FDM BASED 3D PRINTING MACHINE

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Abstract

Rapid prototype (RP) is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three dimensional computer aided design (CAD) data. There are two phases in the birth of a product, first would be the design phase and second would be the manufacturing phase. Both the process involve several steps are per design and manufacturing guide lines. In this competitive age any time reduction in these steps will help in profit maximization. Apart from the conventional manufacturing process which are used for several years while manufacturing process which are used for several years while manufacturing products, additive manufacturing processes have gained momentum in the recent years. The reason behind this is that these processes do not require special tooling and do not remove material which is very beneficial in the making of a components.

1. Introduction

3D printing is any of various processes in which material is joined or solidified under computer control to create a three-dimensional object, with material being added together (such as liquid molecules or powder grains being fused together). 3D printing is used in both rapid prototyping and additive manufacturing. Objects can be of almost any shape or geometry and typically are produced using digital model data from a 3D model or another electronic data source such as an Additive Manufacturing File (AMF) file (usually in sequential layers). There are many different technologies, like stereo lithography (SLA) or fused deposit modelling (FDM). Thus, unlike material removed from a stock in the conventional machining process, 3D printing or Additive Manufacturing builds a three-dimensional object from a computer-aided design (CAD) model or AMF file, usually by successively adding material layer by layer.

The term "3D printing" originally referred to a process that deposits a binder material onto a powder bed with inkjet printer heads layer by layer. More recently, the term is being used in popular vernacular to encompass a wider variety of additive manufacturing techniques. Every 3D printer builds parts based on the same main principle: a digital model is turned into a physical three-dimensional object by adding material a layer at a time. This where the alternative term Additive Manufacturing comes from.3D printing is a fundamentally different way of producing parts compared to traditional subtractive (CNC machining) or formative (Injection moulding) manufacturing technologies. In 3D printing, no special tools are required (for example, a cutting tool with certain geometry or a mould). Instead the part is manufactured directly onto the built platform layer-by-layer, which leads to a unique set of benefits and limitations.

From here, the way a 3D printer works varies by process. For example, desktop FDM printers melt plastic filaments and lay it down onto the print platform through a nozzle (like a high-precision, computer-controlled glue gun). Large industrial SLS machines use a laser to melt (or sinter) thin layers of metal or plastic powders. The available materials also vary by process. Plastics are by far the most common, but metals can also be 3D printed. The produced parts can also have a wide range of specific physical properties, ranging from optically clear to rubber-like objects. Depending on the size of the part and the type of printer, a print usually takes about 4 to 18 hours to complete. 3D printed parts are rarely ready-to-use out of the machine though

2. Literature

Charlie cl wang et.al., [2018], this paper compared with traditional digital light processing (DLP) 3-D printers using a single vertical carriage, the platform of our DLP 3-D printer using delta mechanism can also move horizontally in the plane. We show that this system can print 3-D models much larger than traditional DLP 3-D printers. The major challenge to realize 3-D printing of large models in our system comes from how to cover a planar polygonal domain by a minimum number of rectangles with fixed size, which is NP-hard. We propose a simple yet efficient approximation algorithm to solve this problem. The key idea is to segment a polygonal domain using its medial axis and afterward merge small parts in the segmentation. Given an arbitrary polygon Q with n generators (i.e., line segments and reflex vertices in Q), we show that the time complexity of our algorithm is O(n 2 log 2 n) and the number of output rectangles covering Q is

O(Kn), where K is an input-polygon-dependent constant, also the physical achievement after of a Delta 3D printer after the model.

Betina Madeira Schmitt et.al., [2017], this paper explains about comparative study of 3D printer which uses a more complex control system due to their trajectories generation but may present some advantages over the Cartesian configuration. To increase the knowledge about additive manufacturing, a comparative study with Cartesian and delta printers was performed to evaluate the performance on printing a testing part. Three samples were produced in each printer and compared based on surface quality, manufacturing time, mass and dimensional measurement. The printed objects were 3D scanned for comparing the digitized geometry by aligning the point cloud generated to its virtual 3D model. The parts produced in delta printer obtained better surface quality, while Cartesian printer provided better dimensional accuracy. The results also showed that the variation of the mass and time to produce the parts were not significant.

Ricardo CeliOctuber et.al., [2016], this paper describes the design and implementation of a 3D printer prototype based on a delta parallel robot, which decreases printing time without losing quality in the final product. In addition, the free software, Repertoire, was used for programming and GUI.3D Scanning is widely used for reverse engineering tasks from industry professionals. For height calibration of printer dock, an automatic levelling system was developed through an inductive sensor in order to avoid manual handling

Santa Catarina et.al., [2015], this research paper describe essential advantage of a 3D printer is that it allows the designers to produce a prototype in a very short time, which is tested and quickly remodelled, considerably reducing the required time to get from the prototype phase to the final product. At the same time, through this technique we can achieve components with very precise forms, complex pieces that, through classical methods, could have been accomplished only in a large amount of time. In this paper, there are presented the stages of a 3D model execution, also the physical achievement after of a Delta 3D printer after the model.

3. Methodology

The methodology part of the 3D Printer includes the procedure of the working of the machine. The printer has few major steps for the Printing procedure which has to be followed strictly. Firstly, the blueprint of the

3D digital file of the object sent for the printing. The digital file is nothing but the CAD model; there are many suitable software tools to design the digital file. These designs are in the specific format for coloured or non-coloured i.e., STL format which is suitable for the print physically. Once this digital file is ready, this file is converted to many parts for the 3D printing to be initiated, these parts of the information is the steps command for the printer. These steps are the sliced pieces of the main object which is in the format called G-code. G-codes are the path to communicate with the machines; they understand only this language of programming. Next step is the Printing, this part is done according to the G-code instructions fed, and this part will consist of the raw materials for the printing of the object. Next comes the removal, this needs some professional guidance and skills for the exact equipped removal of the parts from the actual object. This process actually manufactures almost the object, it includes 3D printing technologies. Other 3D objects needs post-processing of the printed parts and also varies with the printing technologies and also the materials printed with. Few will have printed parts instantly for the fabrication process but few will need this post-processing of the printed parts.

Flow chart

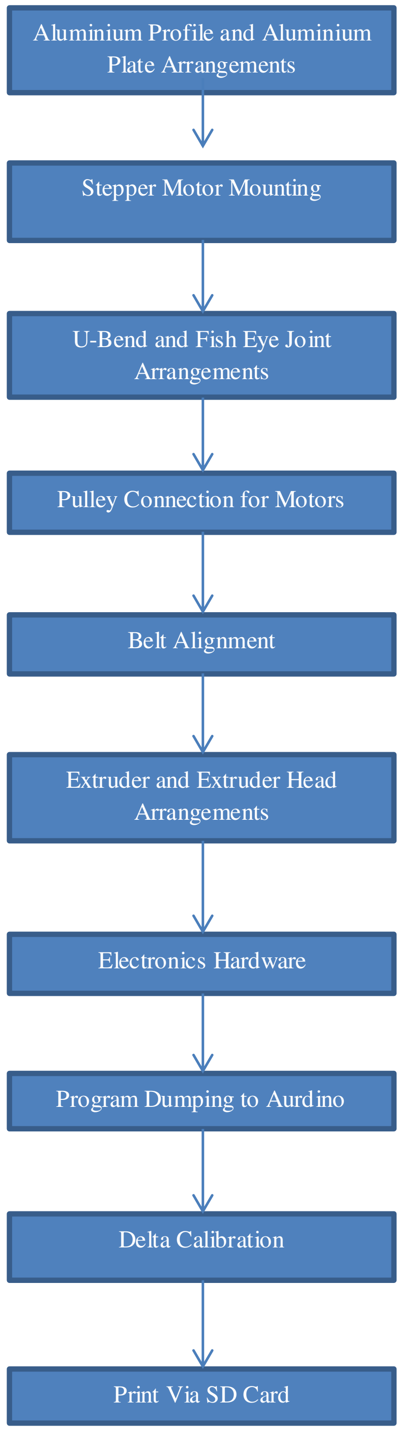

Fig: 1

4. FDM BASED 3D PRINTING MACHINE

4.1 Fused Deposition Modelling (FDM)

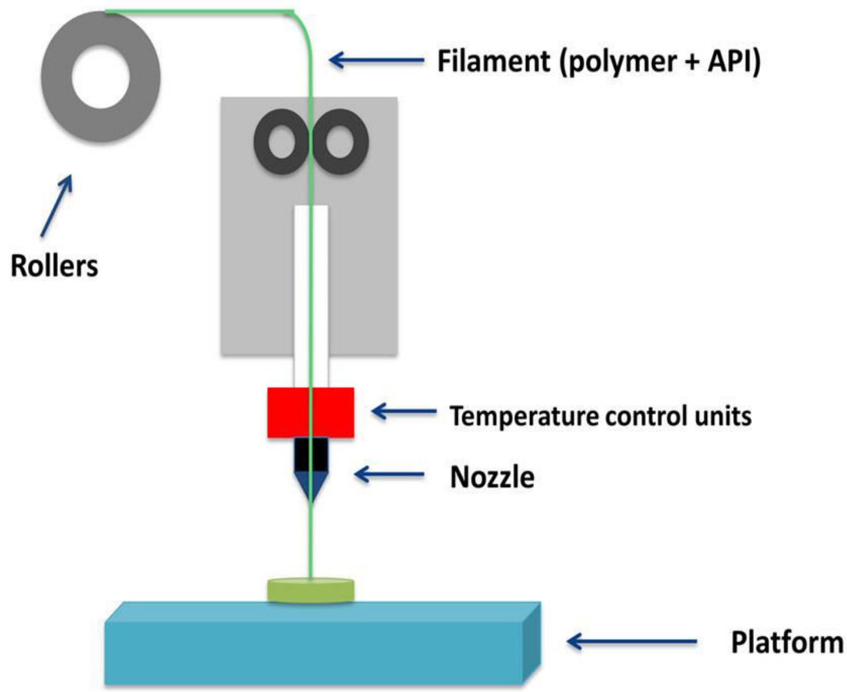

Fig: 2 Fused Deposition Modelling (FDM)

FDM is a 3D printing process developed by Scott Crump, and then implemented by Stratasys Ltd., in the 1980s. It uses production grade thermal plastic materials to print its 3D objects. It's popular for producing functional prototypes, concept models, and manufacturing aids. It's a technology that can create accurate details and boasts an exceptional strength to weight ratio. Before the FDM printing process begins, the user has to slice the 3D CAD data (the 3D model) into multiple layers using special software. The sliced CAD data goes to the printer which then builds the object layer at a time on the build platform. It does this simply by heating and then extruding the thermoplastic lament through the nozzle and onto the base. The printer can also extrude various support materials as well as the thermoplastic. For example, as a way to support upper layers, the printer can add special support material underneath, which then dissolves after the printing process. As with all 3D printers, the time it takes to print all depends on the objects size and its complexity. Like many other 3D technologies, the noshed object needs cleaning. Raw FDM parts can show fairly visible.

Flow chart

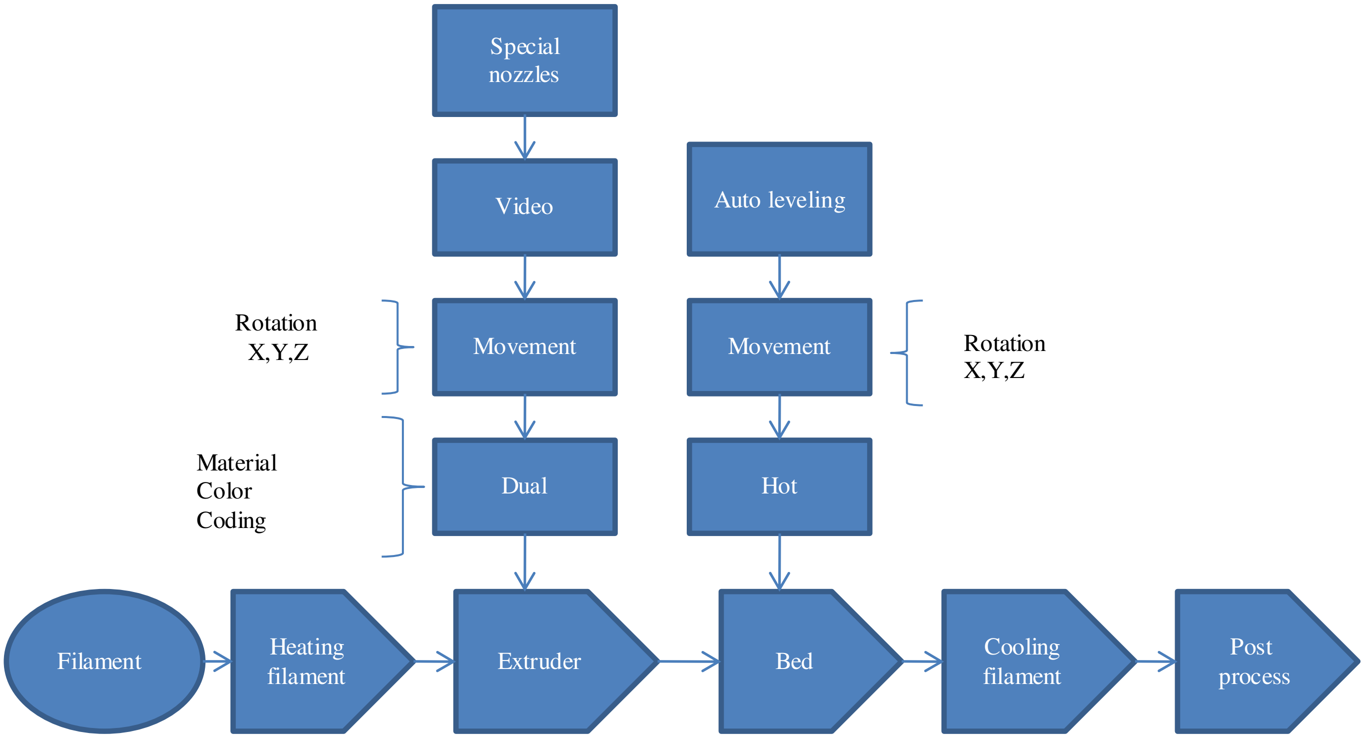

Fig: 3 Flow chart

The fig.3 shows the methodology used by us in construction of 3D printer. The first step is to select one of the additive manufacturing processes among much process. Then an appropriate mechanism is selected for X, Y and Z axis movements, considering various factors such as cost of fabrication, simplicity of design, synchronization, accuracy etc. Once the mechanism is selected the next step is integration of electronics and software then the machine is designed and fabricated. The last step is synchronization of mechanical, electrical and software elements of the machine.

Selection of mechanism

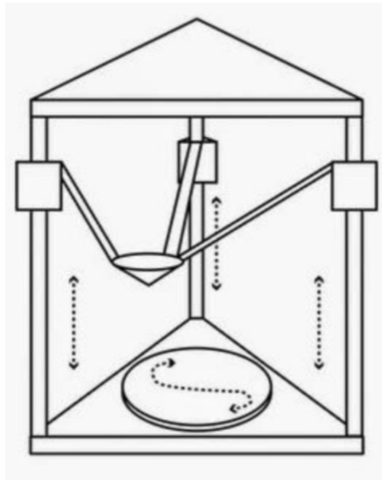

Fig: 4 Delta 3D Printer

Presently mechanisms such as, Cartesian, Polar, Delta and so on are utilized as a part of development of FDM 3D Printers. We have chosen Delta arrangement of developments; delta 3D printer is different from the more popular Cartesian 3D printer, even though it uses the same 3D printing technology, which is fused filament fabrication or FFF. It has a steeper learning curve and a smaller community and is more difficult to troubleshoot. Of course, a delta 3D printer has benefits, too, such as a faster print speed on average and less print bed tinkering once calibrated. Plus you can often 3D print taller items. One of the biggest downsides of delta 3D printers is the limited number of products on the market, which means you don't get a lot of options to choose from, unlike with Cartesian 3D printers. A delta 3D printer can be a pain to deal with. While a delta kit is a bit less complicated to assemble compared to a Cartesian kit on average, the initial calibration is more difficult. The XYZ arms must be all on point because if one arm is off, it will affect the other arms, which in turn will affect the print quality. On the bright side, a delta print bed is 100 percent static or unmoving, unlike with a Cartesian 3D printer. That's one less moving part you need to worry about, once a delta print bed is levelled, it stays that way for a long time. When it comes to performance, a well-built and well-calibrated delta 3D printer can be better than a Cartesian 3D printer in the same class or price range.

5. Working Principle

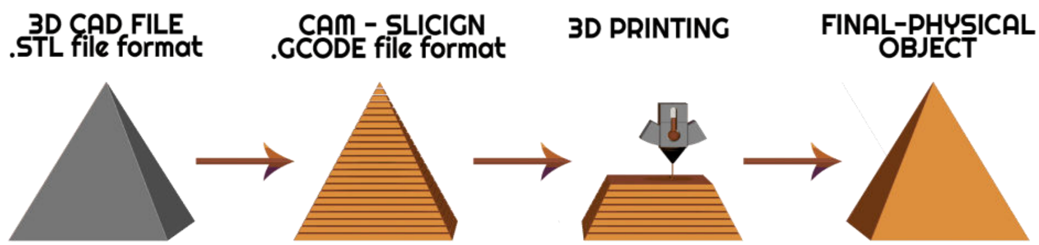

Fig: 5 Working of 3D Printing Machine

- **Creation**

First in 3D Printing is to create a blueprint slash three-dimensional digital file of the object we want to print. The most common way of creating a digital model is with Computer Aided Design – CAD. However, there is a large range of professional and entry level software that can produce a file suitable for 3D Printing.

DESIGN: You can use 3D modelling software like Blender, Sketch Up, AutoCAD, Solid Works, Maya, Photoshop, Thinker Cad or others to create your own designs. Almost any 3D modelling software can be used to create a 3D printable file.

SCAN: Another way to create a three-dimensional digital file is through 3D scanning. 3D scanning is a technology, closely related to 3D printing, that analyses a real-world object and instantly creates a digital replica. 3D Scanning is widely used for reverse engineering tasks from industry professionals. Once an existing object is digitized, we also have the option to modify it before printing. A 3D scanner is needed for this process.

DOWNLOAD: If you have minimal patience and just want to go ahead and print something, you can visit websites like thin givers, You Magine, Crab Cad, and My Mini factory shape ways to download or buy files that other users have modelled. These files are 3D Print ready in most cases.

- **STL**

Once you have a finished the CAD design, it is time to send it to the printer. First, we need to convert it into an appropriate file format. The most common 3D Printing file format is called STL, that stands for Stereo Lithography, and named after the first ever3D printing process. STL has several other meanings such as "Standard Triangle Language" and "Standard Tessellation Language". What is important to remember here is that .STL is the usable file extension. This file format includes triangular mesh (polygons), the data that describes the layout/surface of a three-dimensional object. Alternatives to STL are .OBJ and .3MF. Keep in mind that all those file formats don't contain colour information. For 3D printing in full colour, you need to use file formats like .X3D, .WRL, .DAE, .PLY. An important note here is not every STL or OBJ file is 3D printable by default. In short they have to be designed with 3D printing in mind!

- **Slicing**

This is the process of translating the 3D File into instructions for the 3D printer to follow. Yep, that's the fun part and you need a special software to do only that! Basically, Slicing is dividing or chopping the 3D model into hundreds or thousands of horizontal layers, telling the machine exactly what to do, step by step. After the files are Sliced, a new file format is generated called G-code, with the file extension g-code. G-code is the most widely used numerical code programming language, mainly used in computer-aided manufacturing to control automated machine tools like 3D Printers and CNCs (Computer Numerical Controls). In a nutshell G-code is the language of the machine and what we use to communicate with it!

- **Printing**

The printing machines are made of many moving and intricate parts, and they demand correct maintenance and calibration to produce successful prints. Most 3D Printers do not need to be monitored after the printing has begun. The machine will follow the automated G-code instructions, so as long as there is no software error or the machine doesn't run out of raw material, there should not be issues during the printing process.

- **Removal**

Removing the finished parts from the printer will vary for different 3D printing technologies. In some case, like for Desktop machines, it is as simple as separating the print from the build platform. For some industrial 3D printers, the removal of a part is a technical process that requires professional skills and specialized equipment within a controlled environment.

- **Post-Processing**

Again, post-processing of 3D printed parts will vary with 3D printing technologies and the materials the parts were printed with. Some 3D printing technologies let us handle the finished parts right away, while other technologies require additional steps to finish the fabrication process. Post-processing is an important step for the aesthetic and function of the parts.

6. 3D MODEL OF 3D PRINTING MACHINE

6.1 Design of Delta 3D Printing machine

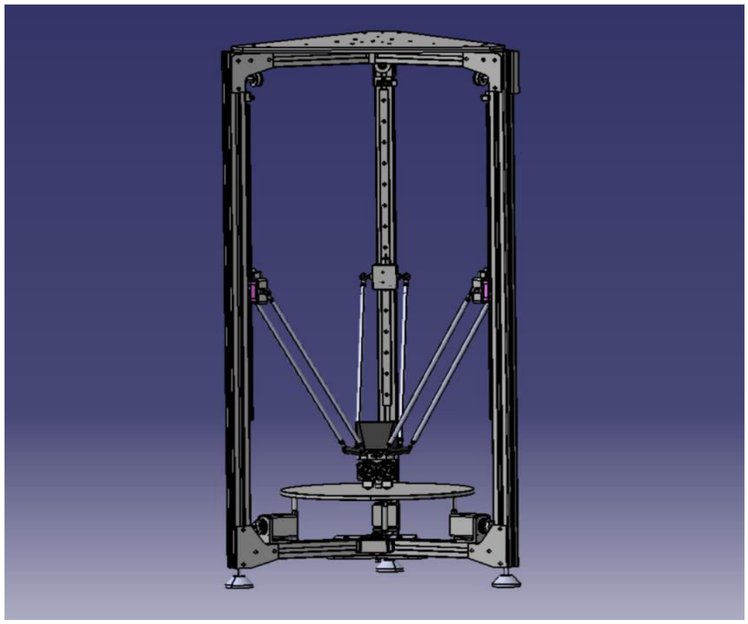

Fig:6 3D Printing Model

6.2 Extruder

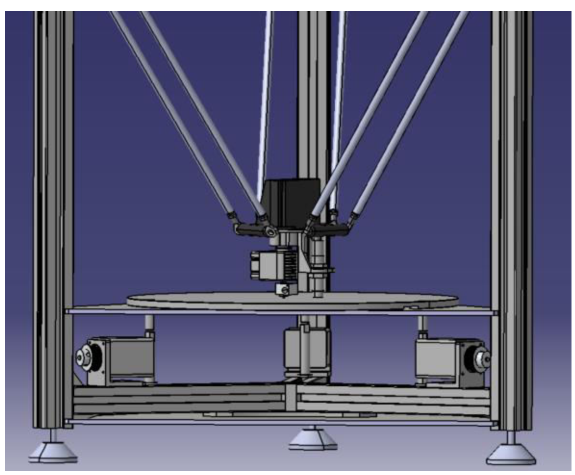

Fig:7 Extruder

3 2D View of 3D Printing machine

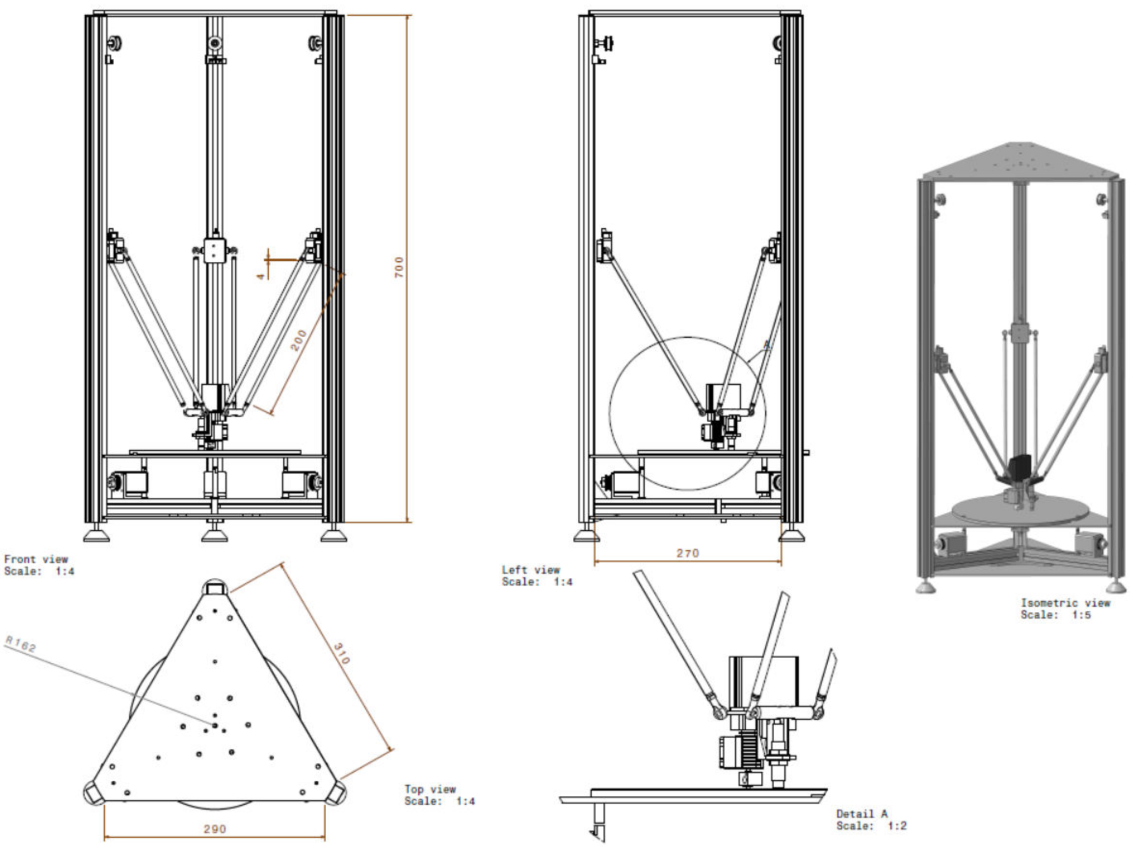

Fig:8 2D diagram

7. Materials



Fig: 9 Frames

Fig: 10 Heat bed

Fig: 11 heating element

Fig: 12 Polycarbonate

Fig: 13 Stainless Steel Rod

Fig: 14 Bearing

Fig: 15 Aluminum Profile

Fig: 16 GT2 Timing Belt and Pulley

Fig: 17 Pulley

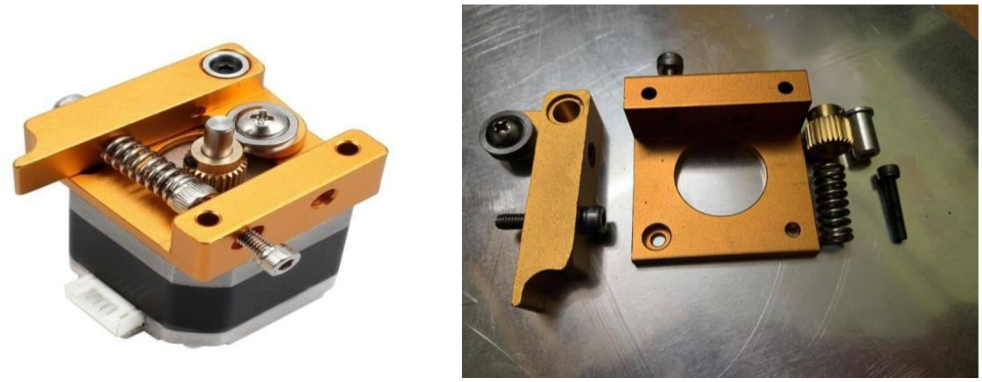

Fig: 18 Feed Mechanism

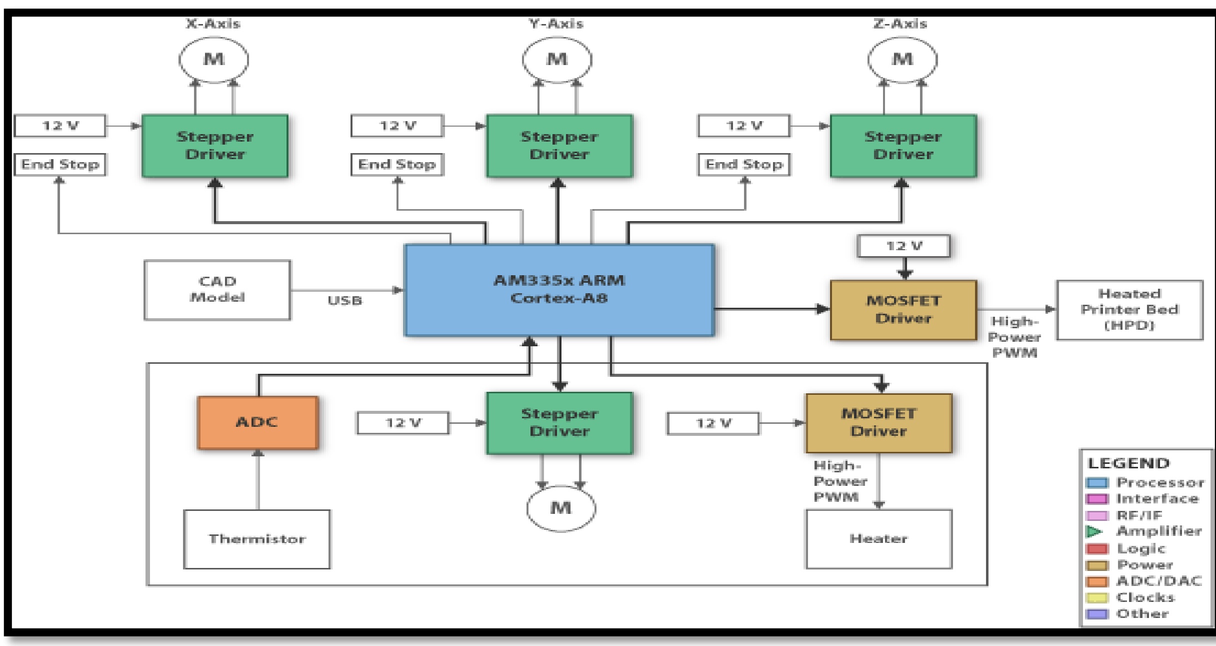

Fig: 19 Electronic hardware details

Fabricated of 3D printing machine

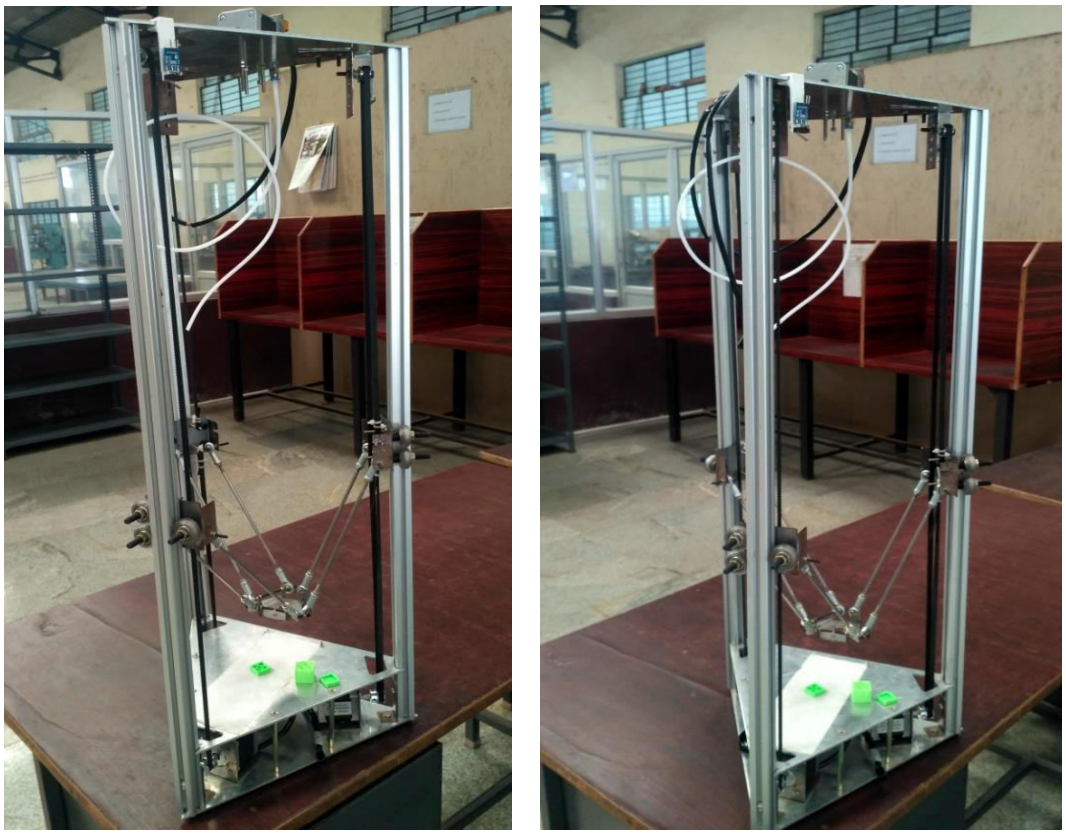

Fig : 20 Fabrication of 3D printing machine

CONCLUSION

The outcome of this paper was to build a portable 3D Printer which has been successfully completed. The design of the frame is made robust and compact using aluminum sections. The material selection of the various elements is economical. Using a single motor for vertical movement along with a proximity sensor makes bed leveling easy and the bed movement is monitored with resolution in microns. The drawback in few of the 3D Printer which uses bed movement in Y axis has distortion of the printed layer at high rates of printing. The control of the mechanism becomes easy because of less number of motors and good synchronization can be achieved using this new 3D printer technique.

The intention behind this research was to develop a low cost 3D Printer by using materials which are easily available and cost effective. We have been successful in reducing the cost to a considerable extent i.e. about 10-15 %. The parts made in 3D design software are successfully imported in the printing software and the product obtained has the same dimension given during the design stage of the product i.e. accuracy close to 100 %. We were able to successfully fabricate the 3D printer according to its virtual design proposed at reduced cost.

SCOPE FOR FUTURE WORK

Given the huge bank of opportunities in this sector and the rapid development of this technology, we can say with a sense of certitude that 3D printing will soon take over many more industries in the near future.

- India is focused on engaging with additive manufacturing as part of a plan to stay competitive. Technology is used to improve education.
- Large companies are even pushing this trend with automotive company Mahindra Group donating 3D printers to a local school under the Attal Innovation Mission.
- 3D 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.
- There is more in the future as this field advances at a staggering rate and futurists are calling it the revolution of 3D printing like never before. Some of the fields where 3D printing application has highest scope in future are:
    - Developing Complex Engine Parts
    - Fashion
    - Medical applications
    - Space Explorations

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