A PROJECT REPORT ON

DESIGN AND FABRICATION OF 3D (FDM) PRINTER

Submitted in partial fulfilment of the requirements

Of the degree of

Bachelor of Engineering

by

1. CHAVAN YASHDEEP MADHUKAR
2. DHURI PUSHKRAJ VINOD
3. KELUSKAR PRATHAMESH RAJENDRA
4. RANE YOGESH DYANESHWAR

Guide:

Prof. JAGUSHTE GANESH S.

University of Mumbai

Department of Mechanical Engineering

Rajendra Mane College of Engineering and Technology,

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2021-22

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ESTD : 1998

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CERTIFICATE

This is to certify that the project entitled "(**DESIGN AND FABRICATION OF 3D (FDM) PRINTER)**" is a bonafide work of **Mr.Yashdeep Chavan(14), Mr.Pushkaraj Dhuri(21) , Mr.Prathamesh Keluskar(36), Mr.Yogesh Rane(60)**,, submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "**Bachelor Of Engineering**" in
"**Mechanical Engineering**.,,

Guide	Project Coordinator
Prof. G. S. Jagushte	Mr. A. V. Javir
Head of Department	Principal
Dr. S. N. Waghmare	Dr. M. M. Bhagwat

Project Report Approval for B. E.

This project report entitled (**DESIGN AND FABRICATION OF 3D (FDM) PRINTER)** by Student listed below is approved for the degree of Bachelor of Engineering in Mechanical Engineering.

Student Name -

1. **CHAVAN YASHDEEP MADHUKAR**
2. **DHURI PUSHKARAJ VINOD**
3. **KELUSKAR PRATHAMESH RAJENDRA**
4. **RANE YOGESH DYANESHWAR**

Examiners

1. ---

2. ---

Declaration

We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Name of Student Signature

1. **CHAVAN YASHDEEP MADHUKAR**
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3. **KELUSKAR PRATHAMESH RAJENDRA**
4. **RANE YOGESH DYANESHWAR**

Date :

Acknowledgement

It gives us an immense pleasure to submit this project report on „Design and Fabrication of 3D (FDM) Printer‟. We have taken efforts in presenting this project. However, it would not have been possible without the kind support and help of many individuals. We would like to extend our sincere thanks to all of them.

It is with the great pleasure that we acknowledge to all those people for their consistent encouragement and support for this project report. We would like to express our special thanks to our guide Prof. G.S.Jagushte sir whose advice has inspired and shaped much of the content of this report.

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CERTIFICATE OF PROJECT COMPLITION

This is to certify that the following students of
Rajendra Mane College of Engineering and Technology, Ambav
Have successfully completed project entitled
"Design and Fabrication of 3D(FDM)printer"

1.Mr.Chavan Yashdeep Madhukar

2.Mr.Dhuri Pushkaraj Vinod

3. Mr.Keluskar Prathamesh Rajendra

4. Mr.Rane Yogesh Dyaneshwar

at our unit **Ashwin Capacitors Private Limited** situated at Goa, Plot no 50,Plierna Industrial estpilerna,Bardez,Goa Pincode: 403114,Goa India. Under the guidance of our Proprietor **Mr. Vinayak Kadam.** From 02 November 2021 to March 2022. During these project work these students were found sincere and hardworking.

We wish them success in future ventures.

For Ashwin Capacitors PVT. LTD.

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Abstract

3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. It is also known as rapid prototyping, Is a mechanized method where 3D object are quickly made on reasonably sized machine connect to a computer containing blueprints for the object. The 3D printing concept of custom manufacturing is exciting to nearly everyone.

This revolutionary method for creating 3D models with the use of inkjet technology saves time and cost b eliminating the need to design; print and glue together separate model parts. Now, you can create a complete model in a single process using 3D printing. The basic principles include material cartridge, flexibility of output, and translation of code into a visible pattern.

3D printers are machines that produce physical 3D models from digital data by printing layer by layer. It can make physical models of objects either designed with a CAD program or scanned with a 3D scanner. It is used in a variety of industries including jewellery, footwear, industrial design, architecture, engineering and construction, automotive, aerospace, dental and medical industries, education and consumer products.

Key words :3D printing, Additive manufacturing, Rapid prototyping, Inkjet technology.

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Chapter 1

Introduction

3D printing called as desktop fabrication. It is a rapid prototyping process whereby a real object can be created from a 3D design. A 3D printer machine uses a CAD model for rapid prototyping process. [1] 3D printing is called as desktop fabrication which is a process of prototyping where by a structure is synthesized from its 3d model. The 3d design is stored in as a STL format and after that forwarded to the 3D printer. 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 is diversifying and accelerating our life, letting various qualities of products to be synthesized easier and faster[2].

Fused deposition modelling (FDM) is one of the methods used in 3D printing. This technique is one of the manufacturing methods under the additive manufacturing engineering class, gaining popularity among researchers and industry to study and develop.

The basic concept of the FDM manufacturing process is simply melting the raw material and forming it to build new shapes. The material is a filament placed in a roll, pulled by a drive wheel, and then put into a temperature controlled nozzle head and heated to semi liquid. The nozzle precisely extrudes and guides materials in an ultrathin layer after layer to produce layer-by-layer structural elements. This follows the contours of the layer specified by the program, usually CAD, which has been inserted into the FDM work system.

1.1 3D PRINTER:

A 3d printer is an additive manufacturing technique where 3D objects and parts are made by the addition of multiple layers of material. It can also be called as rapid prototyping. It is a mechanized method where 3D objects are quickly made as per the required size machine connected to a computer containing blueprints of any object. The additive method may differ with the subtractive process, where the material is removed from a block by sculpting or drilling. The main reason to use 3d printer is for 90% of material utilization, increase product life, lighter and stronger. 3D printing is efficiently utilized in various fields such as aerospace, automobile, medical, construction and in manufacturing of many household products.

1.2 HISTORY:

The 3D printing innovation is not a new concept as many think. When FDM (fused deposition modelling) licenses had expired in 2009, the 3D printing became a new innovation topic. What's more, because of which it turned out to be more mainstream, individuals envisioned that FDM was the just a single added substance producing system. Be that as it may, the initial 3D printing procedure was SLA not FDM, and its first patent was recorded in 1980's. Here is the historical backdrop of 3D printing innovation, from 1980 to today.

In 1980's there was the introduction of 3 primary 3D printing systems. Dr.Kodana was the first person to present layer by layer approach for assembling and furthermore he was the principal individual to create fast prototyping strategy. What's more, he made a progenitor for SLA. He polymerized a photosensitive gum with the assistance of UV light, however, did not succeed. Shockingly for Dr.Kodana, the full patent detail was not recorded by him before the one-year due date after the application. the causes of 3d printing innovation can be followed from 1983.

In 1983 Charles hull was the person to do a patent on stereo lithography. Frame designed the term stereo lithography in august 8, 1984 patent application for "Contraption for creation of 3 dimensional questions by stereo lithography". Furthermore, was the main individual to make SLA-1 (stereo lithography) machine in 1987.

Charles hull was the founder 3D system Corporation (one of the biggest and more propel association working in 3d printer division today). Hull characterized stereo lithography as the unique technique which is used for making solid objects by printing successive layers of ultraviolet curable material on top of other. In frame's patent, he clarifies; a concentrated light emission light is centered around the surface loaded with a fluid photopolymer. The light ray which is controlled by a computer draws each layer of the model on the surface of the liquid. Wherever the bright light strikes the surface, the photopolymer polymerizes and changes to solid. Using the software CAD/CAM mathematically slices (converts into layers) the models. then the process builds the models layer by layer. During the year 1990's the other 3D printing innovation and processes were emerged during this year. And the introduction of new 3D printer manufacturers and cad tools. 3D systems make their first commercial sale of stereo lithography (SLA) system. And the other emerging processes were ballistic particle manufacturing (BPM) patented by William masters, solid ground curing (SGC) was been patented by ItzchakPomerantz et al. Furthermore, other developing organizations saw amid the nineties till today - Stratasys, EOS, and 3D systems. The 1990's were the time of first use of the 3D printer in medical researchers, who consolidated the way of pharmaceutical and 3D printing and opening the chances to numerous clients. In 1992 the patent done on fused deposition modelling was issued to Stratasys, who had developed may 3D printers both for professional and for individuals. The SLA (Stereo lithographic) apparatus was made in this year by 3D systems. The first SLA machine uses a UV laser solidifying photopolymer, and a liquid with the viscosity and colour of honey that makes the object layer by layer. This was the first rapid prototyping form that had changed the engineering world and design for ever. From

1993-1999, the main actors of the 3D printing sector, which had emerged with various techniques. Sanders prototype (later Solid scape) and Z Corporation were set up in 1996 in terms of commercial operation, Arcam was established in 1997. During that time where these 3D printing sector had started to begin the demonstrate distinct diversification with these two very specific regions emphasis that is clearly defined today. They were very high end 3D printing and still they are very expensive which were geared up towards the par production for high value and complex parts. This are growing rapidly and ongoing but the results are now visible in production applications across the automotive, aerospace, medical and in jewellery sectors. And at the other end, some of the 3D printing system manufacturers were developing and advancing the “concept modellers”, they were called at that time. These 3D printers kept on focusing on overall development and improvement of these functioning prototyping that were being developed on specifically as these offices and user friendly and the cost effective systems. However, these systems were very much useful in industrial applications. At the lower end of market, the 3D printers that today are been seen. During this term there, price was a war between the 3D printing companies with the increase in improvement, accuracy, speed and materials. In 2007 the market saw the first system under 10,000$ from 3D systems but it never hit the market as supposed to be. This was due to the market influence of other companies. All through in 2000 3D printing technology kept on developing to make lower-priced models with multiple features. In 2003 there was the new invention that 3D printer was used to construct cells when Thomas Boland of Clemson university patented for the use of inkjet printers for printing of cells. To modify these spotting systems for deposition of the cells into the very much organized 3D matrices placed on a substrate this process were used. The printing of biological structures is known as Bio printing. The millennium saw the first 3D printed kidney working. Additionally, more techniques for printing came into action, such as extrusion bio printing, have been researched and introduced as a means of production. Due to which the organs may be printed using bio printing and can be transplanted. In 2004 the initiating of RepRap project which consists of a self-replicating 3D printer. This open source of the RepRap project led to spreading of FDM 3D desktop 3D printers and popularity of 3D printers begins from here. In 2005, Z-Corp launched the spectrum Z510. The first colour and high definition 3D printer. The first SLS machine commercially accessible in 2000, which gave opportunities to the manufacturer to build industrial parts. A 3D printing start up company Objet built a machine that could print more than one material, which allowed a single part that can be manufactured and fabricated with different material properties. In 2009, was the year where the FDM patents fell into the public domain, giving an expansive wave for the development in FDM printers and due to the drop of the price of desktop 3D printers, the technology was more accessible and increased visibility. A French company named Sculpteo was started in this year which had offered 3D printing cloud and online printing services using stereo lithography or laser sintering. Which was another step towards 3D printing Design and Fabrication of Portable 3D Printer 2017-18 Department of Mechanical Engineering, Atria I T, and Bangalore 4 technology. A host of similar deposition printers have emerged with marginal unique selling point and they continued to do so. The ethos of RepRap is all about open source developments of 3D printing and keep it commercialize. As the various additive processes developed. It is said that soon metal removal will no longer be the only metal removal process done through a moving head through a 3D work envelope converting the mass of raw material into desired shape layer by layer. In 2010 there was a first decade in which metal end use parts like engine brackets and large nuts would be made by printing instead of machining.

1.3Principle:

1.3.1 MODELLING:

The object or the model which has to be printed first it has to designed or modelled using a CAD (computer aided drawing) tool like solid works etc. By the 3D scanner or by the digital camera and a very unique photogrammetric software. These 3D printed models were created with help of the CAD results in the reduction of errors which were found and can be corrected before printing. In manual modelling process of preparing geometric data for 3d computer graphics is similar to plastic arts such as sculpting. Based on this data 3-dimentional models of the scanned object can be produced. After modelling in CAD tool the model often be (in .skp,.dae,.3ds or some other format) then it needs to be converted to either a .STL or .OBJ format, to allow the printing software to be able to read it.

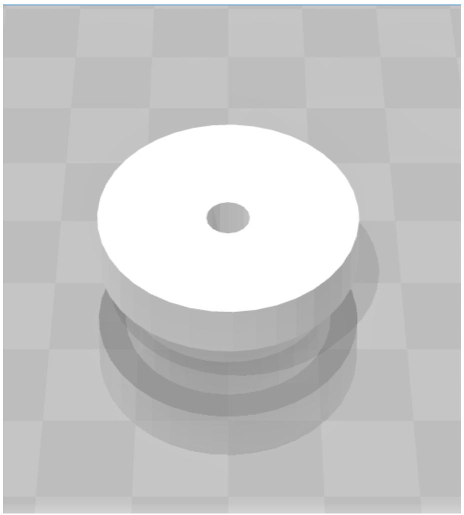

Fig 1.3.1 Capacitor Cap

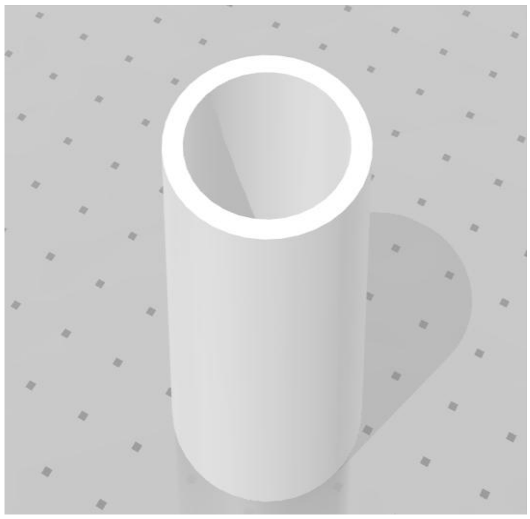

Fig 1.3.2 Capacitor Body

1.3.2 PRINTING:

After the model has been converted to STL, it must be first examined for “errors”, this step is called the “fix up”. In most of the cad applications produce errors in output STL files errors like sekf intersection, improper holes, face normal has to be corrected. Once the file is converted to STL, the file has to be processed by software called “slicer” which will convert the model into series of layers and produces a G-code file containing instructions to a specific type of 3D printer. This G-code file can be printed by using 3D client software (which loads the G-code and uses it to instruct the 3D printer during printing. In practice the client software and the slicer program exist, including Cura, Slic3r, repetier host, pronterface and skeinforge as well as closed source programs like simplify 3D and KISSIicer3D. 3D printer follows the G-code instructions to lay down successive layers of liquid, powder, paper or sheet material to build model from a series of cross sections. The such as plastic, sand, metal etc can be \used through a print nozzle. These layers, which correspond to the virtual cross sections from the CAD model, are joined or automatically fused to create the final shape. Depending on what the printer is making, the process could take up to minutes or hours. Printer resolution describes the layer thickness and X-Y resolution dots per inch (dpi) or micrometers(µm).The layer thickness which can be found can be around the 100gm mark, although some of these machines such as the object convex series and the 3D Systems Pro Jet series can be very much printed as thin layers as 16µm. These resolution of X-Y is comparable to that of laser printers. The particles (3D dots) are around 50 to 500µm (510 to 250 Dpi) in diameter. The method of Construction of models can take away from several hours to several days, depending how big the model is, method used, printing speed, and complexity of the model. Typically, the time can be reduced to few hours depending on the type of machine used and size. 3D printers give designers and concept models using a desktop size of 3D printer.

1.3.3 FINISHING:

The printer produced resolution is very much sufficient for many of the applications but the printing will be a slightly oversized version of this desired object which can be the standard resolution and then the process of removing material can give greater precision. Some printable polymers allow the surface finish to be smoother and improved using chemical vapour processes. There are some of the additive manufacturing techniques which are very capable of using multiple materials in this course of constructing parts. These techniques are very much able to print in multiple colours and colour combinations simultaneously. Some printing techniques require internal supports to be built for overhanging features during construction. These supports must be mechanically removed or dissolved after completion of the printing. The commercialized metal 3D printers which very much likely to involve in cutting the metal component of the metal substrate after deposition. The very new process for the GMAW 3D printing which will allow for substrate surface modifications to remove many aluminium components manually with hammer.

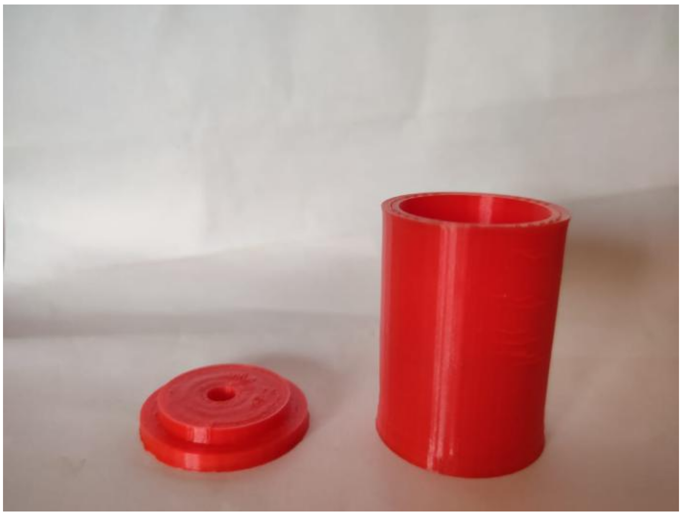

Fig 1.3.3 Finished Part

1.4 PROBLEM STATEMENT:

- 3D printing should be used as a tool for innovation, but troubleshooting frustrating problem is a barrier to progress.
- With the huge demand for end product by consumers, the rapid prototyping industry need to move faster towards production of technologies that are easily accessible by consumers and cost efficient too.
- Prototyping is often the most costly and time consuming stage of the product development lifecycle. It is therefore desirable of individuals and organisations to reduce the time it takes to develop a product.
- 3D printing a product which has an inclination exceed 45^{o} reduces support during the printing process.
- During the process printing support takes time and required additional material to print.

1.5 OBJECTIVES:

1) To define and establish standardization, regulatory issues, qualifications and risks analysis.
2) To investigate new and emerging technologies.
3) To realize further development of 3D printing.
4) To understand how a 3D printer works.
5) To increase knowledge on modelling & characterizations and develop specific tools for that.

Chapter 2

Review of literature

2.1 Review of Books

1) 3D Printing for Dummies,Wiley Brand

This book is a guided guide for amateurs, artists, engineers and entrepreneurs in which the full potential of 3D printing is shown directly and clearly. It offers the basic knowledge for design through software, 3D scanner and even photographs to create lithographs in a fast and simple way.

2) Impresion 3D,Sergio Gomez Gonzalez

We have here a very complete, practical and visual book that covers all aspects of 3D printing. During the reading, there are important aspects such as recommendations when designing parts and checking the mesh before starting an impression.

2.2 Review of Research Papers:

[1] Ksawery Szykiedansa et al (2015)

A recent development of the 3-D printers, has made them readily available to the public at low costs. In order to make 3-D printed parts to be more useful for engineering applications the mechanical properties of printed parts must be known. This paper quantifies the basic tensile strength and elastic modulus of printed components produced with application of FDM and SLA printers.

[2] Venu Madhav et al,

3D printing is one of the most important technological advancement in Additive manufacturing which has been Implemented and recognized as a part of modern industry . Development of various components ranging from simple structures used in everyday life to complicated Components in aerospace applications, 3D printing Provides many advantages few are Simplicity, Reliability and Precision etc this makes it one of the most widely used for making components which can be used as concept. Components.3D printing is the most widely used additive manufacturing processes in the current industry not only limited to Engineering. This paper presents an overview of Additive Manufacturing and Various applications of engineering.

[3] Aman Sharma et al ,

This paper is all about the advanced technology of 3D printing, their implementation in the respective fields and its significant contribution in the global world of science and medical. In this paper we will deal with the term Additive Manufacturing or 3D Printing and a little bit of its history. Its various applications along with the type of materials used in the 3-D are also described. We shall also throw some light on the numerous opportunities provided by this emerging technology as well as the risks and challenges related to it. Its environmental aspects are also shown in the paper. Lastly the scope and scenario in future potential of 3D printing is also evaluated.

[4] Ashish Patil et al,

Additive manufacturing process or 3d printing process is now becoming more popular because of its advantages over conventional processes. A 3d printer is a machine that create objects out of plastic, nylon like many other materials.3D printers now days available are not so portable and also they are very costly. By analyzing this problem, we are trying to make a portable 3D printer which we can take anywhere easily because of it's briefcase like design. The cost of this printer will be very less compared to other 3D printers. In this 14 printer we are also providing more interfacing options like we can control it through computer or we can send Gcodes directly from SD card.

[5] Orugonda Ravali et al,

This paper aimed at Design and Development of metallic 3D printer. The main focus is design the basic analysis of present 3D printers, their parts and mechanism. The requirements that are of metallic 3D printer and its applications. The study on design of 3D printer involves 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.

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Chapter3

Methodology

3.1 FLOWCHART

The following flow chart shows the methodology used by us in construction of 3D printer. The first step is to select one of the additive manufacturing process among many process explained in chapter 2. 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.

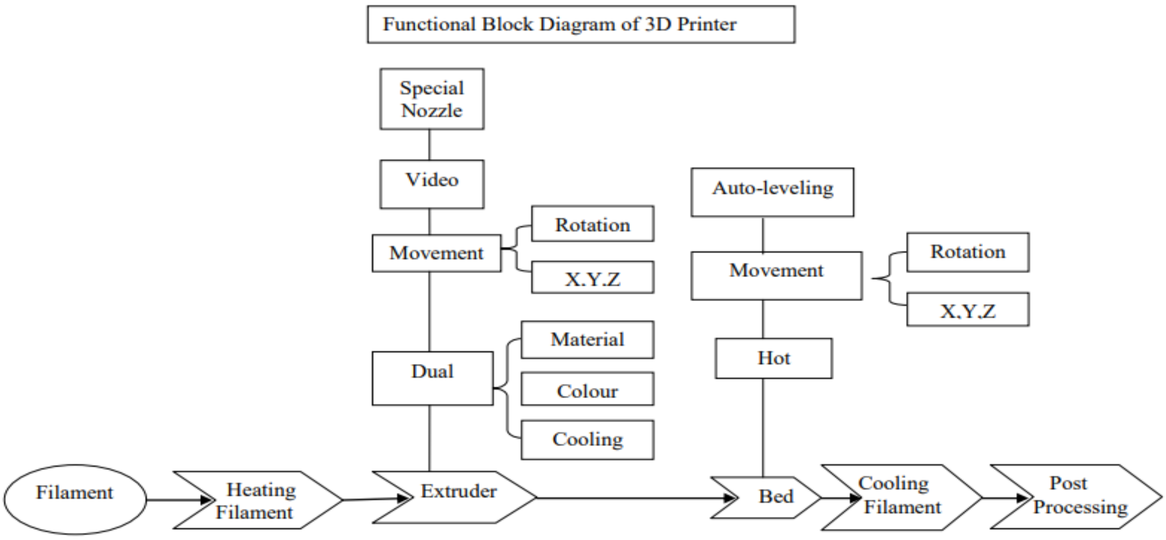


Fig. 3.1.1 Functional block diagram of 3D Printer

Methodology is a process in which how a project or work is done that is discussed. In our case we have fabricated and constructed the 3D (FDM) printer.

3.2 PROCESS OF 3D PRINTING

3D printing process can be described and defined in the following steps:

3.2.1 CAD Model Creation:

Initially, the item to be 3D printed is designed utilizing a Computer Aided Design (CAD) software. Solid modelers, for example, CATIA, and SOLID WORKS have a tendency to represent 3-D objects more precisely than wire-frame modelers, for example, AutoCAD. This procedure is comparative for the majority of the Rapid Prototyping building methods [6].

3.2.2 Conversion to STL Format:

The different CAD models use different methods to present solid parts. To have consistency, the stereo lithography format has been followed as the standard of the 3D printing industry.

3.2.3 Slice the STL File

A pre-processing computer program is done which readies the STL format going to be built. Numerous programs are there, which permit the user to tweak the model. The preprocessing program cuts the Stereo lithography model into numerous layers from 0.01 mm to 0.7 mm thickness, in view of the building method. The program likewise makes an auxiliary structure to help the model amidst of building. Sophisticated structures are bound to use auxiliary support [7].

3.2.4 Layer by Layer Construction:

The fourth step is the actual construction of the part. Using one of various techniques RP machines build one layer at a time from polymers, or powdered metal [7].

3.3SELECTION OF MECHANISM

Presently mechanisms such as, for example, SCARA, Cartesian, Polar, Delta and so on are utilized as a part of development of FDM 3D Printers. We have chosen cartesan arrangement of developments, where the bed moves in the vertical heading i.e., in Z pivot bearing and the extruder spout moves horizontal way i.e., both in X and Y hub course. Z hub development on such a 3D printer is extremely exact and requires low increasing speeds, however the bed should be lightweight with a specific end goal to look after precision, which makes it harder to include a completely programmed bed levelling framework. Controlling a straight Cartesian framework like this is mechanically straightforward and furthermore generally simple from a product point of view, which is the reason most 3D printers available today utilize this kind of plan. The Cartesian arrange frameworks has for quite some time been utilized for instruments like plotters, CNC processing machines, and 2D printers.

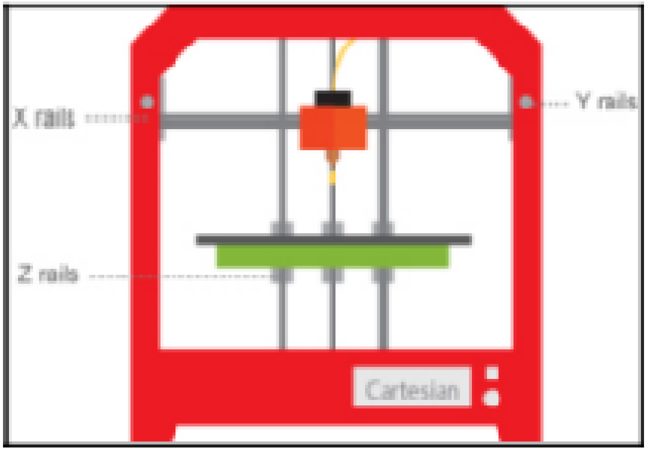
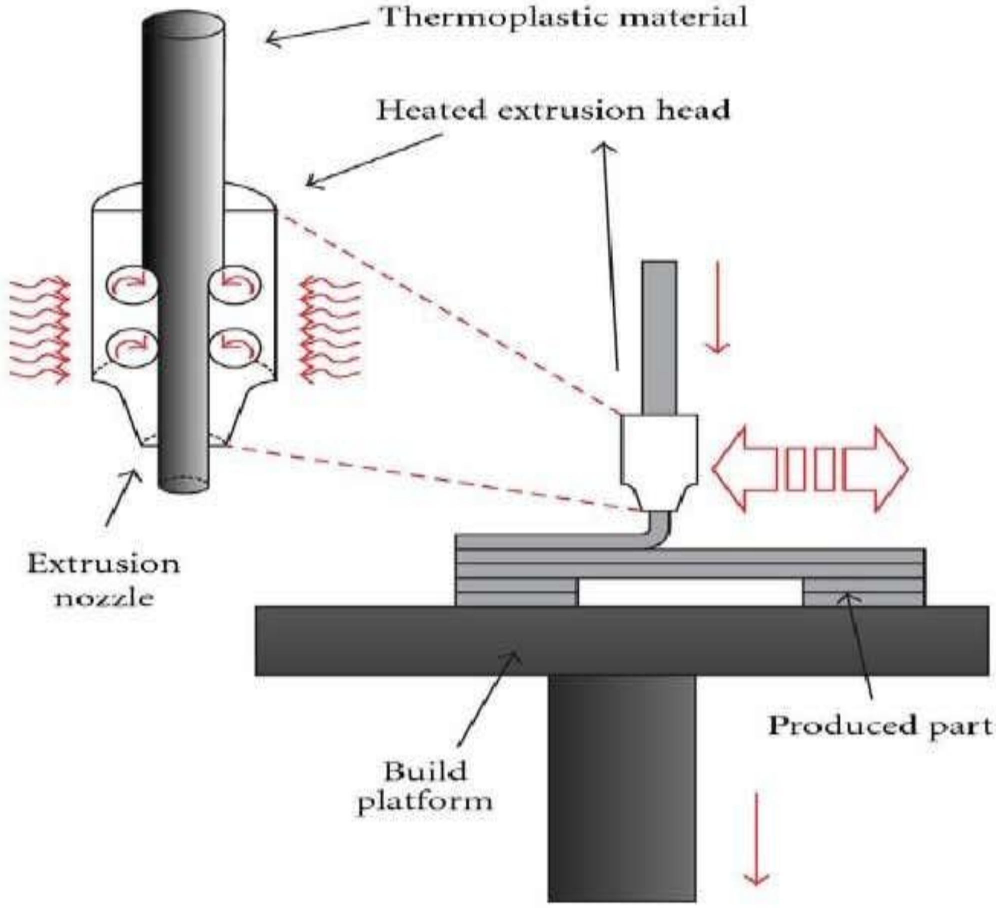


Fig 3.3.1 Diverter Tube

3.4 WORKING PRINCIPLE OF FDM BASED 3D PRINTER

FDM 3D printing is a technology that works both horizontally and vertically, where an extrusion nozzle moves over a build platform. The process involves the use of thermoplastic material that reaches melting point and is then forced out, to create a 3D object layer by layer. As the design takes shape, it is clear to the search layer as a horizontal cross section. Following the completion of one layer, the nozzle of the printer is lowered in order for the next layer of plastic to be added to the design When the FDM printer begins printing, the raw material is extruded as a thin filament through the heated nozzle. It is deposited at the bottom oftheprinter platform, where it solidifies. The next layer that is extruded fuses with the layer be low, building the object from the bottom up layer by layer.Most FDM printers first print the outer edges, the interior edges next and lastly the interior of the layer as either a solid layer or as a fill in matrix. In some objects / models, there are fragile ‘overhangs’ that will droop unless they are given some support. FDM printers incorporate a mechanism where by these support structures (called struts) are printed along with the object. They are later removed once the build is complete. These struts are usually of the same material as the object. Some printers have a second extruder to specifically deposit soluble thermoplastic struts when there is a need to prevent the overhangs from drooping. These struts may be of a different composition than the thermoplastic used for the 3D model. They are later dissolved by an appropriate solvent.



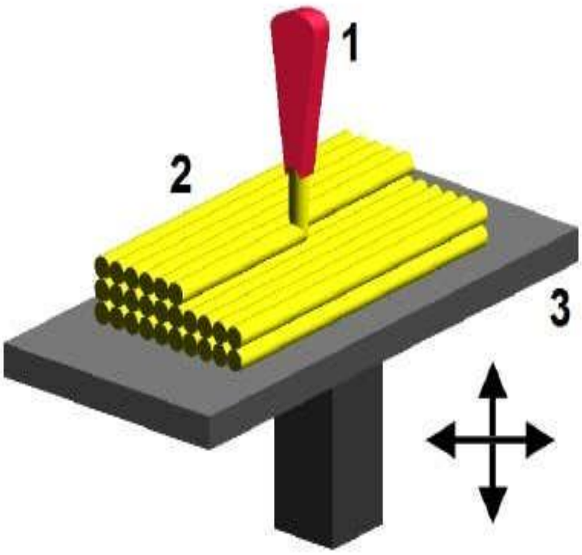


Fig 3.4.1 FDM methodology

Chapter 4

Experimental Setup

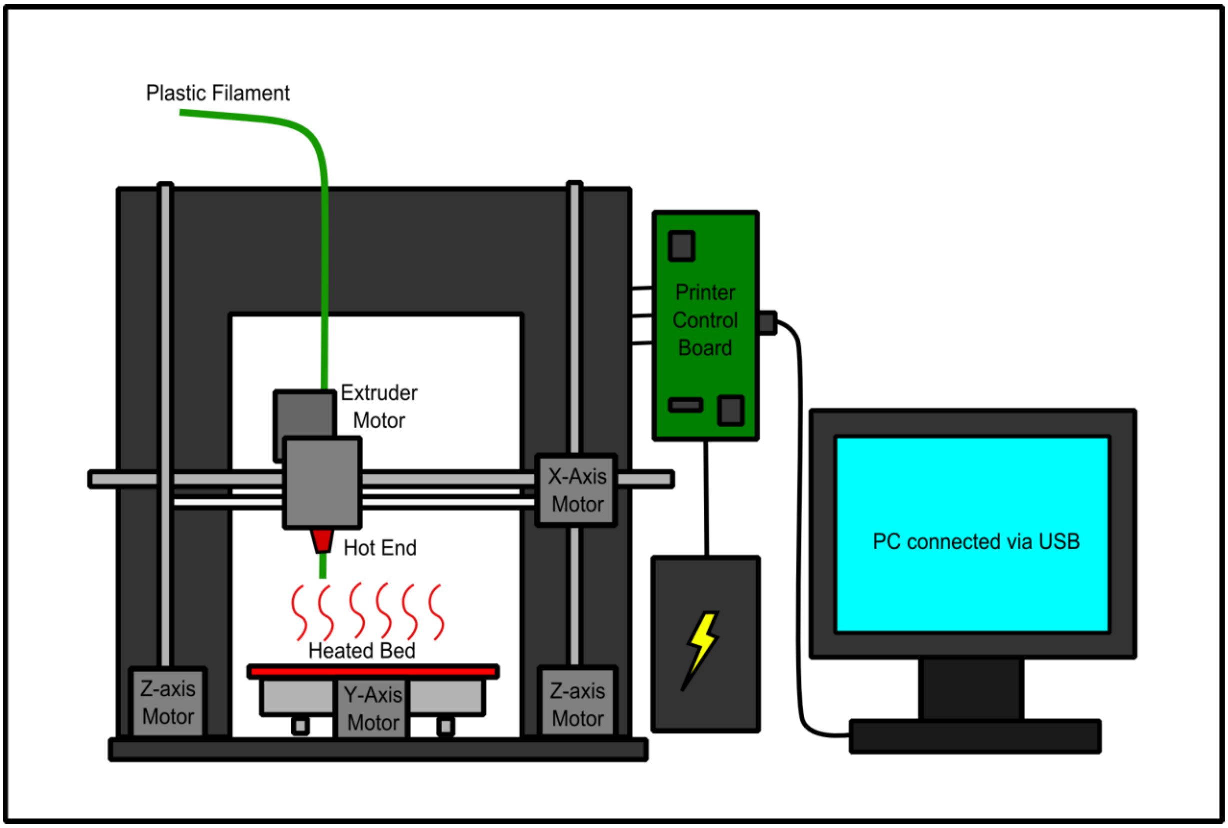


Fig. 4 Experimental Set up of 3D Printer

4.1 COMPONENTS:

1. EXTRUDER:

Fig 4.1.1 Extruder

Extrusion is a procedure used to make objects of a settled cross-sectional profile. A material is pushed or pulled through a die of the desired cross-sectional profile. To extrude molten plastic filament, the "Cold End" forces the raw material into the hot end. The feeding filament then go through the "Hot End" of the extruder with the heater and out of the nozzle at a reasonable speed. The extruded material falls onto the fabricate stage and after that layer by layer onto the part as it is constructed.

2. NOZZLE

Fig 4.1.2 Nozzle

Nozzle is mechanical part of the 3D printer that extrudes the filament. It conducts the thermal energy provided by the heating cartridge and block to the filament, melting it. Based on the material property, it’s clear that three major characteristics are integral to a nozzle’s design: its size, material, and inner diameter. The bigger the nozzle, the more mass and surface area available for transferring heat to the filament, making this process more effective and capable of higher extrusion speeds. In summary, all three nozzle characteristics can have a large impact on how long your part takes to print as well as the quality of the final object.

3.COOLING FAN:

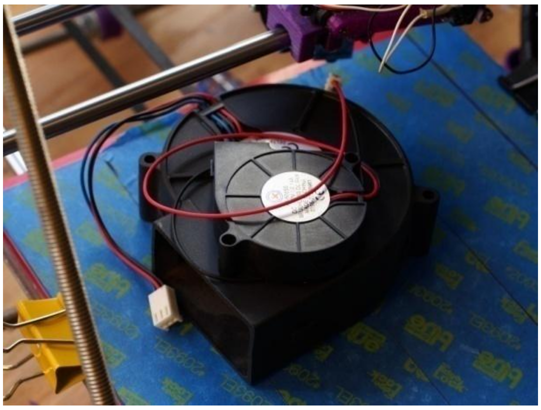


Fig 4.1.3 Cooling Fan

Cooling fan cool the freshly extruded plastic as son as it exits the nozzle. They either push cold air over hot components or pull hot air out of enclosed spaces. Either way, they create a cooling effect. Most of the hot components have heat sinks, these are generally so small. This means that over time, the heat will build up faster than it is dissipated, resulting in the chip eventually overheating. Depending on the quality and efficiency of the hardware, this may or may not occur within the time span of a typical print. A fan helps by providing more air over the heat sinks, helping to dissipate the heat much faster than would otherwise be possible.

4.PITOT TUBE:

Fig 4.1.4 Pitot Tube

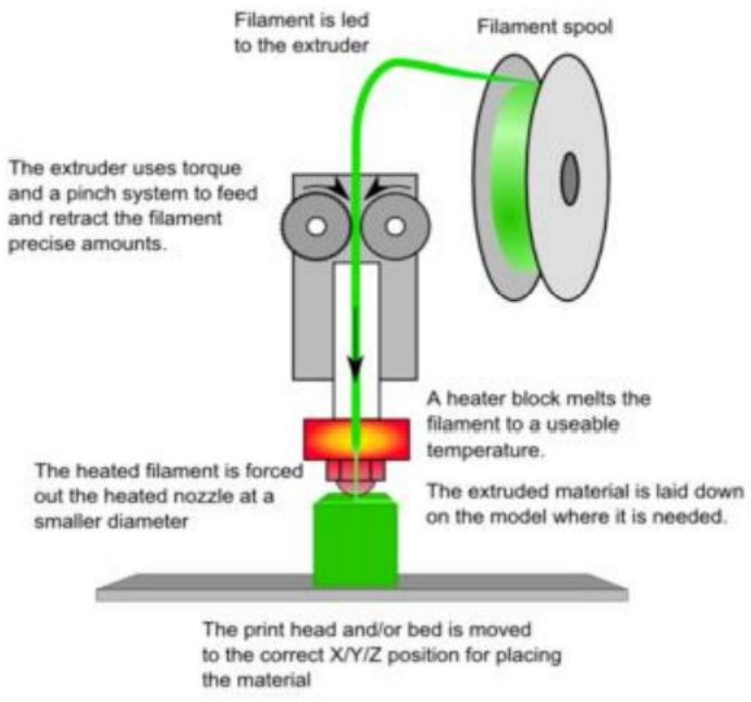
Pitot tube control the feed of filament from extruder to nozzle. For the better surface finish and better strength feeding of proper amount of material is important this is occurred with the help of pitot tube.

Chapter 5

Fabrication and Assembly

5.1Working OF FDM Machine:

In the FDM process, a gantry-robot which is fitted with the extruder head moves in X & Y directions. The table moves in vertical Z-axis. When a layer gets deposited on the table, it goes down according to the layer thickness and the subsequent layers are built in the same way



FDM PROCESS

Fig. 5.1.1 Working of FDM machine

5.2 ASSEMBLY OF FDM 3D PRINTER:

he load carrying structure is frame, which is the first to assemble and then various other parts could be mounted on this frame. Using aluminium profile or acrylic frames and M5 socket head cap screws, frame can be assembled. After assembling the frame, next step is to fix the carriage in the guide rails. Over those carriage, build surface and extruder assembly is to be mounted. Extruder is an important part of FDM 3D printers. There are mainly two types of extruders – direct extruder and Bowden extruder. In this design a direct extruder is used. Inside the extruder, a roller mechanism is used to feed the filament. Two rollers with grove are used to hold the filament firmly and push it inside the heating block, where it gets melted and deposited on the build surface through the nozzle. To keep the heat confined to heating block only, a cooling fan with radiator is attached just above the heating block. Air blower is also assembled with the extruder-nozzle assembly for cooling the printed part. This whole assembly of extruder is mounted over a carriage to have linear motion along an axis. Build surface is the part on which material is deposited. To achieve better part quality, this surface should be hot, hence hot bed is used to make build surface. This surface should also have sufficient adhesion with the extruded material. Hot bed and other mechanical components are used to make the build surface assembly. Then this assembly is also mounted over one of the carriages to have motion along an axis.

5.3 PROCEDURE:

5.3.1 CREATE BUILT FILE:

- In Catalyst or Insight software, open your CAD file (in STL format), and select a material, colour and slice thickness.
- Pick a build and support style to match your application's requirements.
- Select an orientation and then let the software do the rest. It sections the design into layers and creates tool paths for both the part and its disposable support structures. Then it outputs a build file, which defines precise motion control paths.
- Click print to send the build file to the 3D printer.

Fig 5.3.1 Creation of part

5.3.2.PREP MACHINE:

- Insert the part-material and the support-material cartridges; the system will automatically feed the material filament to the extrusion head.
- Insert a base and close the chamber door. You are ready to build.
- Select your job from the queue, and press the machine’s start button.
- The 3D printer heats the build chamber and brings the plastic liquefier up to operating temperature.

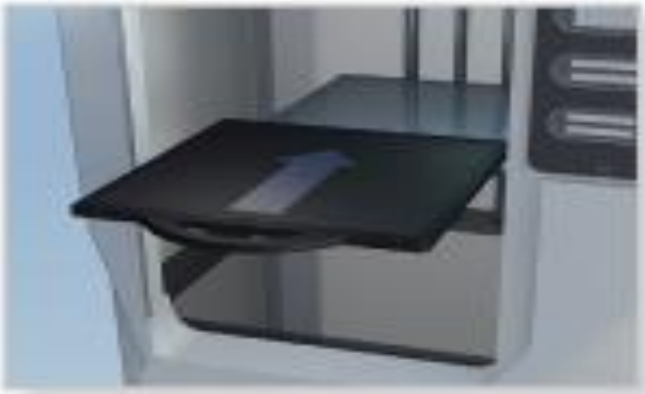


Fig. 5.3.2 Prep machine

5.3.3 BUILD PART:

- The Z stage (platen) rises to its starting position, just a few thousandths of an inch (or tenths of a millimetre) from the material extrusion tips that protrude from the liquefier.
- The 3D printer starts with a few layers of disposable “support material” to provide a foundation. Support material is also used to support features such as overhangs that would otherwise have nothing to rest upon. The extrusion head, which moves about an XY gantry, lays down a ribbon of material. After each layer is complete, the Z stage build platen lowers slightly to make way for the next layer.
- The same process used for the support structure is used for the part, except it employs a different material – a thermoplastic, such as ABS or polycarbonate. When building a part, the extrusion head alternates between part-material and support-material extrusion tips.
- Close-up of process: In the Fused Deposition Modelling process, each layer of molten plastic is deposited on top of the previous one and flattened slightly by the extrusion head. The layers instantly fuse to one another.

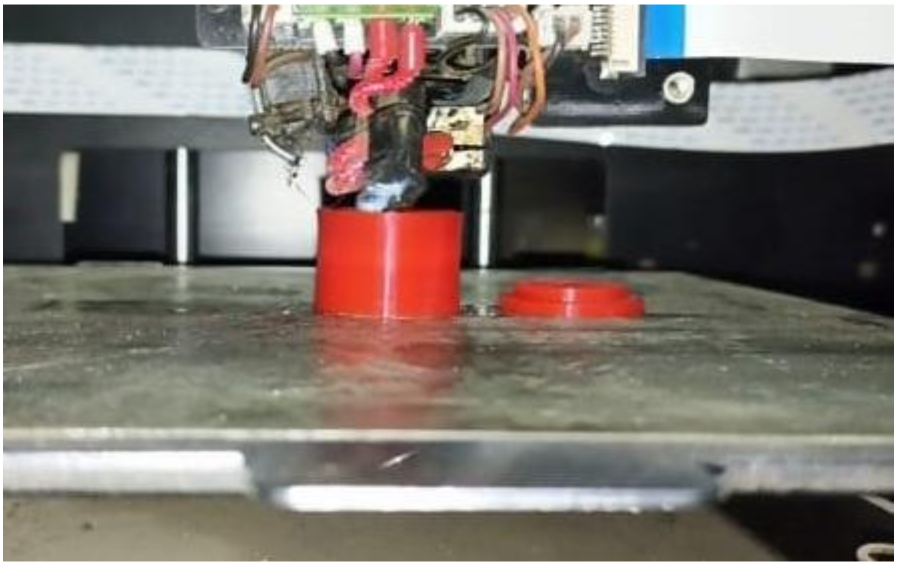


Fig 5.3.3 Actual image of Capacitor printing process

5.3.4 REMOVE PART :

- When the 3D printer display reads "complete," open the chamber door and remove the build tray.
- Give the tray a twist to release the part. Now, you're ready for the final step.

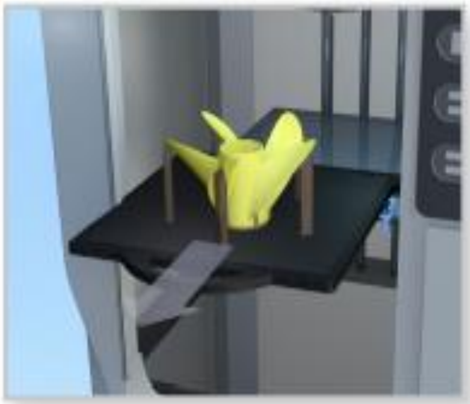


Fig. 5.3.4 Remove part

5.3.5 REMOVE SUPPORTS :

- The supports have done their job, so it is time to remove them.
- The removal depends on the support material type used:

1. Soluble support material: This method uses an automated support-removal process in which the material is removed in a tank via an agitated water based detergent solution.
2. Break Away support material: This is a manual removal process, in which you twist, break, and scrape support material from the part. A needle nose pliers and a pick are usually sufficient.

Fig. 5.3.5 Remove support

Chapter 6

Materials used and Specifications

6.1 MATERIAL SELECTION:

1. Base frame and Levelling nuts

Alloy steel- enhance properties of material such as ,mechanical ,Thermal and Corrosion resistance.

2. Power supply

Lihsolid metal boxes- 240watts(12volts and 20amps).

3. V-profile and Pulley

Made of high quality POM material these wheels are durable and sturdy.

4. Magnetic Platform

Plastic (with magnetic) the temperature required 50 to 75 °C.

5. FDM Machine

FDM utilizes strong, engineering-grade materials like ABS, Polycarbonate and ULTEM 9085 Resin.

6. Cooling Fan

Plastic Size-50mm*15mm ,Ball Bearing,Voltage-12v,Cable length-110cm

7. Extruder

PETG (Polyethylene terephthalate glycol.

8. Stepper Motor Kit

Metal- Lower Noise and running temperature.

9. Main board

Mainboard comes with low decimal and silent TMC2208 Driver ,which makes the sound of the printer running below 50db.

6.2 SPECIFICATIONS OF PRINTER

1) Materials : PLA, ABS, ASA, HIPS, PETG, TPU 85A, TPU 95A, Nylon, Nylon-CF,PC
2) Filament Sensor :Yes
3) Nozzles :0.25 mm, 0.4 mm, 0.6 mm in High Temperature and Hardened variants
4) Nozzle Technology :Fused Deposition Modeling (FDM)
5) Print Head :Direct Drive Extruder with Swap able Nozzles
6) Build Volume : 200mm x 200mm x 200mm ,800cc
7) Filament Diameter :1.75mm
8) Layer Resolution :0.25 mm Nozzle : 20 - 150 micron 0.4 mm Nozzle : 100 - 300 micron 0.6 mm Nozzle
9) XYZ positioning Resolution :X Y : 6.25 micron Z : 1 micron
10) Build Speed :55 mm^3/min up to 972 mm^3/min with 0.6mm Nozzle
11) Build Plate Temperature : 130ºC
12) Build Plate Leveling : Active nozzle-tip probe based leveling
13) Supported Temperature :Upto 290ºC
14) Power Rating :750 W
15) Connectivity :SD Card, USB to PC
16) Monitoring :N/A
17) User Interface :Monochrome Graphic LCD with Dial
18) Physical Dimensions : 435mm x 445mm x 385mm (L x B x H)

6.3 SOFTWARE USED

▪SOLIDWORKS 2016 Version 24

It was published by Dassault system. The solid works are used for solid modelling computer-aided design (CAD). It runs on operating systems like windows7 or 8 etc. the 3D printed parts were designed using solid works to develop an assembly of a 3D printer with complete design with solid works you can print directly to 3D printer, similar to how you would print a document to your normal printer, it can also give different types of output like STL, IGES, VRML and JPEG etc[5].

▪FRACKTAL WORK

Fracktal Works is a 3D printer manufacturing and product development firm that also provides product design and CAD services. Fracktal Works was founded in June of 2013 by two engineering students of Manipal Institute of Technology. They worked on building robots with the university robotics team, Robomanipal.It runs on operation system like windows10, the 3D part was designed and print directly to assemble with complete design using fracktal work.

▪Fusion 360 Version 1.1 700 series

Fusion 360 is a cloud-based 3D modeling, CAD, CAM, CAE, and PCB software platform for product design and manufacturing . It is used to design and engineer product to ensure aesthetics, form, fit and function. Also reduce the impact of design , engineering and PCB changes and ensure manufacturability with simulation and generative design tools. Directly edit existing features or model fixtures with the only truly integrated CAD+CAM software tool. It runs on operation system like windows7 pr 10 etc[5].

▪Siemens

Siemens Digital Industries is a world – leading provider of product lifecycle management and manufacturing operations management software. Siemens Digital Industries software is an American Computer software company specializing in 3D and 2D Product Lifecycle Management(PLM).

6.4 APPLICATIONS OF 3D PRINTING

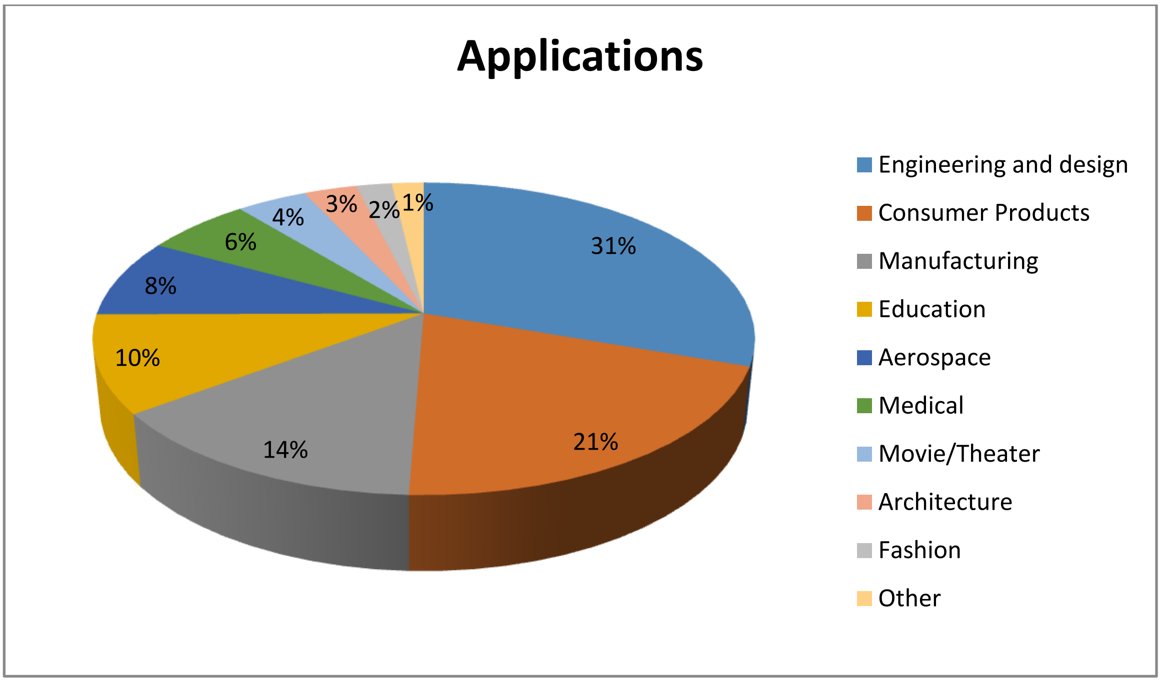


Fig. 6.4 Pie chart of Application of 3D Printing

Chapter 7

Design and Calculation

7.1 Design procedure:

- Maximum Printing Volume
  Length: 200mm , Width: 200mm , Height: 200mm
  Volume =200*200*200 = 8000000 mm2

- Max. weight of printed object
  Weight = density * volume
  =1250 * 5.72 * 10^{-3}
  =7.29 kg = 72.9 σ ≈ 73 σ

- Design of heat Bed

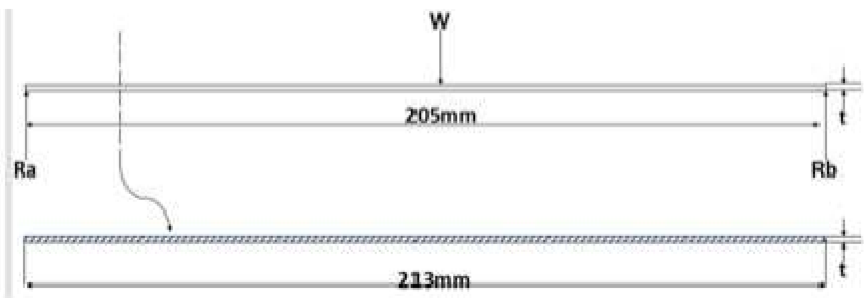


Fig.7.1.1 Heat bed

W= 73 N

MA = MB =73 * (205/2) =7380 N-mm

By flexural formula:

M/I = [ıb]/y (1)

For Aluminium 6065 : σu=310MPa σy=276MPa ρ=2700Kg/m³ σb=0.72MPa σy = 98.72MPa Taking FOS = 3

[σb] = 66.24MPa

[ζs] = 46MPa

7380/ (bt3 / 12) = 66.24 / (t/2)

b= 213 mm

(7380 * 12) /213 = t2 * 2 * 66.24 t = 1.77mm we have available thickness of 3mm.

- Calculation of motor torque (for Z- axis)

Reaction force in L– section = 73 N

Taking lead screw of diameter 8 mm

& Dm= 7.183, P = 1.5

Φ= tan -1 (p*4/πDm)

= tan-1 (2/ π * 7.183) = 5.1º

Φ = tan-1 μ = tan-1(0.25) = 14.03º

Torque required to raise the load Traise= (FDm / 2) tan (d+ij)

= [(73 * 7.183) / 2] * tan (5.1 + 14.03)

=90.94 N/mm

=0.09094 Nm

=0.9094 kg.cm

There are some extra load acting on the motor due to the machining error or misalignment by considering all these aspects We are selecting NEMA–17 motor with holding torque of 4.7 kg-cm.

- Design of chrome platted hardened shaft (for Z-axis)

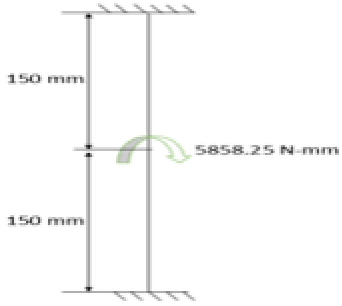


Fig. 7.1.2 Chrome platted Hardened shaft

σy= 700MPa

FOS = 2

[σt] = 0.72,

[σt]= 252MPa

M/I = ıb/y

= (11716.5/2)/(π/64) * d4 = 252/(d/2)

d3 = 236.79

d= 6.186 mm ≈ 8mm

- Design for Belt and Pulley

As per application GT2 pulley and belt are suitable for application.

Specification:

Number of teeth=20

Pitch=2mm

Pulley Material: aluminium

Belt Material: Composite of Polyurethane and Rubber

- Design of aluminium t slot section for frame

Fig. 7.1.3 T slot section frame

Aluminium 6065

σyt = 380MPa

N= 2

[σyt] = 190MPa

[σb] =0.72

[σyt] =136.8MPa

Checking of bending strength

M/I = δb/y

BMmax = (11716.5/2) + 5 * 200 +(11716.5/2)

= 2.5 * 400

RHA=RHV= 2.5N

BMMAX=13716.5 N-mm

y= 10mm I=6227.25mm4

13716.5/6227.25 = σb/10

σb = 22.02Mυa < [σb]

Chapter 8

Result and Discussion

Fig.8.1.1 Printed part

Fig. 8.1.2 Moulded part

The process used in the industry is injection moulding. Through which they cannot make complicated objects . Also the surface finish of the object is poor .Time required for manufacturing the object is more and cost is main factor. The strength of object is not so satisfactory to overcome this problems we make a 3D FDM printer. By using this 3D FDM printers any complicated object can be formed easily. FDM printer requires less time to make product and the surface finish of the object is good as compare to the injection moulding . The two main factors of making project is to avoid more costing and provide better strength. Which can be achieved by the our project. It also reduces the wastage of material which beneficial for company.

Chapter 9

Cost Estimation

The total printer cost as per the individual component and their corresponding rates is as follows,

SR NO.	COMPONENT	COST
1.	USED PRINTER BODY	8000
2.	PRINT PLATFORM	4500
3.	CONTROLLER BOARD	4600
4.	5xNEMA17 STEPPER MOTOR 0.4Nm 1.7A	1500
5.	BREADED CABLE, SLEEVING18 mm FLAT	200
6.	HOT END KIT FOR 3D PRINTER	1999
7.	AXIAL COOLING FAN	1500
8.	NOZZLE (0.4mm)	200
9.	NOZZLE(0.6mm)	450
10.	SOFT MAGANETIC STICKER KIT	850
11.	EXTRUDER	4000
12.	POWER SUPPLY	5000
13.	COLOR TOUCH SCREEN, USER INTERFERANCE , CONNECTIVITY	7000
14.	MISCELLANEOUS COST	1500
TOTAL COST		41299

Chapter 10

Timeline

1	Visit at the company to find the problem	September 2021
2	Literature review	September 2021
3	Visit at the printer authorised centre for purchasing the body of printer.	October 2021
4	Industrial Survey	November 2021
5	Discussion with expert and the guide & determination of basic idea. Prof. G. S. Jagushte	November 2021
6	Functional diagram of determined model.	December 2021
7	Modification of the component.	December 2021
8	Assembly and Fabrication	January 2022
9	Testing of the system	February 2022
10	Conclusion & Results.	March 2022

Chapter 11

Conclusion

The outcome of this project was to build a portable 3D Printer which has been successfully completed. The design of the frame is made robust and compact using aluminium sections. The material selection of the various elements is economical. Using a single motor for vertical movement along with a proximity sensor makes bed levelling 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. To overcome this drawback, a new mechanism has been developed which uses bed movement in Z. 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..

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