

3D Printing Using Fused Deposition Modelling (FDM)

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Abstract- Fused Deposition Modelling (FDM) is an Additive Manufacturing Technology for printing 3D objects layer by layer. The main purpose of the research is to develop a low cost 3D Printer using easily available materials and conventional methods for fabrication which can be used to print objects confined within 200x200x200 (in mm) Printing Area. Many Industries today uses traditional methods for developing proto type for analysis rather than using technologies like 3D printing because it is expensive.

After thorough market survey, we came to a conclusion that 3D Printers available in the Indian market are priced around Rs.50,000 to 60,000 due to type of supporting material used. Main objective of research is to develop a printer which is cost effective and to encourage manufacturers to adopt the method of 3D Printing.

Keywords- Fused Deposition Modelling (FDM), Polylactic Acid (PLA), ABS, CAD

I. INTRODUCTION

3D printing (or additive manufacturing, AM) is any of various processes used to make a three-dimensional object. In 3D printing, additive processes are used, in which successive layers of material are laid down under computer control. These objects can be of almost any shape or geometry, and are produced from a 3D model or other electronic data source. A 3D printer is a type of industrial robot. 3D printing in the term's original sense refers to processes that's equentially deposit material on to a powder bed within kjet printer heads. More recently the meaning of the term has expanded to encompass a wider variety of techniques such as extrusion ands intering based processes. Technical Standards generally use the term additive manufacturing for this broader sense.[1].

A. How FDM Works

3D printer that run on FDM Technology build parts layer-by-layer from the bottom up by Heating and Extruding thermoplastic filament. The process is simple:

- **Pre-processing:** Build-preparation software slices and positions a 3D CAD file and calculates a path to extrude thermoplastic and any necessary support material.
- **Production:** The 3D printer heats the thermoplastic to a semi-liquid state and deposits it in ultra-fine beads along the extrusion path. Where support or buffering is needed, the 3D printer deposits a removable material that acts as scaffolding.
- **Post-processing:** The user breaks away support material away or dissolves it in detergent and water, and the part is ready to use.
- **FDM Benefits**
 - The technology is clean, simple-to-use and office-friendly
 - Supported production-grade thermoplastics are mechanically and environmentally Stable
 - Complex geometries and cavities that would otherwise be problematic become practical with FDM technology

FDM, a prominent form of rapid prototyping, is used for prototyping and rapid manufacturing. Rapid prototyping facilitates iterative testing, and for very short runs, rapid Manufacturing can be a relatively inexpensive alternative. FDM uses the thermoplastics ABS, ABSi, polyphenylsulfone (PPSF), polycarbonate (PC), and Ultem 9085, among others. These materials are used for their heat resistance properties. Ultem 9085 also exhibits fire retardancy making it suitable for aerospace and aviation applications.

FDM is also used in prototyping scaffolds for medical tissue engineering applications. [4]

a. Polylactic Acid (PLA)

We have used 3D Printing filament as Polylactic acid or polylactide (PLA, Poly) which is a biodegradable thermoplastic aliphatic polyester derived from renewable resources, such as cornstarch (in the United States), tapioca roots, chips or starch (mostly in Asia), or sugarcane (in the rest of the world). In 2010, PLA had the second highest consumption volume of any bioplastic of the world.[14] The name "polylactic acid" does not comply with IUPAC standard nomenclature, and is potentially ambiguous or confusing,

because PLA is not a polyacid (polyelectrolyte), but rather a polyester.[3]

B. Complete Design and Fabrication of 3D Printer

Complete design of 3D Printer was made taking into consideration the printing area. Fabrication of frame and base along with the other supporting structure was made using low cost and lightweight materials.

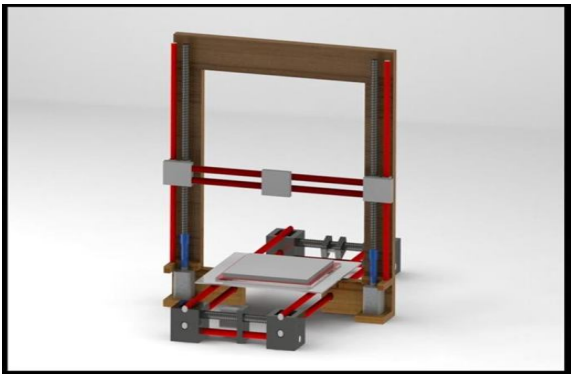


Figure 1: Complete design of 3D Printer[6]

C. Printing Process

STEP 1: Part Design in Solid works

There are various steps involved in the process of printing of a part or model using a 3D Printer. here all the steps involved in the printing process in our 3D Printer are explained in detail.

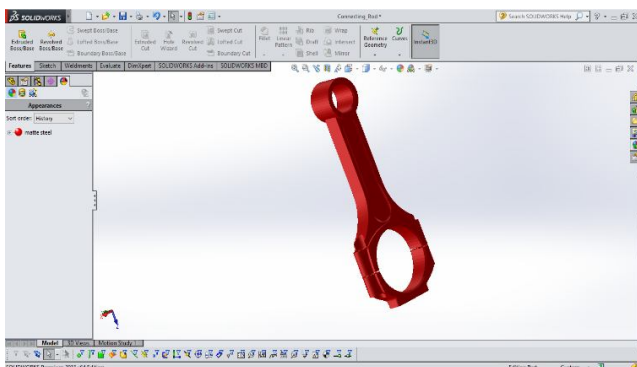


Figure 2: Part design in solidworks

The first and foremost step in the process of 3d Printing is to design the part or model to be Printed in any of the 3D Modelling Softwares such as Pro-E, Catia, Solid works... etc.

- In our case we had used Solidworks 3D Modelling Software to design a part for example in this case a Twisted Hexagon with a circular cut in between.

- Required dimensions for the part to be printed is decided in the design stage for example the height of this hexagon is 15mm.

STEP 2: Saving the Design in .STL format

- The designed file is saved as .STL format (STereoLithography).This file format is supported by many software packages; it is widely used for rapid prototyping, 3D printing and computer-aided manufacturing.
- An STL file describes a raw unstructured triangulated surface by the unit normal and vertices (ordered by the right-hand rule) of the triangles using a three dimensional Cartesian coordinate system.

STEP 3: Opening file in Cura Software

- The .STL file is opened in Cura Software (open source software)where the view of the object or the position in which the object would be printed can be seen.
- After checking the view the G-code of the design in this case a object can be generated by clicking on the option ‘ExportG-Code’.

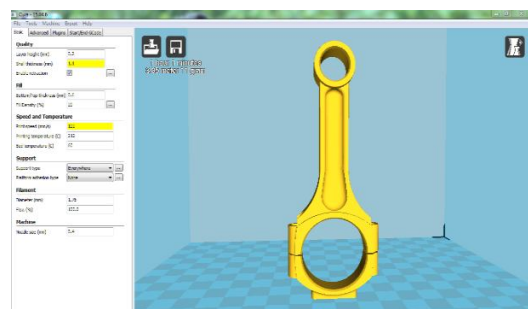


Figure 3: Part design in SlicingSoftware Cura-15.04.6

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Connecting_Rod.gcode - Notepad
File Edit Format View Help
M100 S60.000000
M109 S210.000000
:Silenced at: Sat 21-10-2017 11:54:30
:Basic settings: Layer height: 0.2 walls: 1.2 Fill: 20
:Print time: 2 Hours 11 minutes
:Filament used: 6.614m 19.0g
:Filament cost: None
M100 S60 ;uncomment to add your own bed temperature line
M109 S210 ;uncomment to add your own temperature line
G21 ;metric values positioning
G90 ;set extruder to absolute mode
M107 ;start with the fan off
G28 X0 Y0 ;move x/y to min endstops
G1 Z15.0 F6000 ;move the platform down 15mm
G02 E0 ;zero the extruded length
G1 F200 E3 ;extrude 3mm of feed stock
G02 E0 ;zero the extruded length again
G1 F6000
:Put printing message on LCD screen
M117 Printing...
:Layer count: 623
:Layer:0
M107
G0 X74.265 Y92.212 Z0.200
L1 YPF:SKIRT
G1 F1200 X74.265 Y92.240 E0.03233
G1 X74.665 Y92.183 E0.04577
G1 X74.665 Y92.177 E0.04594
G1 X79.287 Y91.523 E0.20123
G1 X80.951 Y91.177 E0.22664
G1 X81.934 Y91.901 E0.29052
G1 X83.576 Y92.817 E0.35349
G1 X84.368 Y91.609 E0.34371
G1 X84.175 Y93.218 E0.37776
G1 X85.289 Y94.133 E0.42625
G1 X86.192 Y91.870 E0.54899
G1 X86.958 Y92.531 E0.50385
G1 X88.193 Y91.870 E0.58590
G1 X89.313 Y91.870 E0.73554
G1 X90.365 Y88.323 E0.73554
G1 X109.365 Y91.870 E1.48878
G1 X110.365 Y91.870 E1.53428
G1 X110.733 Y91.875 E1.53428
    
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Figure 4: G-Code of .STL object from Cura

II. CONCLUSION

The intention behind this research was to develop a low cost 3D Printer with good surface finish by using materials which are easily available and cost effective. We have been successful in reducing the cost to a considerable extent i.e about 10-15 %. The parts made in 3D design software are successfully imported in the printing software and the product obtained has the same dimension given during the design stage of the product i.e an accuracy close to 100%. It is possible to fabricate 3D printer according to its virtual design proposed at reduced cost

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