes which mean removing of the material from feedstock to get final product. Whereas Rapid Prototyping is a material additive process which uses 3D CAD data to build the machine part, prototype etc. To manufacture prototype first we need to create a 3D model of the prototype by using any CAD software. In the next step convert 3D model CAD data to Rapid Prototyping compatible file format for example STL or IGES formats. Rapid Prototyping machine receives data in this format and creates a complete set of instructions for fabrication such as layer thickness, tool path etc. Rapid Prototyping machine then manufactures the object. After the printing completed object is subjected to post processing treatment for removing support material. Rapid Prototyping is used in various fields like product design, automobile industry, medical applications etc. Some of the Rapid Prototyping techniques to produce prototype are as follows-

- Stereo lithography (SLA)
- Laminated Object Manufacturing (LOM)
- Selective Laser Sintering (SLS)
- Fused Deposition Modeling (FDM)
- 3D Printing
- Solid Ground Curing (SGC)

II. LITERATURE REVIEW:

[1] 3D printing is a form of additive manufacturing technology which prints 3 dimensional object layer by layer by giving .STL format file as input to the 3D printing machine. Whereas traditional machining methods are subtractive processes which remove the material to manufacture the parts .Cell printers use techniques similar to Fusion Deposition Modeling (FDM) to print organs. Advantages and disadvantages of Rapid Prototyping (3D Printing) were also discussed here. [1], [2] Design process in which there are certain steps to create a model and the steps in design process are as follows- Creating a CAD model of the design, Converting the CAD model to STL format, Slicing the STL file into thin cross sectional layers, Layer by layer construction and finally Cleaning and Finish the part and also discussed about various techniques used in Rapid Prototyping such as Stereo lithography, Fusion Deposition Modeling and Selective Laser Sintering. Applications of Rapid Prototyping were also discussed here. [2] Rapid Prototyping used to manufacture a scale model of a part or assembly using 3D CAD, Computer Tomography (CT) and MRI data which shortens the required time to design a product. Challenges associate insight in Rapid Prototyping also discussed in this paper. [3] Applications of Rapid Prototyping in various fields like medical, textile, electrical, foot ware design, furniture design, architectural interior design etc. Challenges associate insight in Rapid Prototyping also discussed here. [4] Rapid Prototyping technologies with main features and specifications. Stages in design process methodology, Rapid Prototyping in architectural scale models along with case studies discussed here. [5] Discussed about Rapid Prototyping along with case studies and design process methodology. [6] Rapid Prototyping can produce the parts which are impossible to be produced conventionally in a single process. It is a review paper about Rapid Prototyping and discussed about characteristics, necessity, stages in design process methodology and also about

advantages and limitations of Rapid Prototyping. [7] Rapid Prototyping Technology transforms digital designs into 3D solid objects for production of machine parts, models etc. It builds solid objects one layer at a time. Rapid prototyping techniques are capable of performing the processes almost completely under computer control. Criteria specified by Burns to decide whether the process is Rapid Prototyping process or not also discussed here. About layered manufacturing in which objects are built as a series of horizontal cross sections and also the issues in layered manufacturing like stair-stepping, Layer thickness selection, Deviation from the CAD geometry, the use of support structures were also discussed in this paper. Applications of Rapid Prototyping, Rapid Manufacturing technology, Rapid Tooling Technology and benefits of Rapid Prototyping were also discussed. [8] It compared the different methods of Rapid Prototyping and also discussed about the applications of Rapid Prototyping in various fields like medical, manufacturing, design, aerospace and automotive applications. Summary of the literature review given in the table 1.

Table 1
SUMMARY OF LITERATURE REVIEW

S. NO.	AUTHORS	TITLE OF THE PAPER	DESCRIPTION	CONCLUSION
1	Nishad V. Chirde, Prof A.N. Shire, Sandip Dhopre	Overview of 3d Printing Technology for Rapid Prototyping	It is a review paper about 3D printing which discussed about various RP techniques such as Stereo Lithography, Fused Deposition Modeling and Selective Laser Sintering etc. Also discussed about applications, advantages and disadvantages of Rapid Prototyping.	Rapid Prototyping manufactures various products by adding material layer by layer using 3D CAD model. RP is one of the fastest growing new technologies.
2	Aman Kaushik, Suman kant, Parveen Kalra	Rapid Prototyping Technologies and Applications in Modern Engineering - A Review	It is a review paper about RPT and its applications This paper discussed about various RPT techniques like Stereo lithography, Laminated Object Manufacturing, Selective Laser Sintering, Fused Deposition Modeling etc. and also discussed about challenges associate insight in RP.	This paper briefly discusses with the numerous RP model related to the field of applications. Also discussed some of the factors are given for developing the RP techniques in Indian scenario.
3	R.Kumaravelan, V.C. Sathish Gandhi, S. Ramesh, M. Venkatesan	Rapid Prototyping Applications in Various Field of Engineering and Technology	The applications of Rapid Prototyping in various fields like medical, textile, electrical, foot ware design, furniture design, architectural interior design etc. Challenges associate insight in Rapid Prototyping also discussed.	Applications of RPT in various fields to create complicated and different contour products.
4	J. Sanchez, J. Gonzalez Prada, A. Oyarbibe	Using Rapid Prototyping for Free-Form Shapes in Architectural Scale Models	Rapid Prototyping used in architecture field to create the scale models of the buildings, sculptures etc. Stages in design process methodology and case studies also discussed here.	The architectural field can take benefits from RPT. It gives the architect to visualize the complex shapes not easily understood on conventional drawings.
5	Dheeraj Nimawat , Mahaveer Meghvanshi	Using Rapid Prototyping Technology In Mechanical Scale Models	Discussed about Rapid Prototyping, design process methodology and also discussed some case studies like impeller casting development, The product of top cover of the natural gas pump is prepared by Renishaw, UK etc.	Rapid Prototyping can be used to build a conceptual model or in later stages when details are needed. Mechanical field can also take benefit from Rapid Prototyping

6	Vishal K. Sapkal, Punam A. Bhamare, Arif K. Mansuri	Rapid Prototype: A Review	It is a review paper about Rapid Prototyping and discussed about characteristics, necessity, stages in design process methodology and also about advantages and limitations of Rapid Prototyping.	Authors concluded that the use of Rapid Prototyping technologies is essential in any Design fields and it can be used to build a conceptual model.
7	S. O. Onuh, Y. Y. Yusuf	Rapid prototyping technology: applications and benefits for rapid product development	This paper gave overview about RPT and its applications, benefits to industries also about problems facing the technology. Criteria specified by Burns to decide whether the process is Rapid Prototyping process or not also discussed here. About layered manufacturing and issues with layered manufacturing also discussed here.	Few technologies have offered as much as Rapid Prototyping in the last few years. Components, parts can now be produced in a fraction of time with reduced costs and more design iterations.
8	Dharipalli Hyndhavi, S. Bhanu Murthy	Rapid Prototyping Technology- Classification and Comprison	It compared the different methods of Rapid Prototyping. The layer height for SLA and SLS are same, but the layer height differs for FDM. Process parameters such as raster width, path speed etc. influence the accuracy of the part fabricated.	Rapid prototyping accelerates the manufacturing field. It also reduces the manufacturing cost and lead times.

III. RAPID PROTOTYPING TECHNIQUES:

Following are some of the techniques used in Rapid Prototyping to produce prototypes

a) STEREO LITHOGRAPHY:

It builds 3D models or prototypes or patterns from liquid photosensitive polymers that solidify when it is exposed to UV light. This machine consists a platform on which the model is built, computer controlled laser and a resin tank etc. The platform situated just below the surface in the tank of liquid photo polymerizing resin. Computer controlled laser traces out the first layer next the platform is lowered to a depth corresponding to the section's thickness and the first layer now covered with liquid resins and computer controlled laser forms the next layer on the top of first layer. This process repeats until the desired model is obtained. Remove the model from the build platform and rinse it in alcohol to clean the uncured resin from the surface. Next step is post curing to finalize the polymerization process. Stereo Lithography process shown in the figure 1.

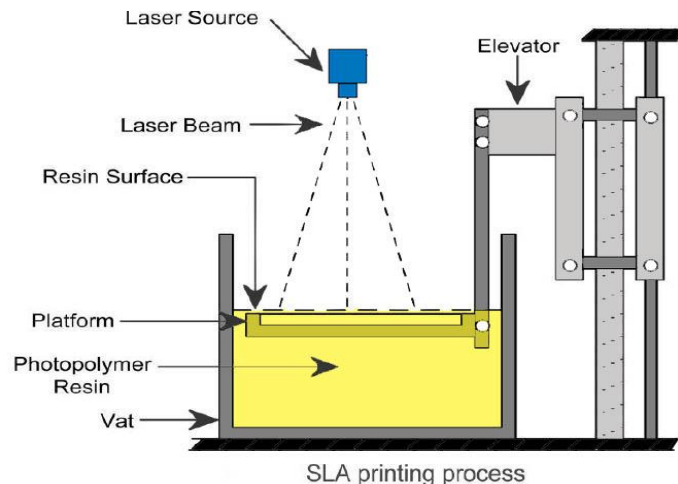


Figure 1: Stereo Lithography [9]

b) FUSED DEPOSITION MODELLING:

Fused Deposition Modeling is one of the 3D printing processes. It uses continuous filament of a thermoplastic material. In this technique, filament is supplied to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the thermoplastic filament and then the controlled extrusion head deposits thin beads of thermoplastic filament onto the build platform to form first layer. Build platform is maintained at low temperature so deposited thermoplastic hardens quickly. Next the build platform is lowered in order to start second layer. This process repeats until the desired model is obtained. Fused deposition modeling machine shown in the figure 2.

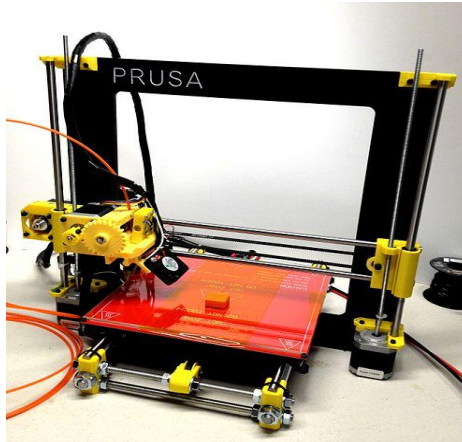


Figure 2: Fusion Deposition Modeling Machine [10]

c) SELECTIVE LASER SINTERING:

It uses a laser beam to selectively heat and fuse powdered materials. Models are built on the platform which is placed just below the surface in a container of heat fusible powder. Laser moves in a pattern to form first layer on the platform. Next the platform is lowered by one layer thickness, a new layer of material is applied on top of the first layer. This process repeats until the desired model is obtained. Excess powder in each layer supports the model during the process. Selective Laser Sintering machine shown in the figure 3.



Figure3: Selective Laser Sintering Machine [11]

IV. APPLICATIONS OF RAPID PROTOTYPING:

Rapid Prototyping is used in various fields like product design, automobile industry, medical applications, textile industry, foot ware design, furniture design, aerospace, automotive applications, also used in concept modeling, Finite Element Analysis and to make jewelry, sculptures etc.

V. ADVANTAGES:

- Design flaws can be detected before the production.
- Parts of complex geometry can be easily produced.
- It is possible to fabricate multiple parts into a single assembly.
- It can use multiple materials in the same model
- It is easy to communicate with the customers with the prototypes developed by Rapid Prototyping.

VI. LIMITATIONS:

- Cost of the machine is high
- Not suitable for large sized part development
- Stair stepping may takes place while processing

VII. CONCLUSIONS:

Rapid Prototyping is a material additive process which produces models, prototypes and patterns etc. using 3D data. It gives the designer, the possibility to visualize those complex shapes not easily seen or understood on conventional drawings, and touch them to verify the shape. Complex shapes can be obtained using CAD software. 3D data obtained from CAD software fed to the Rapid Prototyping machine after converting 3D data into Rapid Prototyping compatible format to manufacture the designed part. Industries using Rapid Prototyping to speed up the design process and also used for Rapid manufacturing which means the use of parts built by Rapid Prototyping as patterns in further manufacturing processes and we use this technology in Rapid tooling also. This paper discussed about Rapid Prototyping, some of the techniques used in Rapid Prototyping, areas of applications along with advantages and limitations of Rapid Prototyping.

VIII. FUTURE SCOPE:

In the future, Rapid Prototyping will be used for creating personalized things such as sculptures, toys, jewelry and also used in fashion industry to produce new looking objects and cloths. RPT can produce the parts with complex shapes which are impossible to produce by traditional methods in a single process, so it may replace the traditional machining methods in the future to produce the parts with complex shapes.

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