Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 5, May-2016

Review of Rapid Prototyping Methodologies and Future Scope

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Abstract:- The term "Rapid Prototyping" (RP) is defined as the set of technologies that automatically build models from computer-Aided Design .The "3 D printing" technique allow the designer to create solid prototypes of their desired designs rapidly and accurately than two dimensional pictures [1,2]. Engineering is aimed to improve the lives of the human race. The complete fraternity must therefore, work together towards the challenges facing us. To fulfil the engineering desires we need to fabricate prototypes before going in for mass production. This process of creating a prototype model takes about few weeks to few months [1, 3]. This is painfully slow but unavoidable process. Rapid Prototyping technology narrows down this process to few hours or few days depending upon the complexity of the model.

Keywords: Solid works, Rapid prototyping, Additive Manufacturing

I. INTRODUCTION

Rapid Prototyping (RPT) is a collection of different technologies that help us to rapidly & automatically build physical models from 3-D Computer Aided Design (CAD) data. It is relatively new process through Rapid Prototyping we can quickly fabricate scaled models of complicated designs without the need for machining and tooling process. This is the process in which the product is made by layer over the layer. The only thing which is required is a CAD model [1, 2].

A prominent set of five prototyping techniques are being used. They have their peculiar advantages and limitations. These technologies are enumerated below [6]:-

- Sterolithography (SLA)
- Selective Laser Sintering (SLS)
- Laminated Object Manufacturing (LOM)
- Three Dimensional Printing (3DP)
- Fused Deposition Modelling (FDM)

II. DESCRIPTION

Basic Process

All the RP methodologies use the same basic five steps. The steps are as follow:

- Make a CAD model of the design.
- Change the CAD File into the Standard Triangulated language(STL) format.
- Slice the STL model
- Make the model layer over layer.
- Finishing of the model.

A) CAD Model Making.

This is the first step in which we need to create the model of the object. This is done using numerous CAD software available at ones end. Few such software's like SOLIDWORKS, CATIA are very helpful in creating accurate 3-D models as compared to making drawing using the AutoCAD software [6]. These software's give the designer an option for creating a file specifically for prototype models or use existing CAD files from the library. This CAD model creation is first step for all Rapid Prototyping techniques [1].

B) Conversion of CAD File to STL Format.

Different CAD software's use different source codes and algorithms to represent 3-D objects. In order to formulate Industry standard, STL has been accepted as a benchmark in RP industry. The second step is now to convert the CAD file to STL format [3,6].

The file contains the coordinates of the vertices and the direction of the outward normal of each triangle. As the STL files use planar elements, they cannot represent curved surfaces precisely. If we increase the number of triangles it will improve the approximation. Large, complicated files require more time to pre-process and build.

C) Slice the STL File.

We need to optimise the build time of the model for which correct orientation of the 3-D object is essential. Orienting the shortest dimension of the model reduces the number of layers required for creating the model and thus reduces the model building time. In this orientation we can use pre-processing software's {1]. This software's orient the object and slice STL model into a number of layers with thickness varying as per build techniques starting from as thin as 0.01mm up to 0.7mm [3].

D) Layer by Layer Construction.

In this step Using one of some methodologies one layer is build up at one time from powdered metal. Some machines need a petite human interference.

E) Finishing of the Model.

Post processing is the last step in which prototype and the used supporting material is removed from the machine. Prototypes also need little bit maintenance.

III. RAPID PROTOTYPING METHODOLOGIES

A. Stereo lithography (SLA):

Stereo Lithography (SLA) is a process in which light sensitive fluid material is subjected to accurate thin beam of light sourced from LASER of halogen depending upon the accuracy desired. A bath of acrylic or epoxy resin is taken and light sourced and subjected on the bath as the algorithms generated. The resin is cured by the light which traces various layers generated by the computer modelling [1]. SLA methodology requires additional structure to create overhangs, undercuts and filigree model parts. Software's detect such parts which can not be created directly by SLA technique and these parts are generated separately to the main object. They are then refolded with the resin and merge with the main object. Tracing the layer is done by lowering the platform by the desired thickness of the layer and refolding it in resin. By the end of it all layers bind together to form a complete 3-D model. This model is then cured in UV light in an oven. The wetting is further improved by heating it to 30-40 deg Celsius. This heating reduces the viscosity [1,3]. Heating does not have any effect on the polymerisation which had taken place earlier due to the light exposure. Post curing is done by running the model in a light chamber to guarantee complete curing. By this method the area which were not exposed fully earlier are now exposed. The supporting structure holding the object in the correct orientation needs to be removed mechanically after curing [6]. The surface of the object is thereafter processed by polishing or coating. SLA technique in this manner provides for high accuracy with layer resolution between 0.05 to 0.15 mm. We also need to solve the inaccuracies which may creep in due to humidity and resistance to Ultra-Violet rays. When these two issues are solved, the object can thereafter be applied to an AM application. Direct serviceability can be achieved by using SLA method leading to broader applicability by targeted development.

Advantages: SLA models have close tolerance and good surface finish. Transparent model can be built as can models with some elasticity.

Disadvantages: both the machines and materials are expensive. Support structures must be removed from finished models. A post-curing apparatus is required and material properties degrade quite quickly.

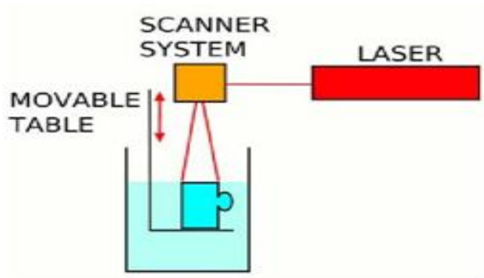

Figure 1 Diagram of Stereo lithography

B. Selective Laser Sintering (SLS):

Selective Laser Sintering is an additive methodology. It uses high power laser to melt and blend small particles of glass, metal or plastic powder into a mass and ultimately create the 3-D object [3]. The Laser picks up data from the CAD file or from scan data and then selectively fuses the powder material by scanning the laser beam on the cross section of the powder material. After one cross-section is fused the platform is lowered and next layer is subjected to the laser scanning. In this manner the complete part is fabricated rapidly [1,3].

Figure 2 Diagram of Selective Laser Sintering

C. Laminated Object Manufacturing:

In this process paper of laminated material is put on a roll. The roll is spread on the platform and then sliced as per the layer configuration using a laser or mechanical blades. This layer is then stacked on the previous layer cut and then subjected to a heated roller which fuses both the layers. In a paper roll the bottom side is plastic coated which melts and fuses by the hot roller [2]. The profiles are cut using an optics system mounted on a 2-D stage. After the cutting the extra paper is removed from the sides and rolled back. In this process the overhangs and undercuts are automatically taken care of. However, removing some geometry from the middle of the paper can be time consuming [4]. Portions which need to be removed in the final object are cross hatched by laser

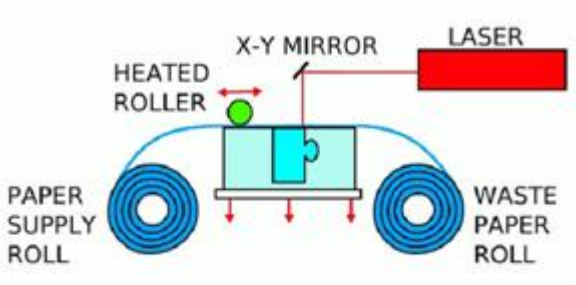

Figure 3 Diagram of Laminated Object Manufacturing

D. Three Dimensional Printing :

The process starts by depositing a layer of powder object material at the top of a fabrication chamber. In order to achieve this, a calculated quantity of powder is first dispensing as of related supply chamber by moving a piston upward incrementally. A roller distributes and compresses the powder to the top of the fabrication chamber [1, 6]. The multi-channel jetting head later deposits a liquid adhesive in 2D model on top of the layer of the powder. The liquid adhesive bond the powder together, after that is solidifies to shape a layer of the objective [1].

When a layer is finished, the piston move toward downward by single layer thickness, the process is repetitive in anticipation of the whole object is formed and when the process ends, object will be removed from the chamber and then the surplus powder will also get removed [3]

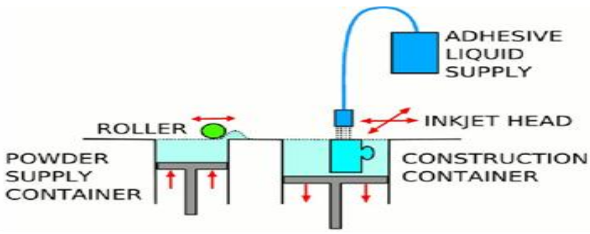

Figure 4 Diagram of Three Dimensional Printing

E. Fused Deposition Modelling :

After Stereo lithography FDM is the most generally used RP technology. A plastic thread is unwound from the coil and supplies material to the nozzle. The plastic got melt when the nozzle is heated and it has a mechanism by which we can turn on or off the flow of melted plastic. The nozzle is mounted to an X-Y plotter type mechanism which traces out the part contours; there is a second extrusion nozzle for the support material [1].

As the nozzle is moved over the table in the required geometry, it deposits a thin bead of extruded plastic to form each layer. The plastic hardens without delay after being squirt from the nozzle and make a bond to the layer below. The object is built vertically downward layer by layer as the part is formed [6]. The whole system is controlled within a chamber maintaining temperature just below the melting point of the plastic.
The procedure is very friendly. FDM is quite speedy for little or small parts. It may be very slow for huge parts.. The resolution is not as fine as with stereo lithography, but the parts are more robust [3].

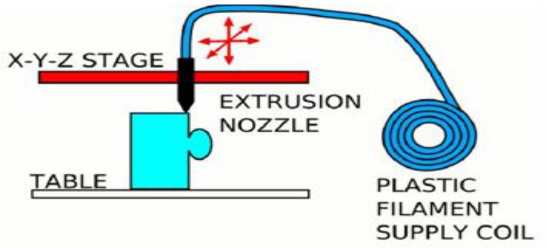

Figure 5 Diagram of Fused Deposition Modeling

IV. Future Development and Scope

Future development and scope:

RPT has a bright future; it can bring down the process time and pattern making as well as model making time. There are however few challenges as mentioned below:-

- The cost of equipment is still high.
- Not all material, especially metals can't be processed easily.
- The strength of parts obtained by giving is limited

Future efforts need to be made

- To develop fabrication of models using metal and ceramics.
- Application of design of experiments.(DOE) to get the optimum variable and their ranges could be done.
- Environmental friendly parameters can be considered for fabrication.

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