Design And Fabrication 3D Printer

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A B S T R A C T

3D printing (also known as additive manufacturing) is an alternate design and manufacturing technology. 3D printers print objects from a digital template to a physical 3-dimensional object. The printing is done layer by layer (additive manufacturing) using plastic, metal, nylon, and different other materials. 3D printing has been extensively used in sectors such as manufacturing, automotive, aeronautical, industrial design, architecture etc. Most of the existing industries mainly use traditional manufacturing processes whereas additive manufacturing only adds up to a fraction of these existing methods. Additive manufacturing in comparison with subtractive manufacturing differ when it comes to material management. Additive manufacturing requires far less amount of material to manufacture a product when compared to the amount of material required by subtractive manufacturing to build the same product. And there is negligible material wastage in additive manufacturing when compared to subtractive manufacturing. Additive manufacturing has several advantages, such as flexible design, lower resource requirement, and substantial savings on tooling as compared to traditional manufacturing technologies such as Computer Numerical Control (CNC) machining, moulding, and casting. It has been found to be a fast and cost-effective solution in whichever field of use. The applications of 3D printing are ever-increasing and it's proving to be a very sought-after technology. In this project, we are going to build a low-costFDM printer.

Keywords:3D Printing, Additive Manufacturing, Design, Materials, Alternate

1. Introduction

A 3D printer is a computer-aided manufacturing (CAM) machine similar to a CNC device that creates three-dimensional objects. Like a traditional printer, a 3D printer receives digital data from a computer as input. However,a 3D printer builds a three-dimensional model out of special materials.3D printers use a process called additive manufacturing to form physical objects layer by layer until the model is complete. This is different than subtractive manufacturing, in which a machine reshapes or removes material from an existing mould. Since 3D printers create models from scratch, they are more efficient and produce less waste than subtractive manufacturing devices.

FDM printing is the most direct and simplest form of 3D printing. In an FDM printer the material is heated to a semi-solid state in the hot end and extruded out through the nozzle and is deposited on the print (heated) bed. This process happens layer by layer until the printing process is completed. Material extrusion was invented and patented by Scott Crump in 1989.It was introduced to the market as Fused Deposition Modelling (FDM) by Stratasys. Soon FDM became synonymous with material extrusion.

2. Components

Electrical Components

- Arduino Board
- Shield Board
- Stepper Motors
- Extruder
- Stepper Motor Drivers
- Power Supply Unit

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- Power Supply Switch
- Limit Switches
- Heat Bed
- Hot End
- Thermistor
- Cooling Fan

    Mechanical Components

- L shaped aluminium profile
- Linear rods
- Linear motion bearings
- Radial bearings
- Lead screw and nut
- Flexible shaft coupler
- Teethed pulley
- GT2 timing belt
- Nuts and bolts
- Filament
- Levelling screws
- Nuts and bolts

3. Component Specification

Table 1

Component Name	Quantity	Specification
Power Supply Unit	1	12V, 20A
Stepper Motor	4	3-6V, Torque; 4.2 kg-cm
Stepper Motor Driver	5	8V, 1A
Limit switches	3	-
Extruder	1	-
Heat Bed	1	12V, 144W, 22mmx22mm
Hot end	1	12V
Lead Screw	2	Length: 500mm, Diameter:8mm, Pitch: 2mm
Linear rods	6	Diameter: 8mm, Length: 500mm
Linear motion bearing	10	Diameter: 8mm
Radial bearing	2	Diameter: 8mm
Aluminium profile	7	500mm
Shaft Coupler	2	5mmx8mm
Timing Belt	2	Length: 1m, Pitch: 2mm, Width: 6mm
Teethed pulley	4	Bore Diameter:5mm, Diameter: 16mm, Teeth: 20
Filament	1	PLA 1kg, Diameter: 1.75
Nuts and bolts	As required	3mm, 5mm, 6mm

4. Assembly

Frame:

Along X axis: 350mm
Along Y axis: 500mm
Along Z axis: 500mm
Material: Aluminium(L shaped extrusion)

Base: Wooden plank
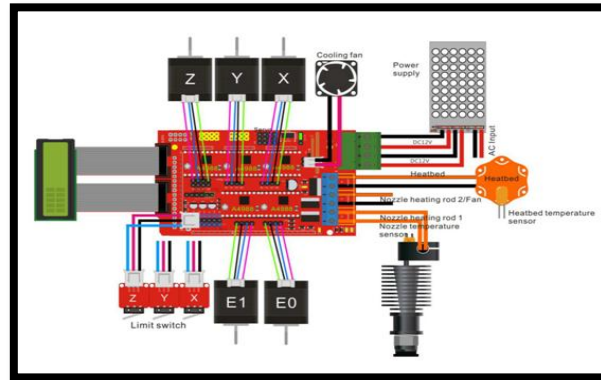
Electronics:

Fig 1: Electronic Connections

The necessary electronic connections are made as shown in Fig 1

Final assembly:

After combining the mechanical and electrical components together the marlin firmware is uploaded to the Arduino board. After uploading the firmware, the printer is functional and can be used for printing 3D objects. Before doing a full first print there are some necessary tweaks that are needed to be done to the printer. First and foremost, the printer stepper motors are to be calibrated in order to ensure dimensional accuracy and proper extruding. The next thing to be considered is to ensure that the print bed is level using a spirit level with respect to the axes. After doing these necessary changes the printer is ready for printing.
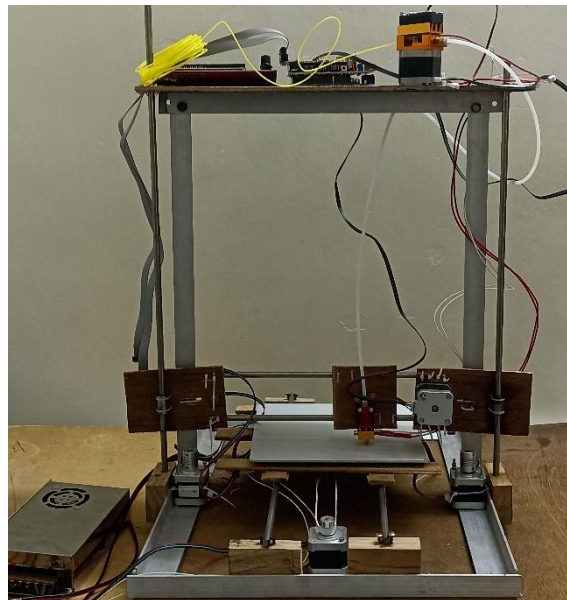

Fig 2: Final assembly

5. Procedure

Modelling

In order to print a model, the first step is to have a digital 3d model. A digital 3d model can be generated by two methods:

Scanning: Use a scanner and scan the object that needs to be printed from various angle in order to generate as much detail as possible. After scanning all the files are uploaded and aligned to create a 3D mesh model. This model is imported to a CAD software in which the necessary tweaks are made. This file is then saved as an STL file.

Creating: The other method in modelling is to create a new model from scratch using a CAD software (Fusion 360, Tinker cad, Simplify 3D). After creating the model, the file is saved as an STL file.

Slicing

After creating the 3D model, the next step is slicing. The STL file is imported into a slicer software (Slic3r, Ultimaker cura). Slicing is done in order to generate the necessary g-code to print the file. A slicer software slices the digital file into layers and develops an optimal g-code in order to print the file. The g-code can also be edited manually in order to make change that satisfies the user. The sliced file is saved as a g-code file on a peripheral device or in directly in the system.

Printing:

After generating the g-code file, if the printer is connected to a computer; the file can be sent directly to the printer via a printer host software (Repetier host, Pronterface). If the file is saved on a peripheral device, it can be connected to the printer directly and the g-code file can be accessed for printing.

6. Formula

In order to get accurate prints, the stepper motors must be calibrated. The motions in the printer are mainly achieved using a timing belt system and a lead screw system.

Calibration formula for timing belt system:

Value = $(S_{rev}*f_m)/(p_t*N_t)$

S_{rev} = Steps per revolution
f_m = Micro stepping factor
p_t = Pitch of timing belt
N_t = Number of teeth on pulley

Calibration formula for lead screw system:

Value = $(S_{rev}*f_m)/(p_l)$

S_{rev} = Steps per revolution
f_m = Micro stepping factor
p_l = Pitch of lead screw

Based on the components used for building the 3D printer the values required for calibrating the stepper motors are:

S_{rev} = 200
f_m = 16
p_t = 2 mm
N_t = 20
p_l = 2 mm

For timing belt system

Value = 80 steps/mm

For lead screw system

Value = 1600 steps/mm

7. Conclusion

In our project work, we were able to achieve our object of a building a low-cost 3D printer. We set a budget of Rs 20000 and we achieved our objective in building the printer within Rs 16700. Considering the maximum build volume of our printer the cost is very low when compared to preassembled 3D printers that are available. One of the biggest advantages of building the 3D printer ourselves was that we got know how the entire printer works. The other advantage is that that the cost's involved is reduced significantly. This 3D printer can always be upgraded by printing parts for itself and replacing the existing parts.

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