Design and Fabrication of Polymer Based 3d Printer Model Using FDM Technique

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Abstract: *The process of 3D printing, which is also called as Additive Manufacturing (AM) has been applied in different fields such as aerospace, automotive, biomedical, and energy industries. In recent years, FDM technology (Fused Deposition Modeling) has become one of the most widely-used rapid prototyping methods for various types of applications. This method is based on fused fibre material deposition on a drop-down platform, which offers the opportunity to design and introduce new materials, including composites. The material most commonly used in FDM is ABS, followed by PC, PLA, PPSF, ULTEM9085 and their combinations. This report is on the development of a low cost FDM based 3D Printer using easily available materials and conventional methods for fabrication without compromising on features and functionality. The methodology used along with the various parts used and their detailed functions are listed. The materials and the design used for 3D printing were selected on the basis of availability and cost effectiveness. The designs for the printer parts and assembly were made through computer software and all the necessary electronic components were procured. The fabrication of parts was made though CNC machining as well as 3D printing. The parts were finally assembled together and fitted with the electronic components to make the finished 3D Printer model. This report also shows its various applications along with the type of materials used. The advantages, limitations and alternatives of the process are also evaluated. This study help in understanding the design and fabrication process of a cost effective FDM based 3D printer.*

Keywords: *Additive manufacturing, Fused deposition modeling, Acrylonitrile butadiene styrene, 3D Printing*

I. Introduction

1.1 Additive Manufacturing

Additive Manufacturing as we know is a process or a technologies which builds 3D objects by adding layer upon layer of material. The material which can be used for building of layers can be plastic, metal, concrete and one day human tissue. The things common for the usage of the AM technologies is a computer, 3D modelling software or CAD, machine equipment and layering material. So when the model is designed in the CAD or the modelling software, the CAD file is read by the AM equipment and according to g-code generated it will lay down or add successive layers of liquid, powder or other in layer upon layer fashion to fabricate a 3D object.

There are different types of subsets present in Additive Manufacturing technologies itself like 3D printing, Rapid Prototyping, Direct Digital Manufacturing, Layered Manufacturing and Additive Fabrication. AM technologies have developed many applications over the recent years, like from the early use which had a focus on the preproduction visualisation model to building end products in aircraft, dental restoration, medical, automobiles and so on over the recent years. [3]

1.2 3D Printing

3D printer is a device which creates three dimensional objects. A 3D printer has the same functions like a normal printer as it receives digital data from the computer as its input, but instead of printing the output data on the normal page the 3D printer prints or builds the output model in the form of 3D dimensional object.

3D printing is a term which covers a variety of processes by itself. The process includes joining of material which are in the form of liquid molecules or powdered grains which are fused together and later kept to solidify to create a 3D dimensional object. All these processes which are carried out from joining to solidifying are all controlled by the computer. So the software in the computer keeps a note on how much the extruding material has been used to defining the cost of the complete model. [1]

1.3 FDM Technique

FDM also known as Fused Deposition Modelling is a 3d printing technique in which the raw material which is the form of thin filament is extruded through a heated nozzle and is deposited on the heat-bed where it solidifies. The next layer which is extruded will fuses with the bottom layer and will continue to fuse until required dimensions of the design model is obtained. The filament which has to be extruded can be thermoplastic

polymers. so the benefits of using the technique is that its clean, environment friendly, simple to use, complex geometric and cavities can be made very easily and there is no wastage of filament material. [4]

1.4 Acrylonitrile butadiene styrene

Acrylonitrile butadiene styrene or ABS as we know is a terpolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. It has 15-35% acrylonitrile, 5-30% butadiene and 40-60% styrene. ABS tends to be stronger than pure polystyrene because of the presence of nitrile bonds being polar they attract the neighbouring chains and make the bond stronger. The presence of styrence gives the polymer a shiny and impervious surface. The toughness at low temperature in ABS is due to the presence polybutadiene.

II. Design And Construction

2.1 Base and Frame

The design of base and vertical frame of the Printer was made using Solid Works software. The fabrication of the same was done using CNC machine. The material used was wood.
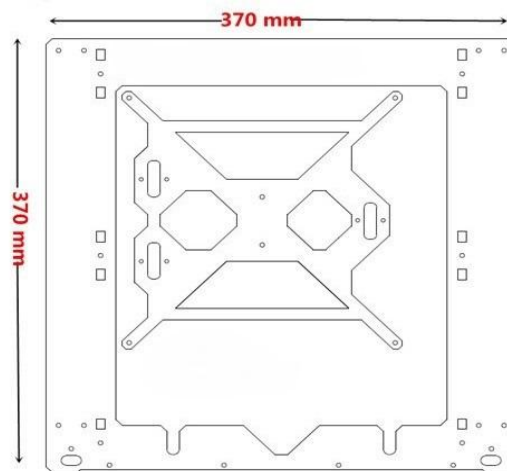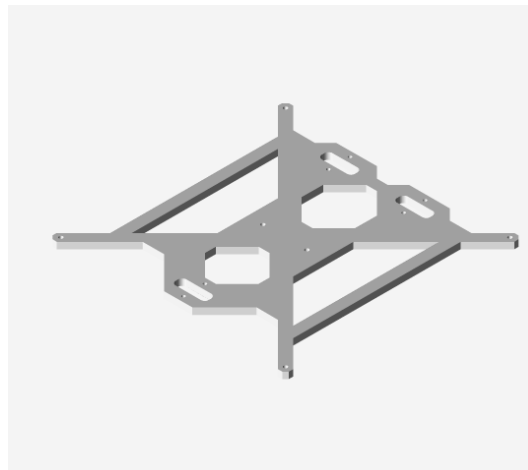

Figure 1 Design of Base frame and Vertical frame

Figure 2 3D model of the Base frame

2.2 Construction and Assembly of X, Y and Z-axis

Rods used for these assemblies were of steel and the holders, guides, hinges, covers etc. were made from PLA using another 3D printing machine. The X, Y and Z-axis components were assembled together as shown in the figures below.
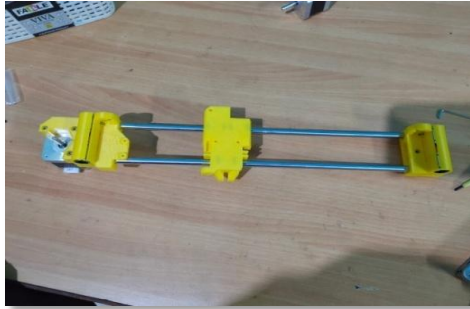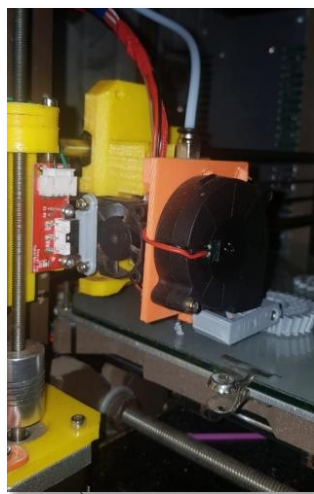
Fig 3 X axis assembly

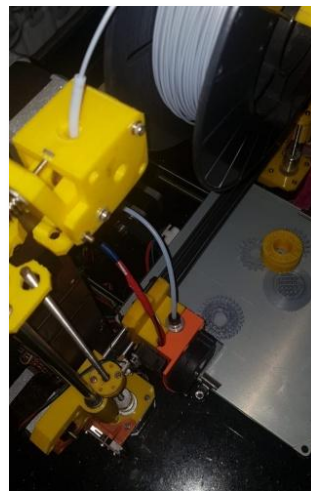**Figure 4** Y axis assembly

Figure 5 Z axis assembly

2.3 Extruder Assembly

The method of extrusion used was Bowden Extrusion. The extruder was fitted on the frame of the printer and the hot end was fitted on the X-axis. A tube was used which connected the extruder to the heating element and pushed the filament through it.

a)   b)

Figure 6 a) and b) Extruder assembly

2.4 Electronic Assembly

The Arduino Mega 2560 board was mounted on the Z axis frame over which the RAMPS 1.4 daughter board was fitted. The stepper motor drivers, end stop controls, heatbed controls, extruder pins, PSU pins etc were connected to the RAMPS 1.4 board.
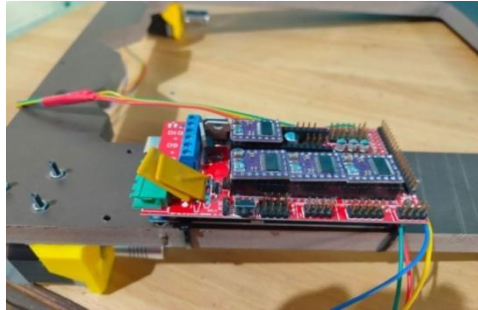

Figure 7 Electronic Assembly

2.5 Final Assembly

  The X, Y, Z assemblies where fitted together on the base and vertical frame. After that the electronic parts such as End stops, Arduino board, PSU unit and also the Extruder were fitted on the vertical frame of the printer. The final completed build of the 3D printer is shown below.
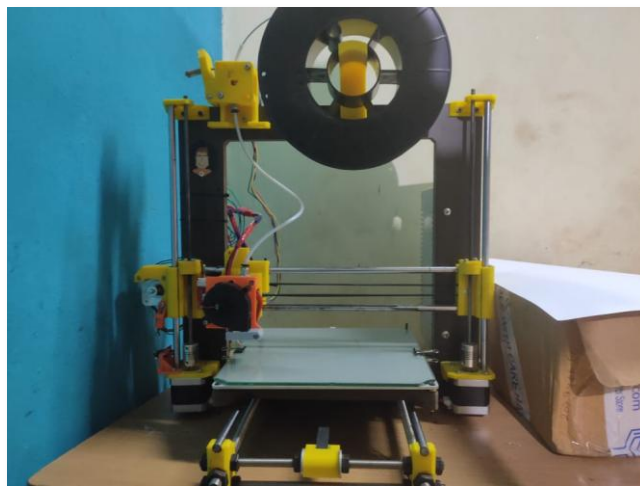

Figure 8 Final Assembly

III. Process Procedure Chain

1) Designing the model
2) Converting the designed model into STL format
3) Slicing the STL file and generating the G-code
4) Machine setup and transferring the G-code to the printer
5) Removal
6) Post-processing

1) Designing the Model:

  All Additive manufacturing parts start from a software model that fully describes the external geometry of the model, this can involve the use of any CAD software regardless the output is in a 3d solid format, the different softwares that can be used are AutoCAD,Fusion360,Solid works, CATIA, Onshape, Solid edge, Turbocad etc
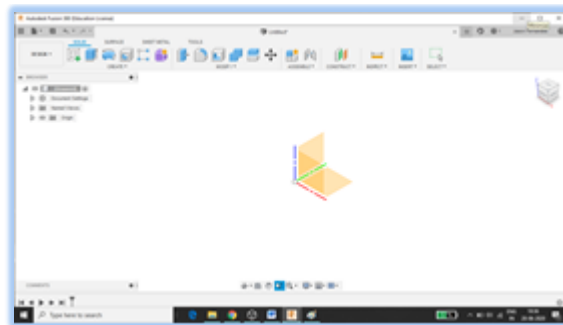
a)
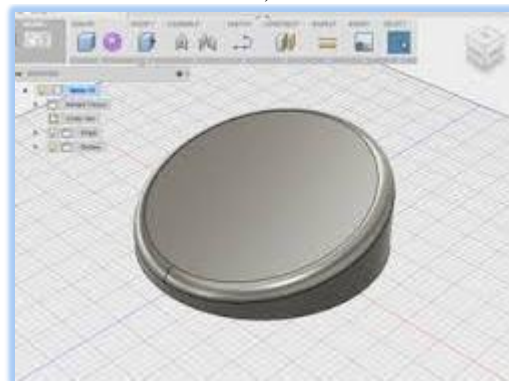
b)

Figure 9 a) and b) Images of Designing application (Fusion 360)

2) Converting the designed model into STL format:
It is a very important step that is carried out after the designing process where in the designed model is converted to STL format where STL (Standard Triangle Language) so that it can proceed the slicing of the model.

3) Slicing the STL file and generating the G-code
The **Slicer,** is a computer software used in the majority of 3D printing processes. It is used for the conversion of a 3D object model to specific instructions for the printer. The instructions for the printer are in G-codes.
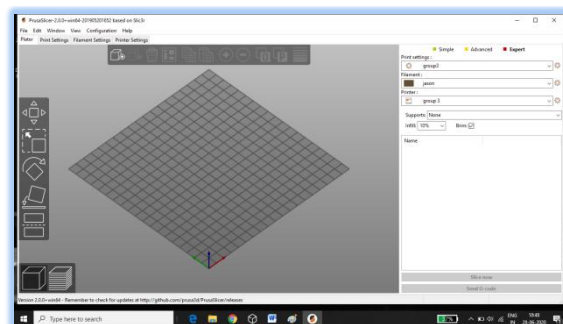

Figure 10 Image of Slicer (Slicing software)

4) Machine setup and transferring the G-code to the printer
Machine setup is one of the important steps that involve the calibration of the 3d printer bed and its surrounding. Once the printer is set we are ready for the transfer of the G-codes the 3D printer, the transfer of the G-codes to the printer can be done though PC as well as through an SD card, through a PC, we can use a software called as Prontaface that can send the signals to the 3D printer or else through a SD card we can directly transfer the G-code file to the SD card n insert it in the slot in the printer to print the designed model
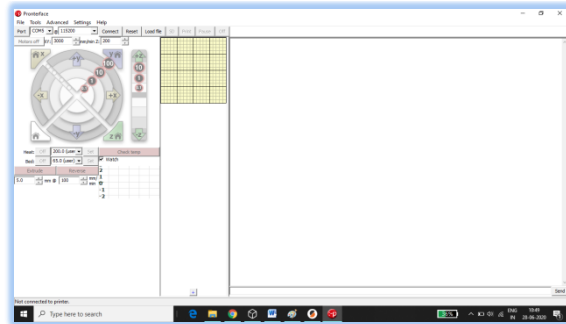
Figure 11 Image of software Prontaface

5) Removal

After the 3D model is printed on the printer it is removed from the bed of the 3D printer but it cannot be removed soon after the print is complete we have to wait for the decrease in the temperature of the bed so that the printed part can be removed easily if removed before there are possibilities of the printed model to get destroyed as it is sticking to the bed of the 3D printer

6) Post processing

Post processing involves the removal of the supporting material and also the polishing of the surfaces of the printed model.

Figure 12 Finished product

IV. Conclusion

The main goal for this research was to develop a low cost 3D printer, using materials which are easily available and also cost effective. We were successfully able to reduce its cost about 40-50% by building most of the parts using another 3D printer (which also makes it a self replicating printer) and by making the frame of the printer using wood. Using the low cost printer, we were able to achieve 90% accuracy.

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