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Metallic 3d Printer- New Era In Printing

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Abstract: *This paper aimed at Design and Development of metallic 3D printer. The main focus is design of metallic 3D printer and its applications. The study on design of 3D printer involves the basic analysis of present 3D printers, their parts and mechanism. The requirements that are suitable for working of 3D printer. 3D printing machine is designed and developed with different parts like extruders, nozzle, stepped motors, Teflon tube etc which are assembled, tested and also printed some objects. The development involves the preparation of the filament that could print the metallic objects. Trials were made on different filaments and conclusions are drawn. Betterments are made to improve the performance of the filament in all the aspects required.*

Keywords: *Metallic, 3D Printing, Teflon tube, Filament*

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I. Introduction

3D Printing, also known as additive manufacturing (AM), refers to various processes used to synthesize a three-dimensional object. In 3D printing, successive layers of material are formed under computer control to create an object. These objects can be of almost any 3D shape or geometry and are produced from electronic data source .A 3D printer is a type of industrial robot.

1.1 GENERAL PRINCIPLES OF 3D PRINTING MODELING

The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting. 3D scanning is a process of collecting digital data on the shape and appearance of a real object, creating a digital model based on it.3D printable models may be created with a computer aided design (CAD) package, via a 3D scanner or by a plain digital camera and photo grammetry software. 3D printed models created with CAD results in reduced errors and can be corrected before printing, allowing verification in the design of the object before it is printed.

1.2 PRINTING

Before printing a 3D model from an STL file, it must first be examined for errors. In fact, most of the CAD software’s produced errors in the STL files: holes, faces normal, self-intersections, noise shells or manifold errors. This step is called "repair", as the original model needs to be fixed. Generally STLs that have been produced from a model obtained through 3D scanning often have more of these errors. This is due to how 3D scanning works as it's often point to point acquisition, reconstruction will include errors in most cases.

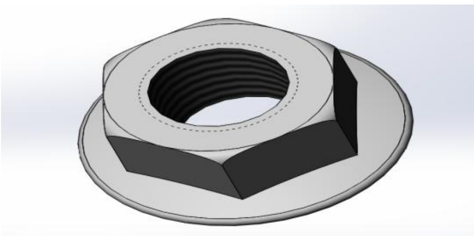


Fig 1: Shows the model used for CAD

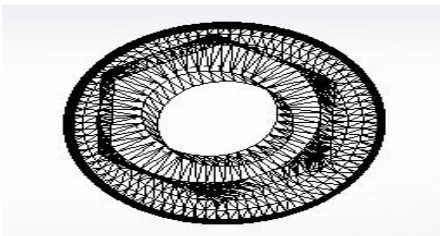


Fig 2: shows an STL file.

1.3 FINISHING

Though the printer-produced resolution is sufficient for many applications, printing a slightly oversized version of the desired object in standard resolution and then removing material with higher-resolution subtractive process can achieve greater precision.

1.4 PROCESSES

Several 3D printing processes have been invented since the late 1970s. The printers were originally large, expensive, and highly limited in what they could produce a large number of additive processes are now available. The main differences between processes are in the way layers are deposited to create parts and in the materials that are used. Frequently used material for printing are PLA, ABS, POLYMAX, HIPS, WOOD, T-GLASE, FLEXIBLE.

1.5 DIFFERERNCE BETWEEN PLASTIC AND METALIC PRINTING

3D printing, or 'additive manufacturing' use layer-by-layer principle to build an object. But to achieve a rigid object, bonding between subsequent layers needs to happen. This is where probably metals and plastics differ the most as they need different temperature for bonding to happen - they need to melt then solidify in each layer deposition. Both metals and plastics can be printed using Selective Laser Sintering (SLS). This involves the materials to be contained in powder form. A laser powerful enough to melt any of the material will then etch while strictly melting the powder that is exposed to the beam, this is called laser sintering. The mechanism will draw patterns conforming to the shape of the 'sliced' object - then rise up to draw another layer. Thus Fused Filament Deposition is used, where molten thermoplastic (one that retains reversibility through liquid-solid transition cycle) are extruded via metal nozzles to deposit patterns of the sliced object. This process is much cheaper and more common than SLS. Metals are impossible to be printed this way.

1.6 MAJOR DIFFICULTIES FACED TO PRINT ON METAL WHEN COMPARED WITH PLASTIC

- Very high temperatures are required melt metal as melting point for nearly every metal is very high, whereas plastics have low melting points and this helps the nozzles to work with plastics easier.
- Viscosity of metals when melted is very low which doesn’t allow it to be printed as done with plastics.The flow rate of metal is very high and it splashes on to the base plate and starts spreading there by unable to get desired shapes.

II. Components Of Metallic 3d Printer

Frame - Laser cut 6mm of Baltic birch plywood and a 5'x5' sheet from Windsor Plywood - a Western Canadian and North Western US supplier of wood product is taken as shown in figure 7. "frame-6mm-colored-lines dxf" is used to design as a basis but narrowed the slots a little to make the 6mm ply fit tighter. we will need select 6x 6-32 x 1" bolts and 6x 6-32 nuts to match. You could use 3mm or 4mm x 25mm bolts but found the 6-32 a better fit. Sliding Rods - The dimensions of the sliding Rods should be taken for the X, Y and Z axis, are 2x 370mm, 2x 360mm and 2x 320mm respectively. Straight sliding rods are essential for good prints. LM8UU Bearings – The LM8UU linear bearings as shown in the figure 9 are used for the bed movement on the Y-axis and the extruder/hot-end movement on the X-axis and the Z-axis. Pulleys, Belts & Idler Bearings – Synchronous pulleys and timing belts are used to advance in X and Y-directions. The dimensions taken for the design are 20 tooth GT2 pulleys and approx 1 meter of toothed belt. Idler 623 bearings are tiny and printed guides which fit over them. Stepper Motors – The NEMA 17 is a stepper motor with a 1.7" x1.7" face plate. The RepRapwikihas quite a bit of info on them. These are 1.2A which will keep the RAMPS drivers cooler, have approx 47N-m holding, are 1.8° stepping, 5mm shaft. The number of stepper motors as shown in the figure 11 required are 17. MK2A Heat Bed -As per the RepRap.orgwiki articleonehas to besure to get a good heated bed. The information is taken from Botech Eng. There are a lot of other vendors listed on the wiki page. We brought a 214mmx214mm size one. We also brought a 3mm thick sheet of glass 8"x8" and blue painters tape or wide kapton tape.The hot end is another place not to cheap out as it plays a major role. This RepRap.org wiki article has more info on hot ends. Extruder - Extruder is one of the key component in the printed parts. "Wades" style, the extruder along with the hot head as shown in the below figure 3 .

Fig 3: (i)Frame. (ii).Sliding rods .(iii) LM8UU bearings. (iv)Shows Timing belts and Synchronous pulley (v)Stepper motor (vi) Head bed without Kapton tape (vii)Hot end (viii)Extruder

III. Assembly Of 3d Printer (Steps Involved)

3D printer assembly is quite a difficult task. The complete assembly of metallic 3d printer is discussed in the following steps.

Step 1: Assemble of Y-axis motor and Y-axis Limit switch

A synchronous pulley is fixed on the motor by using keys and the Y-axis motor is fixed to the base plate frame. Limit switches are mechanical device that cuts motor connection before any physical damage occurs. The Y-axis motor is controlled by the Y-axis switch, which is fixed to its holder using head screws and nuts on the either side of the holder.

Step 2: Assemble Z-axis motor, Z-axis & Z-axis Limit switch

The Z-axis motor is fixed with motor support on the either side of the motor and also on top of the motor using screws and nuts. A coupling is fixed on top bottom right corner of the motor support using jackscrews. Put the Z-axis limit switch on the top left corner of the base plate andfix them with M3*20mm screws and nuts. Put the two z-axis motors assembly on the either side of the bottom plate and fix them using three M3*20mm screws and nuts.

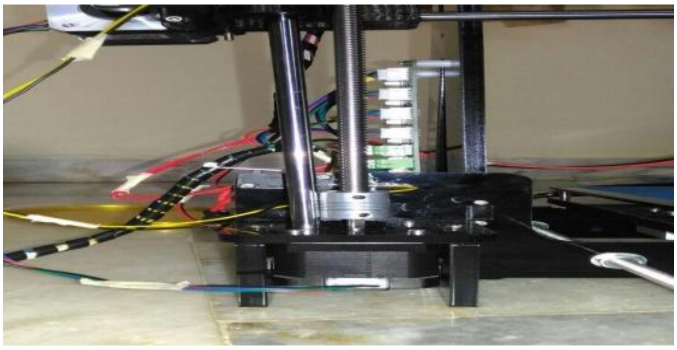
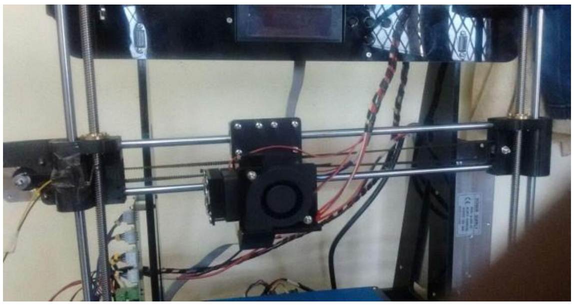


Fig 4: Shows the Z-axis motor assembly (bottom) fixed to the side frame and the figure also shows the Z-axis limit switch

Step 3: Install X-axis Motor, Pulley mount-axis

Now place the X-axis motor on the X-axis motor mount and fixing them to the left and right side of the side frames using M3*10mm inner hexagonal screws. Insert a M8*380 mm sliding rod through the X-axis motor and M8*345 mm screw arbor through the pulley mount. The sliding rod and arbor screw are restricted over the top of the left and right side frames by a sliding rod restriction. Now connect the arbor screw with the couplings at the bottom and fixing them using jackscrew in coupling. Now two sliding rods M8*443mm are made to pass through the extruder motor mount and pulley mount. Sliding rods are used for the movement of the nozzle. Now the X-axis limit switch is placed on the left side of the side frame on the motor mount and are locked using M2.5*10mm screws.



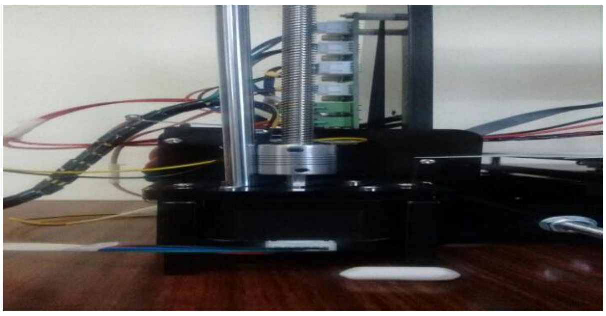


Fig 5 : (i) pulley mount and X-axis switch (ii)Extruder mounted on X-axis frame

Step 4: Install X-axis timing belt & Install Y-axis Timing belt

Tighten one end of the Timing Belt to the belt clip with nylon cable ties and the other end to through the X- axis pulley and motor, then tighten another end of the belt with belt clip with nylon cable ties. Now fix a timing belt for the movement of the heat bed. Now one end of the timing belt is place under a belt clip of the base frame and is tightened and in similar way the other end of the timing belt is made to pass over a synchronous pulley fixed to the motor. The other end of the timing belt is placed under the other belt clip is fixed, using screws.

Fig 6 : (i)X-axis Timing belt (ii) Y-axis Timing belt

Step 5: Assemble Base Frame Holder _ Back& Front

Two of the sliding rod Restriction are placed in front of the Base Frame holder (back) and are locked using two M3*20mm round screws and nuts. Previously misassemble limit switch is fixed on the frame using M3*20 mm round head screw and nut. Now another y-axis holder is supposed to be fixed to the framed using M3*20 mm head screw and nut. The Y-axis motor which has been assembled previously is fixed on the frame such that the either end of the motor is supported. Two of the sliding rod restriction are placed infront of the base frame holder and are fixed using round head screws and nuts. Now the Y-axis belt pulley wheel assembly is placed behind the base frame holder and are locked using two M3*20mm round head screws and nuts.

Step 6: Assemble Heat Bed Frame Extruder

In the assembly of heat bed frame the major components are bearings, belt clips, aluminum plate, heat bed and compressive springs Firstly three bearings are taken and are fixed on the bed frame in such a way that two of the bearings are placed in a straight line on the right side of the bed frame and the other bearing is placed to the left. Belt clips should be placed in the center perpendicular to the axis of the bearings.M3*20mm screws are to be used to fix them. Next, the Aluminum plate and Heat bed are to be placed together and should be fixed together using M4*15 round head cross screws. Four Compressive springs are placed between the Heat bed and bed frame and then screws are made to pass through the springs and are fixed using thumb nuts from under the bed frame. Assembly of Extruder is little complicated when compared to the others .Firstly three Bearings are to be fixed on the U-Metal plate using round head cross screws. Put the Motor and Hot end module and metal plate together and are fixed using Hexagonal screws. Cooler Fan and heat sink are fixed in front of the Motor and Hot end, Finally Fan and Fan holder are fixed together, and are fixed right side of the Motor and Hot end.

Fig 7: (i) Shows the Heat Bed Frame setup (ii) Assembled extruder fixed on sliding frame

Step 7: Assemble Side plate, Top Plate and Junction plate

Now put the two side plate on the left and right side of the bottom plate,Fixing them with four M3*20mm screws and nuts.Now place the top plate on the side plate and fix them using four of the M3825mm flat head screws and nuts.Place the two junction plate on the top of the side plate and fix them using four M3*20 screws and nuts.Place the two sliding rod restrictions on top of the left and rights sides and fix them with the screws.Power supply is installed at the bottom of the right side plate.

Step 8: Install PCBA Control Board & Install Platform Assembly

A PCBA is placed in the bottom of the left side plate. Now the plastic pillars are placed between the control board and the side plate and then M3*25mm flat head crews should be made pass through the plastic pillars. The other end of the screws is locked using M3 nuts. Place the heat bed which was assembled previously and place it on base and fix them with the screw archers and now insert two sliding rods and fix them and lock them using sliding rod restrictions at both the front and back base frame. The two sliding rods used here are M8*380mm.One bearing should be fixed on the left side of the hot bed and the hot bed wires are adjusted on the back side

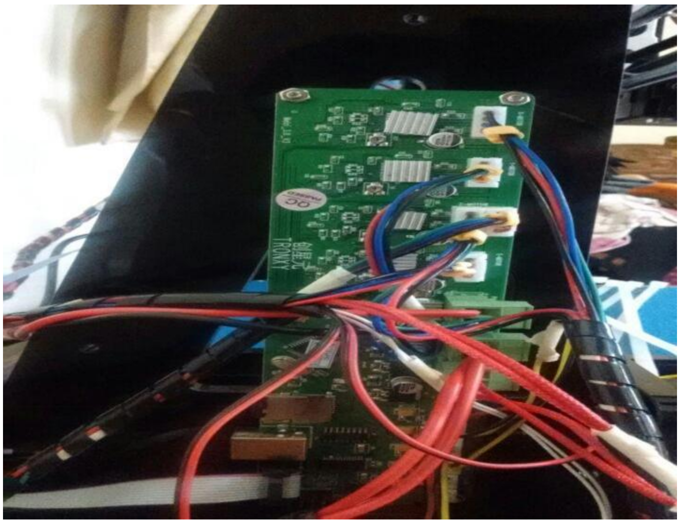
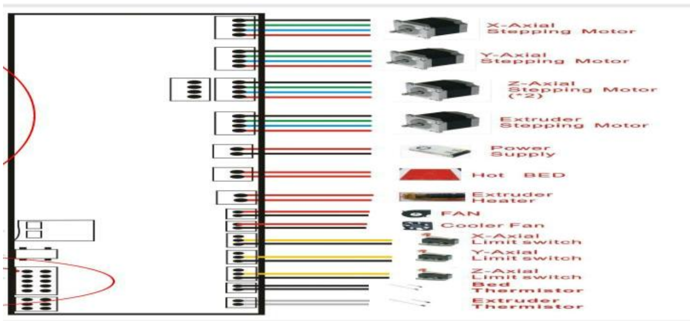


Fig 8: Control Board

Step 9: Control Board Wiring & AC Power Connector Wiring Diagram



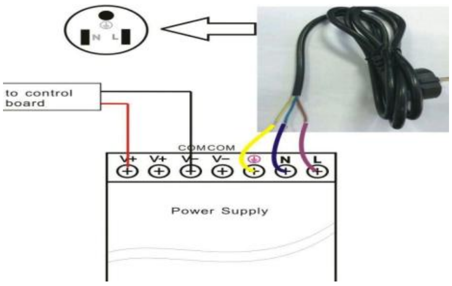


Fig 9 : (i) control board wiring (ii) Power Supply wiring

Fig.11. Models made using 3D printer

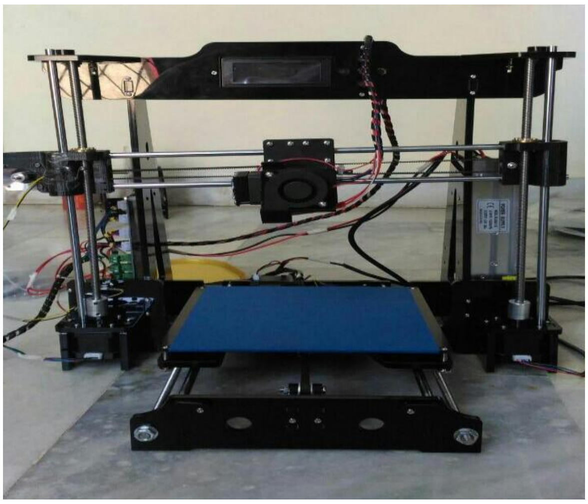


Fig 10: Shows Metallic 3D printer after assembly

IV. Technical specifications

Print size (X Y Z)- 210 x 210 x 210 mm.

XY Axis Positioning Accuracy - .012mm

Z Axis Positioning accuracy –0.004mm

The Layer Thickness- 0.1 mm–0.4 mm.

Layer Resolution –100 microns

Print speed –40 to 100 mm/sec

Print Precision –0.1-0.4mm

Print Plate Size –213 * 200 mm

Print Plate (Build Platform) - Heated Bed (Aluminium).

Filament Diameter –1.75mm

Nozzle Diameter –0.4 mm

Nozzle Temperature –210C to 250 C

Heating Plate Temperature –50 C to 110 C

The File Print Format –STL G-code

V. Conclusion

From the overall work carried out in design and development sections of the metallic 3D printer, the final structure of the machine is made physically and set to work with the filament under all the required criteria to print a metallic object.

3-D printing is moving in several directions at this time and all indications are that it will continue to expand in many areas in the future. Some of the most promising areas include medical applications, custom parts replacement, and customized consumer products. As materials improve and costs go down, other applications we can barely imagine today will become possible. There is an assurance for accuracy of the geometry of the object if it is made using a 3D printer. The highest scale of accuracy is seen in the objects that are printed out of a 3D printer. Especially metallic 3D printer can be applied in all the areas where metallic objects are required. The heavy objects can be made out of casting and can be further used by machining. In case of tiny objects that require high accuracy there is a scope of this metallic 3D printer to built the object easily. This avoids high level industrial effort and gives the best product.

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