Design and Fabrication of Cartesian 3D Printer at Low Cost

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Abstract:- 3D printing is called as desktop fabrication. It is a process of prototyping where a structure is synthesized from a 3D model. The 3D model is stored in as an STL format and after that forwarded to a 3D printer. Then the 3D printer creates 3D parts by depositing materials layer by layer. Hence it is also called as Additive manufacturing. It can use a wide range of materials such as ABS, PLA, etc., The 3D printer which we are manufacturing can produce the products of size up to 229x229 mm. This work is carried out to make a 3D printer available at a lower cost than the 3D printer available in the market and also to make it easy to operate. We designed the parts of the 3D printer in Solid works and 2D drawings of the parts. After the Fabrication, a part is printed using the 3D printer to check the print quality. To make it easy to use we are installing an SD card reader in the 3D printer to input the program into the 3D printer instead of using a computer.

Keywords: Low cost 3D printer, Fusion deposition method, Design of 3D printer, Cartesian 3D printer, 3D printer.

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1. Introduction

Scientists and engineers are impressing us daily with revolutionary technologies that turned what was recently considered as science fiction or inconceivable futuristic into reality, making our lives much easier and more interesting. For example we had never imagined being able to make our own designed glasses frame, kid's toys, or any other prototypes at our home using raw materials and a single machine. The 3D printing technology enables us to do this and it has much more complicated applications in science and industry.

3D printing (3DP) is a term to describe technology used for the rapid production of 3D objects directly from digital computer aided design (CAD) files. [2]

3D printing technologies first became visible in the 1980s; at that time they were called Rapid Prototyping (RP) technologies. The very first patent application for RP technology was filed by Dr. Kodama in 1985. He became the co-founder of the 3D corporations which is one of the largest and most major companies in the field of 3D printing and rapid prototyping.

The 3D printing process allows 3D objects to be fabricated in a bottom-up, additive fashion directly from digital designs, with no milling or molding. It can be likened to clicking on the print button on a computer and sending a digital file, such as a letter, to a printer sitting on an office desk. The difference is that in a 3D printer the material or ink is deposited in successive, thin layers on top of each other to build-up a solid 3D object. [3]

3D printing or additive manufacturing (AM) is a group of technologies that are used to build prototypes, physical models and finished parts from three-dimensional (3D) computer aided design (CAD) data. Study showed the technology has developed rapidly and has proven its effectiveness, especially for design and small production. According to research, AM technology allowed for the direct fabrication of physically complex shapes from its by using a layer-by-layer deposition technique. [1]

3D printing is also called as Additive manufacturing because of its working procedure. 3D printer manufactures a product by laying successive layers of the molten plastic one above the other. Most commonly ABS or Nylon is used as raw material for printing. There were other printing methods before but a 3D printer is an improvised version of all of them. But the principle followed by them is almost similar.

2. Material and Methodology

2.1 Objectives under Study:

- To design and fabricate a 3D printer with low cost.
- To produce 3D Printer compatible to use with SD card for program input.

2.2 Working Principle:

Fusion Deposition Modeling:

The Fusion Deposition Modeling is the working principle of the 3D printer. It uses the thermoplastics; which constitute ABS (Acrylonitrile butadiene styrene), wax, and nylon. The introductory venture of the FDM procedure was to warmth up the thermoplastic constituent until it is at an intertwined state.

Then the 3D printer uses advanced demonstrating information from a CAD record to create the 3D item layer by layer, the printer join a much weaker bolster composite. The bolster material goes about as a framework for the test item. This is valuable amid the building procedure when parts have overhangs that could not bolster it. The thermoplastic for the most part has a filamentous structure that benefits warmth exchange and serves to move with a print head that navigates in the x and y bearings. After every layer is printed, a cylinder navigates the stage beneath (z-hub) the separation of the thickness of the printed layer. There are numerous benefits of FDM innovation; it is anything but difficult to control, use, and fix. The major advantage of this process is the reduction in wastage of the raw material while printing. Whereas the part manufactured using this process does not need any kind of finishing process like cutting down extra projections, grinding, polishing, etc., Therefore the over manufacturing time is reduced as compared to conventional manufacturing processes. Hence the raw material is used completely without any wastage.

2.3 Flow chart of work:

International Journal of Scientific & Engineering Research Volume 11, Issue 6, June-2020
ISSN 2229-5518

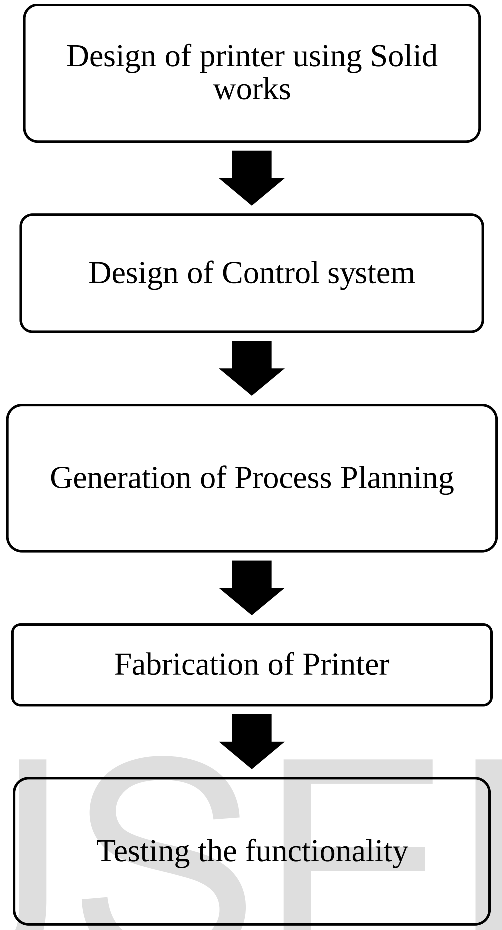

Figure 1.1: Flow chart of project

2.4 Design of 3D Models of 3D Printer:

Extruder:

Extruder shown in fig 2.1 is a device that performs a specific process called Extrusion. The process of extrusion means, initially the given input raw material will be in solid-state, to spray the material through 0.4 mm nozzle, the solid material should be converted into its molten state. Further the raw material is passed through the Heat block inside the Extruder, which converts solid into the molten state by its temperature around 210°C-230°C.

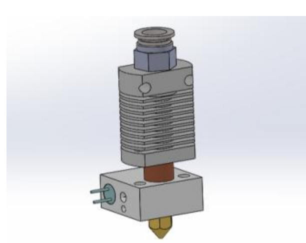

Figure 2.1: Extruder

Heatbed:

International Journal of Scientific & Engineering Research Volume 11, Issue 6, June-2020
ISSN 2229-5518

The hot bed shown in fig 2.2 is where the Extruder deposits the filament to print a 3D part. The Hot bed will also moves in X direction with the help of wheels to facilitate the extrusion process. The heat bed is fitted with the heaters to raise the temperature of the hot bed up to 100°C. The temperature is raised to prevent the sticking of the print throughout the printing process.

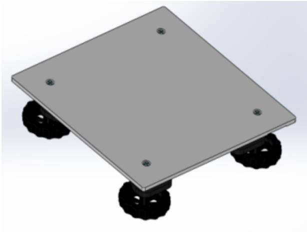

Figure 2.2: Heatbed

Wheel with bearing:

The wheels are fitted with the bearings of high-quality 625ZZ Bearings as shown in fig 2.3. The features and advantages includes, Smooth motion, low noise, can greatly improve the printing speed. Parts of the printer like extruder, Heat bed are fitted with these wheels, these wheels settle in the guide ways of the aluminium profile. Therefore the parts can be moved by rolling wheels in the guide ways.

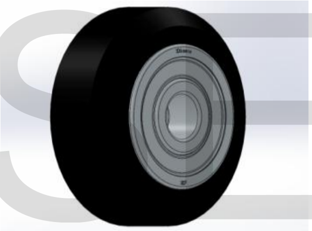

Figure 2.3: Wheel with bearing

Gt2 Timing pulley:

The Aluminum GT2 Timing Pulley shown in fig 2.4 is meant for use with GT2 6mm wide belts only – MXL belts will slip due to the different tooth profiles. This pulley has 20 teeth and an 8mm inner bore. Two set screws can be used to attach it firmly to any 8mm diameter shaft. This pulley helps to draw power from the stepper motor with the help of the belt which is responsible for extrusion in X and Y directions.

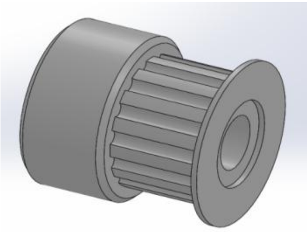

Figure 2.4: Gt2 Timing Pulley

Aluminium profile:

The Standard Anodized profiles are made up of High grade tempered Aluminum alloy 6063 - T5. The structural cross-section thickness of the profile is 1.5 mm. The profile is used for building the structure of a 3D printer. The profile is anodized in natural aluminum colours to provide a hard layer to prevent corrosion and wear. The profile has guide ways for the rollers embedded in the profile structure itself as shown in fig 2.5. We use nuts and bolts to assemble the profiles.

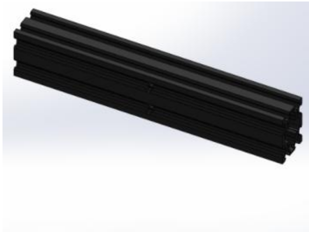

Figure 2.5: Aluminium profile

Complete assembly:

After assembling all the designed parts of a 3D printer, the complete assembly of a 3D printer looks like the fig 2.6.

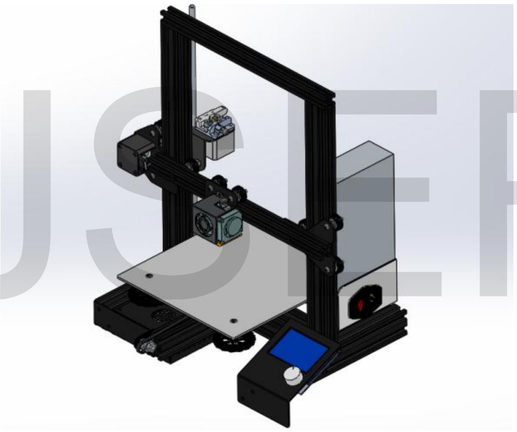

Figure: 2.6

2D Drawings:

Since the designed parts are in 3D form, the dimensions of the parts cannot be identified. To know the dimensions of the parts the given 3D parts are converted to 2D drawing as shown in fig 2.7 using Solid works software.

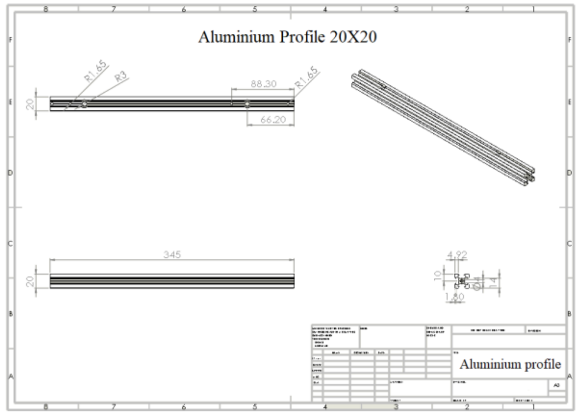

Figure 2.7: 2D drawing of Aluminium profile

2.5 Printing process:

Initially the 3D printer is kept in idle state for few minutes to allow the Extruder to attain stable temperature to facilitate uniform printing process. After the temperature is stable, the filament is pushed into the nozzle through the Heat block, which causes the melting of the filament. Based on the dimensions of the part to be printed, the extruder moves in X, Y and Z directions. For the movement of extruder, the extruder is mounted on the wheels settled in the guide ways in the Aluminium frame. Theses wheels are driven with the help of NEMA 17 motors through belts and the screw rod. The part is printed on the Heat bed. The Heat is bed heated up to certain temperature to prevent the sticking of the print.

3. Results and discussion:

Item	Quantity	Cost
Aluminium profile	4 meters	1648
Heatbed	1	760
Wheels with bearings	9	798
Y Belt	2	180
Nuts and bolts	18	20
pulley	2	180
Lead screw	1	600
Mechanical end switch	3	210
Coupler	1	200
Bracket	1	140

Filament	1	300
Cooling Fan	1	150
Extruder set	1	1700
Power supply unit	1	980
LCD display	1	803
NEMA 17 motor	4	2360
Wiring	1	200
SD card	1	120
Software usage	-	1500
Miscellaneous	-	300
Total cost	-	13149

Table 1: Cost estimation of the 3D printer.

4. Conclusion:

The cost of a 3D printer is reduced.

The variation between the manufactured 3D printer and the 3D printer available in the market is around 2000 INR.

The selected extruder nozzle diameter gives better printing speed and uniformity.