

Design and Fabrication of 3D Printer

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ABSTRACT

3D printing is called as desktop fabrication. It is a process of prototyping where by a structure is synthesized from a 3d model. The 3d model is stored in as a STL format and after that forwarded to a 3D printer. It can use a wide range of materials such as ABS, PLA, and composites as well. 3D printing is a rapidly developing and cost optimized form of rapid prototyping. The 3D printer prints the CAD design layer by layer forming a real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CAD 3D data.

3D printing significantly challenges mass production processes in the future. This type of printing is predicted to influence industries, like automotive, research and development team, medical, education, consumer products industries and various businesses.

KEYWORDS: 3D printing, Rapid Prototyping, ABS, PLA

INTRODUCTION

3D-printing or additive manufacturing is the construction of a three-dimensional object from a CAD model or a digital 3D model. It can be done in a variety of processes in which material is deposited, joined or solidified under computer control, with material being added together (such as plastics, liquids or powder grains being fused), typically layer by layer.

In the 1980s, 3D printing techniques were considered suitable only for the production of functional or aesthetic prototypes, and a more appropriate term for it at the time was rapid prototyping.^[3] As of 2019, the precision, repeatability, and material range of 3D printing have increased to the point that some 3D printing processes are considered viable as an industrial-production technology, whereby the term additive manufacturing can be used synonymously with 3D printing. One of the key advantages of 3D printing is the ability to produce very complex shapes or geometries that would be otherwise impossible to construct by hand, including hollow parts or parts with internal truss structures to reduce weight. Fused deposition modeling (FDM), which uses a continuous filament of a thermoplastic material, is the most common 3D printing process

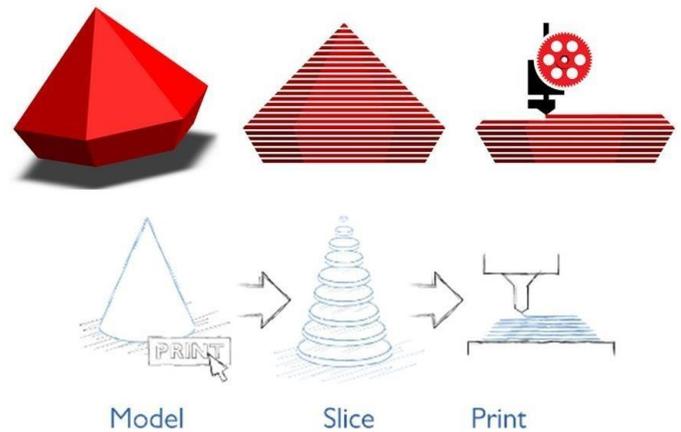


Fig : Process of 3D Printing

EXPERIMENT AND METHODOLOGY:

Our objective is to study, design and fabrication of a 3d printer. We studied the history, different printing methods and overview of the past research in the previous chapter. This chapter includes design and fabrication of the same mentioned earlier. First we ordered the whole tool-kit including all the parts and components those are used to manufacture a 3d printer. It took a while

to procure the whole kit. In the meanwhile a CAD model of a 3d printer has been created using NXCAD 11. First we designed all the parts required for the assembly and dimensions were strictly taken from internet as we didn't have the kit or manual to find out the original dimensions. Then all the parts are assembled in the NXCAD11 workbench to create the 3d printer assembly. Here are the real life pictures, designed model of individual parts and their working process.

DIFFERENT PARTS OF A 3DPRINTER:

Various components of 3D printers are: Frame, Y-axis and bushing, Extruder, printplate, stepper motors, Z-axis and Y- axis, X-carriage, Electronics parts, stepper motor controllers and end-stops.

Description of a 3d printer parts:

FRAME:

The frame provides the printer its property regarding stiffness. The three axes of the printer are added to frame. The frame consists of threaded rods combined together with printed parts. Aside from the vertex the edge likewise comprises of printed parts to hold and recreate the Y-axis and Z-axis. On the upper left and upper right we observe the printed parts that hold the stepper motors of the Z-axis.

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X-CARRIAGE:

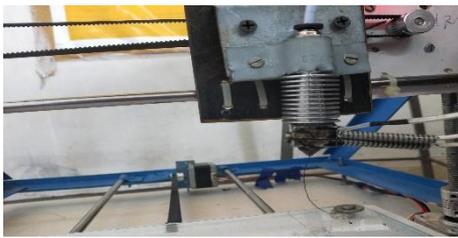
The assembled extruder along with cold end, heat barrier and hot-end is fitted on the X-axis carriage demonstrates an assembled X-axis with two smooth poles, a X-end idler and a X-end motor parts. The movement of the X-carriage is taken care by one stepper motor and a belt.

EXTRUDER:

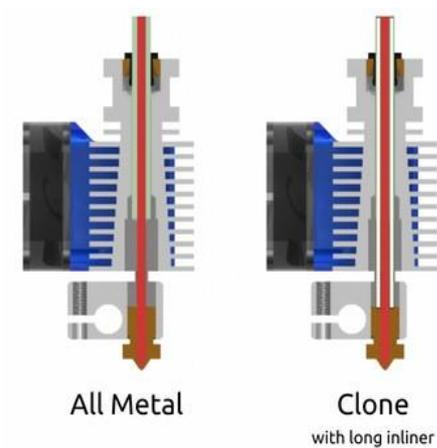
The 3D printer is generally assembled with a spring extruder. This extruder contains two parts: a cold top part which feeds or provides the plastic filament and a hot bottom part which helps in melting and in turn the plastic gets extruded. These two parts, usually known as the spring extruder (the cold part) and the hot-end (the hot part).The spring extruder holds of a small gear which is driven by a stepper motor. This small gear drives a bolt, which extracts the plastic filament and pushes it into the hot-end.



HOT END:



WORKING IMAGE OF HOTEND



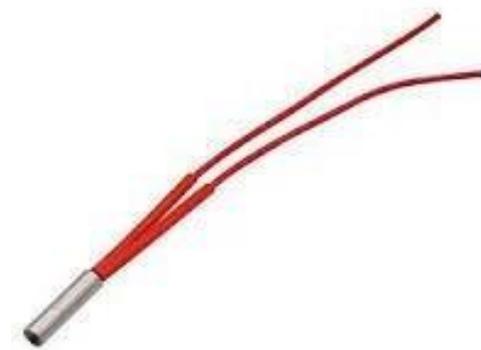
HOTENDDESIGN

A hot-end have three basic parts: Thermistor, to discover the temperature, a heat barrier to keep the hot-end far from the cool end, the chilly end will dissolve without heat barrier and a spout which permits the dissolved plastic to be flown out of the heater barrel. A connection has been made in the middle of thermistor and the gadgets board - only like the resistor or NiChrome wire – and this helps the hardware to quantify and choose the temperature

of the warmer barrel. The radiator barrel meets expectations at a temperature configurationally, and that temperature could be come to utilizing a thermistor .The detailed information about the thermistor and the ceramic heater is given below.

12V CERAMIC HEATER:

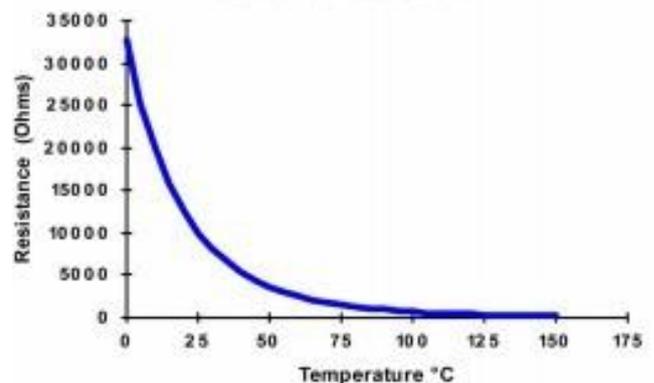
The 12v ceramic heater is the heat source for the hotend assembly. This will heat the plastic slightly more than its melting point.



Ceramic Heater, 12V Rated

NTC 100K THERMISTOR:

Figure 1 - Typical Thermistor Output Curve 10K-2 Sensor



CHARACTERISTIC CURVE OF THERMISTOR



NTC 100K THERMISTOR

PRINT PLATE:

Printed parts are intended to be imprinted on the print plate. The three axes move with respect to one another so that the nozzle can be set simply over the print plate for the printing reason in a range given by the particular of the print plate. The print plate for the most part constitutes two plates: the print base plate which is fitted and mounted on the X-pivot smooth poles by utilizing a bushing or a direct bearing and the print top plate which is mounted on the base plate and in this way, shapes the print surface.

LCD MODULE:

The LCD module consists of SD card reader, rotary encoders and a 20-character x 4 line LCD display. It can be easily connected it to the RAMPS 1.4 board using “smart adapter cable”. This panel connect the RAMPS 1.4 and does not need the computer, SD card intelligent controller will act like the buffer storage and store the g-codes. All further operations, such as calibration, the axis movement can be done only with a rotary encoder intelligent controller. 3D design print without a computer, just use the G codes stored on the SD card is used to print it.

The home screen of the lcd module will show the details of following information:

- Temperature of the hotend
- Set temperature value
- Position of the x,y and z axis
- Status of hotend fan with speed
- Printing speed
- Acts as input device for reading the G-codes, as it has SD support.
- Printing status.



LCD MODULE WITH SD CARD SUPPORT

ELECTRONICS:

The electronics board known as microcontroller controls the entire printing process. Several electronics options do available for 3D printers which are all open-source. Presently the most popular is RAMPS1.4, a DIY shield board for Arduino MEGA2560

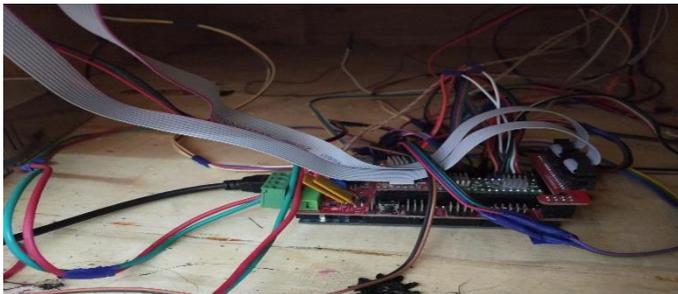
Functions of a 3d printer electronicsboard:

- Processes G-code instructions.
- Controls and regulates the four stepper motor controllers where both Z-axis motors are essentially connected to the same stepper motor controller.
- Monitors the end-stops.

IMAGES OF ELECTRONICS:



12V Power Supply



Arduino,Ramps1.4 And Drivers

STEPPER MOTOR:

There are five stepper motors used in the 3D printer are One to control the Y-axis, One to control the X-axis, Two to control the Z-axis, One to control the extruder.

STEPPER MOTOR CONTROLLER:

Controlling a bipolar stepper motor is truly muddled, particularly in the matter of smaller scale venturing the assistance of such controller stand out small scale step can be made. Consequently controlling of a stepper motor has been rearranged. mode. Unipolar stepper motors are much simpler to control however they give lesser torque given the motor size is same. Exceptionally outlined stepper motor controllers are

being utilized to assume control over the troubles of directing a stepper motor.

END STOPS:

While printing an object, all three axes need to be altered the initial position to their starting one. This is known as the zero position of any Cartesian robot. The axes can't move any further than zero. To acquire this, three end stops are to be installed one for each axis. An end stop needs to be mounted at such a position where the axis shouldn't go beyond. For the X-axis, this ought to be the position where the nozzle achieves the left-hand side of the print plate, For the Y-axis this ought to be on the posterior of the pivot such that the print plate is permitted to move to the back sufficiently far so that the nozzle winds up on the forward of the print plate, For the Z-axis position ought to be the place the nozzle scarcely touches the printplate. In a 3d printer 1 psu ,1 micro cotroller,5 stepper motors and 2 belt drives are considered as important components. After all the connection is made, AC power supply is given to the PSU. Later this voltage is supplied to the voltage converter which is basically a step down transformer which reduces the voltage up to a noticeable level. This reduced voltage is just high enough to propel a 3d printer and this voltage is supplied to the micro controller. All the motors are connected to the micro controller which sends appropriate signal to each component for it towork.

MATERIALUSED:

PLA (Polylactic Acid) is one of the two most commonly used desktop 3D printing filaments (with the other being ABS filament). It is the "default" recommended material for many desktop 3D printers, and with good reason - PLA is useful in a broad range of printing applications, has the virtue of being both odorless and low-warp, and does not require a heated bed. PLA filament is also one of the more eco-friendly 3D printer materials available, it is made from annually renewable resources (corn-starch) and requires less energy to process compared to traditional (petroleum-based) plastics. Outside of 3D printing, PLA plastic is often used in food containers, such as candy wrappers, and biodegradable medical implants, such as sutures. PLA filament for 3D Printing is available in a wide range of colors in both 1.75mm and 3mm.

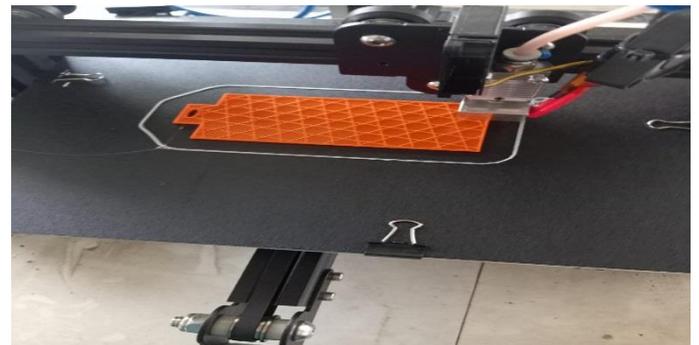


PLA PLASTIC

RESULTS AND DISCUSSIONS:

After the procurement of the whole tool kit, a detailed study of all the components is made so as to gain knowledge about the working procedure and connection of each part. Then the 3d printer is

structured using manual, with the help of internet and some research students. Electronics parts are connected very carefully so as to avoid any kind of accidents. After building the 3d printer it is put into working condition and some products are manufactured. Here is an image of a working 3-D printer manufacturing a product sample:



CONCLUSION:

The following recommendations can be considered for the improvement in the field of 3D printer hotend. While using the hotend assembly one should definitely use a dedicated cooling fan to get the best effective results and it will avoid the plastic to clogging and jamming in the hot end. Not all technical information about 3D printing could be shared in this introduction of the subject. Documenting the technology, very much a work-in-progress, must also recognize that not all authors agree on the likelihood of 3D printing gaining wide dissemination into the homes of individuals. Also, as a still emerging technology, 3D printing is not without its problems, such as slow printing speeds.

REFERNCES:

[1] Thomas, "3D printed jellyfish robots created to monitor fragile coral reefs" 3D Printer and 3D Printing News, 2018

[2] A. Ramya et al., '3D Printing, Technologies in Various Applications', International Journal of Mechanical Engineering and Technology', Volume 7-issue 3, May-June 2016, Pp. 396-409

[3] A. M. T. Syed, P. K. Elias, B. Amit, B. Susmita, O. Lisa, & C. Charitidis, "Additive manufacturing: scientific and technological challenges, market uptake and opportunities," Materials today, Vol. 1, pp. 1-16, 2017.

[4] L. Ze-Xian, T.C. Yen, M. R. Ray, D. Mattia, I.S. Metcalfe, & D. A. Patterson, "Perspective on 3D printing of separation membranes and comparison to related unconventional fabrication techniques," Journal of Membrane Science, Vol 523, No.1, pp. 596-613, 2016.

[5] V. Rajan, B. Sniderman, & P. Baum, "3D opportunity for life: Additive manufacturing takes humanitarian action," Delight Insight, Vol. 1 No. 19, pp. 1-8, 2016.

[6] O. Keles, C.W. Blevins, & K. J. Bowman, "Effect of build orientation on the mechanical reliability of 3D printed ABS," Rapid Prototyping Journal, Vol. 23, No.2, pp. 320-328, 2017.

[7] A. Pirjan & D. M. Petrosanu, "The impact of 3D printing technology on the society and economy," Journal of Information Systems & Operations Management, pp. 1-11, 2013.