A PROJECT REPORT

ON

“3D PRINTER INTEGRATED WITH EMERGING TECHNOLOGIES”

Submitted by

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In partial fulfilment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. Nawaz Motiwala

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

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CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by them under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University of Mumbai**, is approved.

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APPROVAL OF DISSERTATION

This is to certify that the thesis entitled

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In partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

____________________ ____________________

Date: ___________

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Declaration

I 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.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Industry 4.0 has boosted technological advancements at a very rapid pace and is becoming extremely difficult to keep up with it. 3D Printing, which is also a product of Industry Revolution 4.0 is also gaining rapid momentum in advancements. Such is also the same for the FDM Method on which most 3D Printers work. This project focuses on these enhancements in the traditionally available FDM based 3D Printer and its integration with Augmented Reality (AR) technology. The primary goal is to reduce the time taken to print an object, use of different material, and colors. Also the traditional 3D Printer faces the difficulty of Bed-Leveling[1]. Most 3D Printers available do not provide ease of use, are somewhat costly, less mobile and more complex in construction. Thus, the design, development and making of such a 3D Printer which will remove such impairments and implement a method of 'Dual-Extruder' and Auto-Bed Leveling based FDM 3D Printer is discussed. Addition of another extruder and a sensor which can automatically level the bed solves the aforementioned problems of the 3D Printer.

To provide ease of understanding and working of a 3D Printer, implementation of Marker-based AR Technology to depict the 3D Printer is implemented which is in compliance with Industry 4.0.[2] Additionally, emerging technologies such as ChatBot AI, Wireless Printing, Touch-based interaction system to make things easier for the user to understand and work out with the 3D Printer can also implemented.

The following report contains a detailed explanation of the work done. The initial chapters discuss the need of this project, its history, available literature surveys carried out, available design and methods of 3D Printing. Next chapters deals with the depiction and explanation of a FDM based 3D Printer, its methodology, uses and its merits over other available methods. Further chapters deal with the components used, their specifications, designing procedure and fabrication. Finally the cost report, results and conclusion is stated in the remaining chapters.

KEYWORDS: Dual Extrusion, FDM, 3D Printer, Auto-Bed Leveling, Augmented Reality.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

3D printing or also known as additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each layer can be seen as a very thinly sliced cross-section of the object. 3D printing is the inverse of subtractive fabrication which involves cutting out or hollowing out a bit of metal or plastic with a processing machine. 3D printing empowers you to deliver complex shapes utilizing less fabric than conventional fabricating strategies[3].

1.1.1 HISTORY OF 3D PRINTING

The innovation for printing actual 3D items from computerized information was first evolved by Charles Hull in 1984. He named the procedure as Stereo lithography and acquired a patent for the method in 1986. While Stereolithography frameworks had gotten famous before the 1980s, other comparative advances like Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS) were presented. In 1993, Massachusetts Institute of Technology (MIT) protected another innovation, named "3-Dimensional Printing methods", which is like the inkjet innovation utilized in 2D Printers. In 1996, three significant items, "Genisys" from Stratasys, "Actua 2100" from 3D Systems and "Z402" from Z Corporation, were presented. In 2005, Z Corp. dispatched an advancement item, named Spectrum Z510, which was the primary top notch shading 3D Printer on the lookout. Another forward leap in 3D Printing happened in 2006 with the inception of an open source project, named Reprap, which was pointed toward building up a self-replicating 3D printer.

As of late Engineers at the University of Southampton in the UK have planned, printed, and sent heavenward the world's first airplane produced primarily by means of 3-D printing innovation. The UAV named SULSA is fueled by an electric engine that is practically the solitary piece of the airplane not made through added substance producing techniques. Made on an EOS EOSINT P730 nylon laser sintering machine, its wings, incubates and control surfaces fundamentally all that makes up its design and streamlined controls was exceptionally printed to snap together.

Figure 1.1 SULSA UAV, UK[6].

1.1.2 CURRENT 3D PRINTING TECHNOLOGIES

1. STEREO-LITHOGRAPHY

In this process photosensitive liquid resin which forms a solid polymer when exposed to ultraviolet light is used as a fundamental concept. Due to the absorption and scattering of the beam, the reaction only takes place near the surface and voxels of solid polymeric resin are formed. A SL machine consists of a build platform, which is mounted in a vat of resin and a UV Helium-Cadmium or Argon ion laser. The laser examines the primary layer and stage is then brought equivalent down to one cut thickness and left for a brief timeframe so fluid polymer settles to a level and even surface and restrain bubble formation. The new slice is then scanned. Schematic diagram of a typical Stereo-lithography apparatus is shown in figure. In new SL systems, a blade spreads resin on the part as the blade traverses the vat. This ensures a smoother surface and reduced recoating time. It also reduces trapped volumes which are sometimes formed due to excessive polymerization at the ends of the slices and an island of liquid resin having thickness more than slice thickness is formed. Once the complete part is deposited, it is removed from the vat and then excess resin is drained. It may take a long time due to high viscosity of liquid resin. The green part is then post-cured in an UV oven after removing support structures. Overhangs or cantilever walls need support structures as a green layer has relatively low stability and strength. These overhangs etc. are supported if they exceed a certain size or angle, i.e., build orientation. The main functions of these structures are to support projecting parts and also to pull other parts down which due to shrinkage tends to curl up.

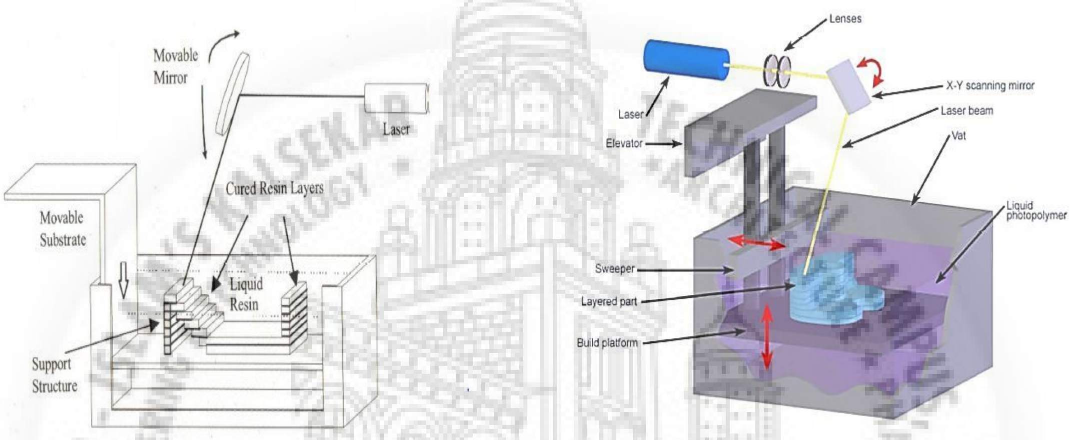


Figure 1.2 Stereo-Lithography Process[4].

2. FUSED DEPOSITION MODELLING

In Fused Deposition Modeling (FDM) process a movable (x-y movement) nozzle on to a substrate deposits thread of molten polymeric material. The build material is heated slightly above its melting temperature so that it solidifies within a very short time after extrusion and cold-welds to the previous layer as shown in figure. Various important factors need to be considered and are steady nozzle and material extrusion rates, addition of support structures for overhanging features and speed of the nozzle head, which affects the slice thickness. Later FDM frameworks incorporate two nozzles, one for part material and other for support material. The support material is moderately of low quality and can be broken effectively once the total part is kept and is eliminated from substrate. In later FDM innovation, water-dissolvable support structure material is utilized.

Support structure can be deposited with lesser density as compared to part density by providing air gaps between two consecutive roads.

Materials: ABS, Polycarbonate, Polyphenylsulfone; Elastomers **Min layer thickness**: 0.15 mm

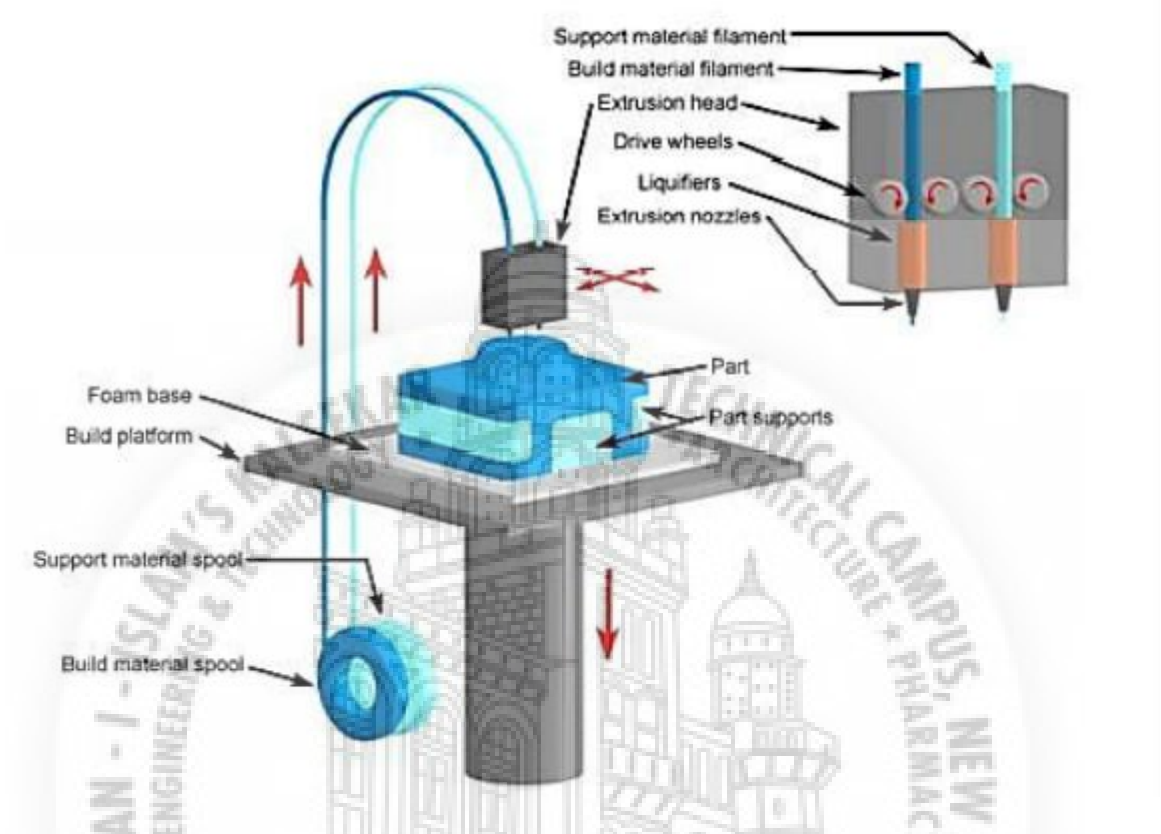


Figure 1.3 Fused Deposition Modelling[4].

3. LAMINATED OBJECT MANUFACTURING

Typical system of Laminated Object Manufacturing (LOM) has been shown in figure. It can be seen from the figure that the slices are cut in required contour from the roll of material by using a 25-50 watt CO2 laser beam. A new slice is bonded to previously deposited slice by using a hot roller, which activates a heat sensitive adhesive. Apart from the slice unwanted material is also hatched in rectangles to facilitate its later removal but remains in place during the build to act as supports. Once one slice is completed, the platform can be lowered and a roll of material can be advanced by winding this excess onto a second roller until a fresh area of the sheet lies over the part. After completion of the part they are sealed with a urethane lacquer, silicone fluid or epoxy resin to prevent later distortion of the paper prototype through water absorption. In this process, materials that are relatively cheaper like paper, plastic roll etc. can be used. Parts of fiber-reinforced glass ceramics can be produced. Large models can be produced and the building speed is 5-10 times as compared to other RP processes. The limitation of the process included fabrication of hollow models with undercuts and reentrant features. Large amount of scrap is formed.

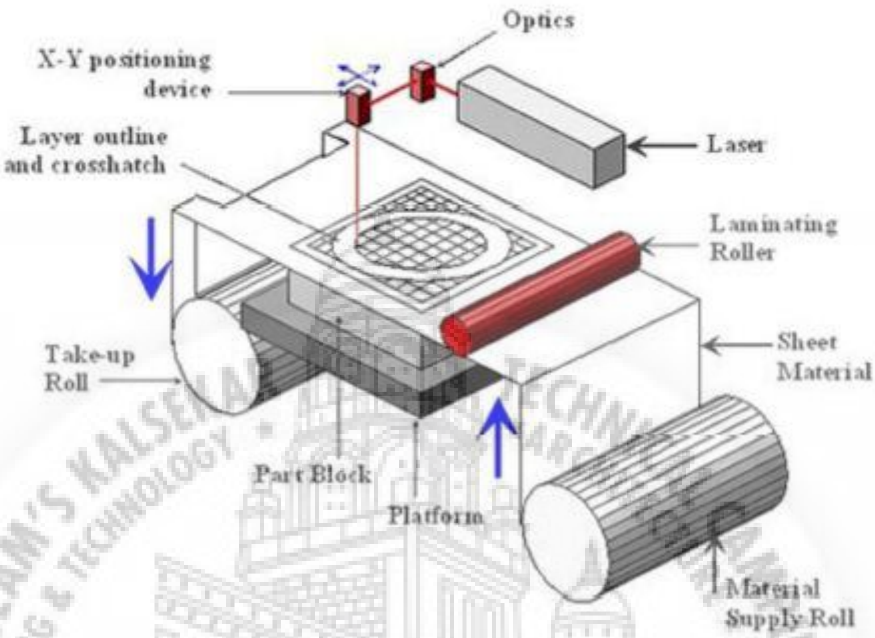


Figure 1.4 Laminated Object Manufacturing[4].

4. SELECTIVE LASER SINTERING

In the Selective Laser Sintering (SLS) process, fine polymeric powder like polystyrene, polycarbonate or polyamide etc. is spread on the substrate using a roller. Before starting CO_2 laser scanning for sintering of a slice the temperature of the entire bed is raised just below its melting point by infrared heating in order to minimize thermal distortion also known as curling and facilitate fusion to the previous layer. The laser is focused in such a way that only those grains, which are in direct contact with the beam, are affected. Once laser scanning cures a slice, the bed is lowered and the powder feed chamber is raised so that a covering of powder can be spread evenly over the build area by the counter rotating roller. In this process support structures are not required as the un-sintered powder remains at the places of support structure. It is cleaned away and can be recycled once the model is complete. The schematic diagram of a typical SLS apparatus is given in figure.

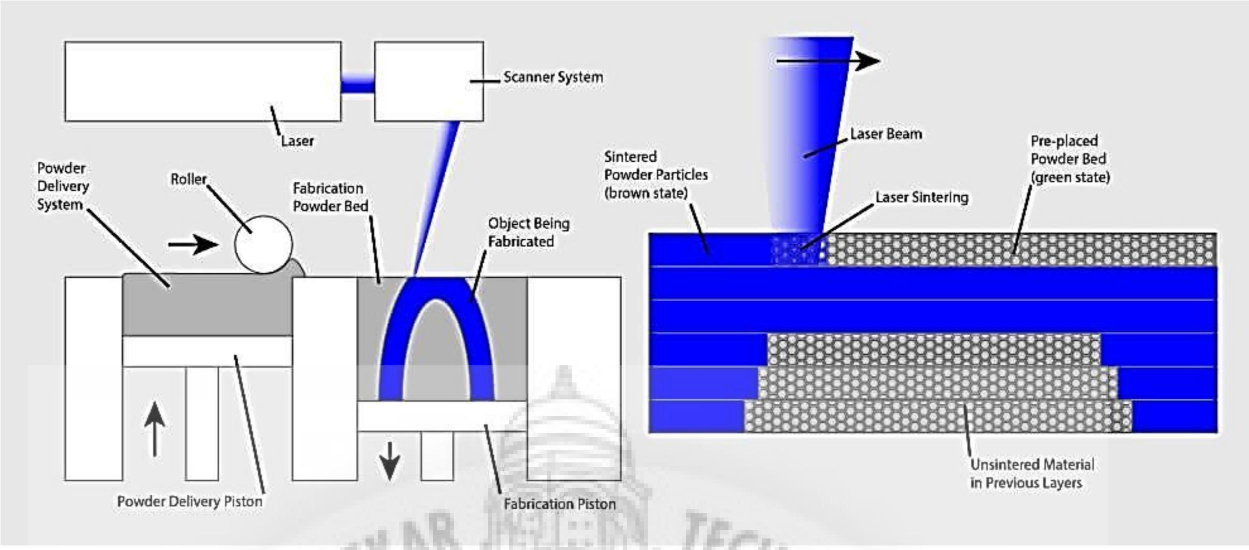


Figure 1.5 Selective Laser Sintering[4].

5. MATERIAL JETTING

Material jetting makes objects in a comparable strategy to a two dimensional ink jet printer. Material is streamed onto a form stage utilizing either a ceaseless or Drop on Demand (DOD) approach. Material is streamed onto the form surface or stage, where it hardens and the model is assembled layer by layer. Material is kept from a nozzle which moves evenly across the form stage. Machines fluctuate in intricacy and in their strategies for controlling the statement of material. The material layers are then relieved or solidified utilizing bright (UV) light. As material should be kept in drops, the quantity of materials accessible to utilize is restricted. Polymers and waxes are appropriate and ordinarily utilized materials, because of their gooey nature and capacity to frame drops.

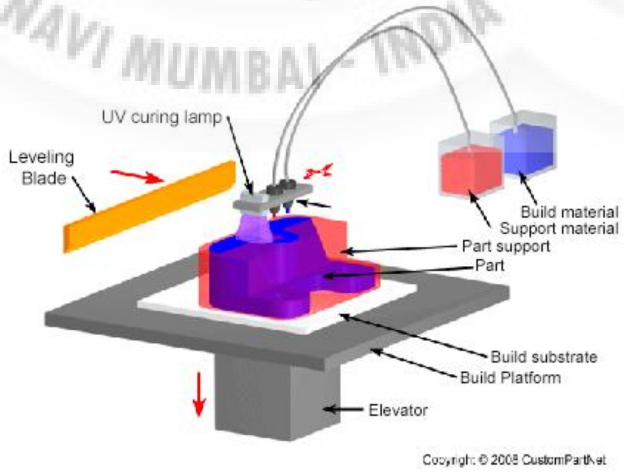


Figure 1.6 Material Jetting[4].

6. BINDER JETTING

The Binder jetting process utilizes two materials; a powder based material and a binder. The binder goes about as a glue between powder layers. The binder is for the most part in fluid structure and the form material in powder structure. A print head moves on a level plane along the x and y axis of the machine and stores exchanging layers of the form material and the limiting material. After each layer, the article being printed is brought down on its construct stage. Because of the strategy for restricting, the material qualities are not generally reasonable for primary parts and in spite of the general speed of printing, extra post preparation can add critical opportunity to the general process. Similarly as with other powder based assembling techniques, the item being printed is self-upheld inside the powder bed and is taken out from the unbound powder once finished. The innovation is regularly alluded to as 3DP innovation and is protected under this name.

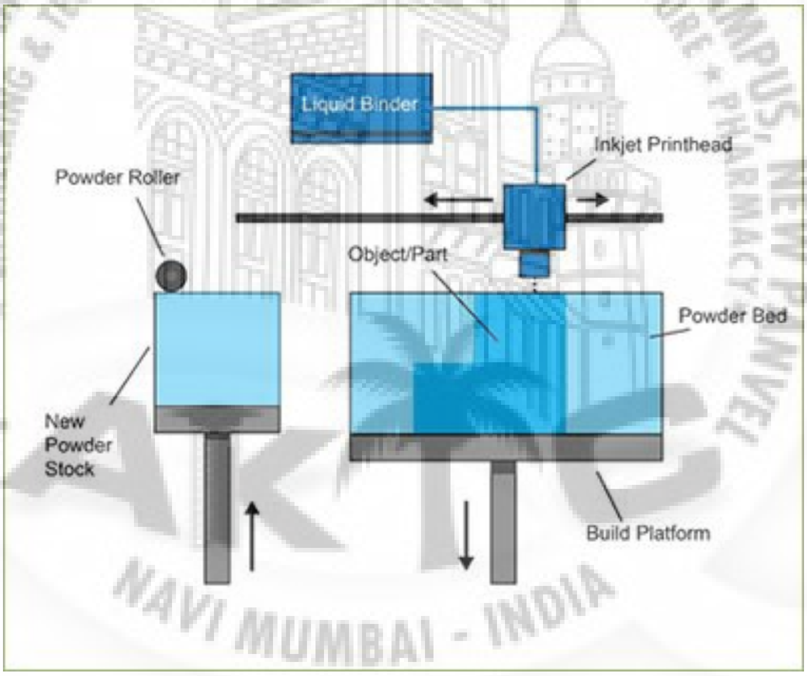


Figure 1.7 Binder Jetting[4].

1.1.3 APPLICATIONS OF A 3D PRINTER

1. HEALTHCARE

It's normal these days to see features about 3D printed inserts. Frequently, those cases are tested, which can cause it to seem like 3D printing is as yet a periphery innovation in the clinical and medical care areas, yet that is not the case any longer. Throughout the most recent decade, in excess of 100,000 hip substitutions have been 3D printed by GE Additive.

The Delta-TT Cup planned by Dr. Guido Grappiolo and LimaCorporate is made of Trabecular Titanium, which is portrayed by an ordinary, three-dimensional, hexagonal cell structure that impersonates trabecular bone morphology. The trabecular design expands the biocompatibility of the titanium by empowering bone development into the embed. A portion of the principal Delta-TT inserts are as yet running solid longer than 10 years after the fact.

Another 3D printed medical services part that works really hard of being imperceptible is the portable hearing assistant. Essentially every listening device over the most recent 17 years has been 3D printed because of a coordinated effort among Materialize and Phonak. Phonak created Rapid Shell Modeling (RSM) in 2001. Preceding RSM, making one portable amplifier required nine arduous advances including hand chiseling and shape making, and the outcomes were frequently sick fitting. With RSM, an expert uses silicone to take an impression of the ear waterway, that impression is 3D examined, and after some minor tweaking the model is 3D printed with a gum 3D printer. The gadgets are added and afterward it's dispatched to the client. Utilizing this cycle, a huge number of portable amplifiers are 3D printed every year.

Figure 1.8 Portable Amplifier using Rapid Shell Modelling[7].

2. DENTAL

In the dental industry, we see molds for clear aligners being possibly the most 3D printed objects in the world. Currently, the molds are 3D printed with both resin and powder based 3D printing processes, but also via material jetting. Crowns and dentures are already directly 3D printed, along with surgical guides.

Figure 1.9 Dental Implants using RP[5].

3. JEWELLERY

In jewelry you can print in two ways one is direct method and other is indirect method.

In the direct method the object is directly created by the 3D design and in the indirect method it is printed in the form of a pattern.

Figure 1.10 Jewelry using 3D Printing[5].

4. FOOTWEAR

Adidas' 4D territory has a completely 3D printed padded sole and is being imprinted in enormous volumes. In 2018 they've printed 100,000 padded soles and hope to print significantly more in 2019.

Figure 1.11 Footwear using 3D Printing[5].

5. AUTOMOTIVE

Car producers have been using 3D printing for quite a while. Auto organizations are printing spare parts, devices, apparatuses yet in addition end-use parts. 3D printing has empowered on-request fabricating which has led to bringing down stock levels and has abbreviated plan and creation cycles. Auto fans everywhere in the world are utilizing 3D printed parts to update old vehicles. One such model is when Australian specialists printed parts to resurrect a Delage Type-C. In doing as such, they needed to print parts that were out of creation for quite a long time

Figure 1.12 Automotive Vehicle using 3D Printing[5].

6. AVIATION

The Aviation industry utilizes 3D printing from various perspectives. The accompanying model denotes a huge 3D printing producing achievement: GE Aviation has 3D printed 30,000 Cobalt-chrome fuel nozzles for its LEAP airplane engine. They accomplished that achievement in October of 2018, and considering that they produce 600 every week on forty 3D printers, it's conceivably a lot higher than that at this point.

Around twenty individual parts that recently must be welded together were combined into one 3D printed segment that weighs 25% less and is multiple times more grounded. The LEAP engine is the top rated engine in the aeronautic trade because of its undeniable degree of efficiency and GE saves $3 million for each airplane by 3D printing the fuel spouts, so this single 3D printed part produces a huge number of dollars of monetary advantage.

Figure 1.13 Aviation industry jet using 3D Printing[5].

7. EDUCATION

Teachers and Students have for quite some time been utilizing 3D printers in the study hall. 3D printing empowers Students to emerge their thoughts in a quick and reasonable manner.While added substance producing explicit degrees are genuinely new, colleges have for some time been utilizing 3D printers in different controls. There are numerous instructive courses one can take to draw in with 3D printing. Colleges offer seminars on things that are contiguous 3D printing like CAD and 3D plan, which can be applied to 3D printing at a specific stage. As far as prototyping, numerous college programs are going to printers. There are specializations in added substance fabricating one can achieve through engineering or mechanical plan degrees. Printed models are additionally exceptionally normal in expressions of the human experience, activity and design concentrates too.

Figure 1.14 Educational use of 3D Printing[5].

8. BIO-PRINTING

As of the mid two-thousands 3D printing innovation has been concentrated by biotech firms and the scholarly world for conceivable use in tissue designing applications where organs and body parts are constructed utilizing inkjet procedures. Layers of living cells are stored onto a gel medium and gradually developed to frame three dimensional designs.

Figure 1.15 Bio-Printing[5].

9. FOOD

Additive Manufacturing has been implemented in the food industry quite a while past. Cafés like Food Ink and Melisse utilize this as a special offering point to draw in clients from across the world.

Figure 1.16 Food Production using 3D Printing[5].

10. SHELTER

From the outset, it would seem that the shell of some other half-got done with building. However, after looking into it further, you see there are no blocks. All things being equal, layers of material are stuck on top of one another to make a mind boggling structure. This is the cutting edge universe of 3D imprinting in development, where mechanical arms naturally press layers of concrete, plastic or other material onto an establishment and 'assemble' a design.

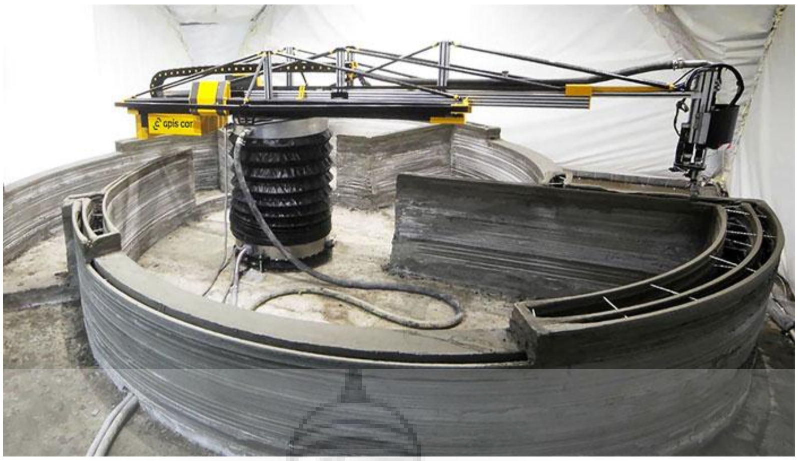


Figure 1.17 Shelter[5].

1.2 PROBLEM DEFINITION

To design and fabricate a 3D Printer as per the needs and requirements for our institute and the students studying, to resolve the issues which were present in the previously fabricated 3D

Printer in a cost effective and easy way so as to produce required objects and products smoothly & also by integrating emerging technologies such as Augmented Reality (AR) to depict the process.

1.3 MOTIVATION

For over a century we have been imagining and visualizing the 2D models in the two dimensional format i.e with the use of 2D printing methods on a paper, walls, etc. But when it comes to real life models which are used in the design and manufacturing sector it becomes a headache or else we can say it as a very complex method. It's difficult to imagine such data and represent it in a 3D model in a 2D workplace. In order to avoid this, 3D printing came into existence which can print the object in 3D format on the print bed. But as usual the market price of this machine is too high and we want our further batches to get a glimpse of 3D printing and also some advanced technologies like Augmented Reality so we decided to make this project[5].

1.4 AIM AND OBJECTIVE

Aim of this project is to Study, Design and fabricate a Dual Extrusion 3D Printer

Objective of doing this project is given as:

- To resolve the issues that were present in the existing 3D printer.
- The current 3D printer consists of one extruder which has the following drawbacks:- limited to one material, color and nozzle size at one time which we will try to resolve by introducing dual extruders.
- To resolve the issue of bed leveling.
- To find out optimum speed of printing and flow of material.
- To carry out some modifications that will enhance the quality of 3D printing.
- To integrate the newly emerging technology.

1.5 LITERATURE REVIEW

1. Design of a 3D Printer by Prof Nawaz Motiwala[7]:

Here is a mention of a project on 3D Printing. This additive manufacturing technique also known as 3D Printing, creates a 3-Dimensional object with the help of filler material melted at a high temperature. There are various technologies available on which the 3D Printer can work, out of which, Fused Deposition Modelling (FDM) is used due to it being cheap and supporting dual extrusion for further future scope and its speciality to use various colors for making the object look more realistic and appealing to the end user. Specifications of the printer, including its dimensions and temperature of be, material used, etc are explained. Design procedure of the 3D Printer is then explained step by step as which part is assembled first, etc. The calculations pertaining to the design is carried out and the dimensions of the assembly and various frame members are found out. This results in a mechanically balanced structure supporting the incoming load of the in-creation of the object and the components, etc. Finally, a cost report is generated depending on the components and a total estimation of the cost of the total printer is shown which is less than the ones available in the market thus solving the problem is done by the creation of a cost effective 3D Printer. Thus the author concludes that a cost effective 3D Printer is made which has a scope for future modifications as per the need arises.

2. Hardware improvement of FDM 3D Printer: Issue of Bed Levelling Failures by Rudi Kurniawan Arief[2].

In this paper, hardware improvements of a FDM based 3D Printer per the research papers were tabulated in the form of a bar chart and categorized into 5 main parts, Bed, Feeder, Frame, Head. These parts were tallied with the research paper and a bar chart with respect to year was formed. Out of the total 39 research paper, the author finds out the different causes of failures of 3D Printer hardware related in an FDM Process and categorizes them into 10 main parts collectively forming a 100% out of which 12.2% goes out to Bed Leveling, 21.6% to Extrusion Head, 22% to Application Setting. Thus the author recognizes the need to solve the issue pertaining to bed leveling. Also 3 forums were read and it was found out that 26% of total failures that affect bed is the Auto-Bed Leveling. Thus based on all the data gathered by the author so far, it is noted that the biggest obstacle for a 3D Printer owner also, especially a RepRap 3D Printer owner is to overcome the issue of bed leveling. Thus to overcome this issue, there are various leveling tools available in the market as per the requirements which vary anywhere from a high-tech automatic leveller to a simple water level tool. Thus addressing the need of a feasible probable solution the author announces to remove threaded bolt system and proposes to use pine trees like pins to assure ease of installation and perform a quick leveling. A force is required to push down the bed either by hands or by extruder head to make sure the rings will move until the same level.

3. Design and Development of Multi-Material Extrusion in FDM 3D Printers by Vedant Daaramwar[8].

In this research paper, the author gives a brief description about the disadvantages of the currently available 3D Printers and to overcome these disadvantages, the author suggests dual/multi extrusion based FDM Process by explaining its needs thoroughly by stating its advantages, disadvantages, challenges, etc. The author then explains the different types of designs for this 3D Printer. These are as stated, Iteration 1: Cam Operated Movable Hot End. Its components include barrel cam, teflon roller, follower plate connected to hot end, main slider, spring, semi-threaded bolt, heat sink, heat break, heat sink tube, heater block, brass nozzle, main body, etc. For design iteration 2: Dual Hot End Lifting Mechanism. The aim of this is to accurately lift the head upwards vertically or else it might have the danger of scratching the printing surface. This mechanism is designed so as when nozzle A is being used for printing, nozzle B would move 3mm upwards from the printing surface and vice-versa to prevent scratching of the printing surface. The components include spring casing, nylon bush, hub, heat sink, heat break, etc. Then for design iteration 3: Multiple Printing Heads. This is the final iteration of the author’s suggestion and is the outcome of all above combined iterations. In this, dual extruders are integrated into a single head assembly with each one having its filament preload. This new design has basically two parts, a docking side where all the printing heads are placed and whenever requirement of a head arises, the carriage side or simply the carriage carries the printing head safely and accurately, performs the printing operation and then is placed back to the docking side. The Printing head consists of disc magnet, brass ring, servo motor, servo motor mount, steel balls, carriage block, stepper motor, direct extruder, sheet metal plate, docking plate, docking pins, hot end holder, rod plate, and hot end. Also the printing head as per requirements, must be picked up and carried out with greater accuracy and precision and must hold it in place rigidly which is resolved with the use of Maxwell Coupling and permanent magnets.

4. An innovative Self-Learning Approach to 3D Printing Using Multimedia and Augmented Reality on Mobile Devices by Vianney Lara-Prieto[9].

In this, the author stated that the students in a University were unaware of 3D Printing Technology, how to perform a 3D Print, how does it work, what steps are to be taken to perform a print, etc. To overcome this situation, the author suggests using Augmented Reality (AR) Technology to easily demonstrate the process of 3D Printing, its components, etc. As the faculty in the university was given a tedious task of explaining to the students the process of 3D Printer, much time was consumed to demonstrate each and every thing in the 3D Printer such as 3D Model Verification, STL File Generation, Printing Time, Raw Material, etc. Thus to overcome such issues faced by the expert, the author suggests using Augmented Reality, Multimedia tutorials for self-learning, with the use of Mobile Devices, Wireless Technologies and E-Learning thus eliminating the traditional instructor-oriented scheme with the use of scanning a Quick Response code also known as QR Code. Now the first step is to use a QR Code to download a mobile app for Augmented Reality (AR) known as Layar app. The next step is to use the Layar app to perform the scanning of other different images to view the videos on the same. Graphically and step by step explanation of all the processes involved in it and different options of the software are then given in these videos. The author states that these videos are/ should be easy to follow so that each and everyone who goes through these videos must be able to understand easily. Thus it is an innovative learning approach which fosters self-learning and the resources of technology are efficiently utilized.

5. Troubleshooting for FDM Technology by Ishtiaq Ahmed[10].

Here, the most common problems faced by the 3D Printers available which are Clogged Extruder, Layer Shifting, Grinding Filament, Weak Infill, Overheating, etc. And the printer used by the author is based on the FDM Process, and its problems are discussed and solved. It is stated that without the resolution of these problems, it is not possible to get a good print. The problems faced by the FDM based 3D Printer are: Clogged Extruder, Weak Infill, Grinding Filament, Blobs and Zits, Stringing, Overheating, Poor Surface above Support, Extruder not Extruding Enough Plastic, Inconsistent Extrusion, Extruder Not Extruding At The Beginning Of Print, Print Not Adhering To The Bed, Too Much Extrusion Of Filament Material, Gaps And Holes Present In The Top Layer, Layer Separation And Splitting. Solution for these were discussed and resolutions were made.

CHAPTER 2

PRINCIPLE, COMPONENTS AND OPERATION

2.1 BASIC PRINCIPLE

There are Various 3D printing technologies but the most popular and reliable technique is the Fused Deposition Modelling(FDM) also called Fused Filament Fabrication (FFF). We made a Dual Extrusion 3D printer which works on Fused Deposition Modelling (FDM) principle.

2.2 PRINCIPLE OF OPERATION

The Fused Deposition Modelling (FDM) process constructs three-dimensional objects directly from 3D CAD data. A temperature-controlled head extrudes thermoplastic material layer by layer. The FDM process starts with importing an STL file of a model into a pre-processing software. This model is oriented and geometrically sliced into horizontal layers. A support structure is made where required, in view of the part's position and geometry. Subsequent to checking on the way information and producing the tool paths, the information is downloaded to the FDM machine. The machine works in the X, Y and Z axis, drawing the model of each layer in turn. This interaction is like how a heated glue gun expels softened layers of paste. The temperature-controlled extrusion head is taken care of with thermoplastic displaying material that is warmed to a semi-fluid state. The head expels and coordinates the material with accuracy in ultrathin layers onto a fixtureless base. The consequence of the hardened material covering to the previous layer is a plastic 3D model developed each layer in turn. When the part is finished the support material is taken out and the surface is done. A few materials are accessible with various compromises among strength and temperature properties. Just as acrylonitrile butadiene styrene (ABS) polymer, polycarbonates, polycaprolactone, polyphenylsulfone and waxes. A "water-solvent" material can be utilized for making transitory backings while production is in progress, this solvent help material is immediately broken up with particular mechanical fomentation gear using an accurately warmed sodium hydroxide arrangement.

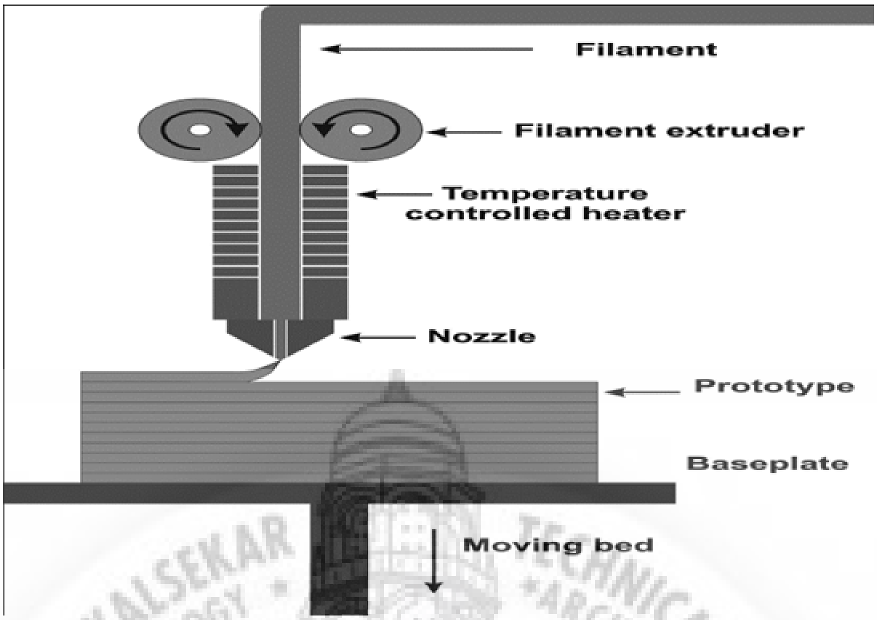


Figure 2.1 Fused Deposition Modeling Technique[11].

FDM technology is broadly spread these days in an assortment of ventures like auto organizations like Hyundai and BMW or food organizations like Nestle and Dial. FDM is utilized for new item advancement, model idea and prototyping and surprisingly in assembling advancement. This innovation is viewed as easy-to-utilize and environment friendly. With utilization of this 3d printing strategy it became possible to assemble objects with complex calculations and cavities. Distinctive sort of thermoplastic can be utilized to print parts. The most common of those are ABS (acrylonitrile butadiene styrene) and PC (polycarbonate) fibers. There are additionally a few sorts of help materials including water-dissolvable wax or PPSF Pieces printed utilizing this innovation have generally excellent nature of strength, temperature sustainability and mechanical rigidness that permits to utilize printed pieces for testing of models. FDM is generally helpful to create end-use items, especially little, nitty gritty parts and concentrated producing devices. A few thermoplastics can even be utilized in food and medication fields, making FDM a well known 3D printing technique overall[11].

2.3 DUAL EXTRUSION METHOD

1) Parallel

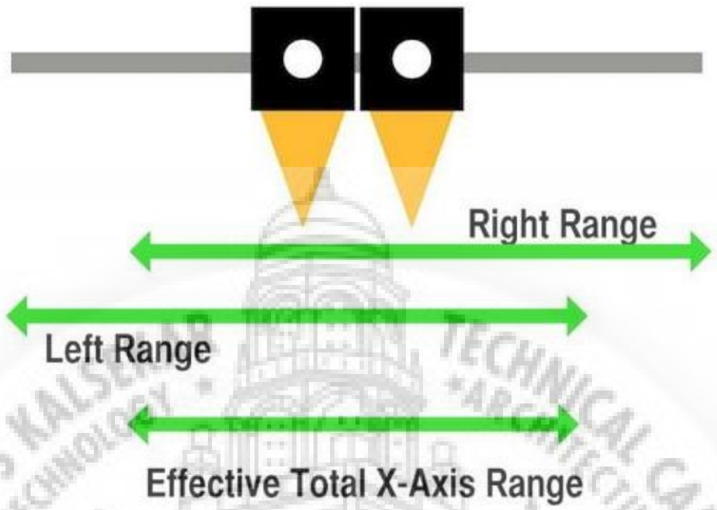


Figure 2.2 Parallel Arrangement of Dual Heads[12].

The earliest type of double extrusion was, and still is the least difficult methodology: lash on a second hot end and extruder to work in corresponding with the first toolhead. These were generally easy to plan into equipment, however had a few inconveniences and are in this manner not supported as much nowadays. Three primary issues are available in the parallel methodology. In the first place, the compelling build volume reduces considerably, as the two hot ends can't reach beyond the "other" hot end. The subsequent issue is weight. Two hot ends, and once in a while extruder motors too, weigh a considerable amount and cause a lot of energy consumption in order to move the nozzle or print head quickly. At last, and the weak spot in this methodology, is that the "other" non-dynamic nozzle can regularly drip material while it anticipates use in a heated state. These drips can contaminate the print, or more worse, set and get messed up with the print, causing the printed object to fail altogether.

2) Tilting

Figure 2.3 Tilting Arrangement of Dual Head[12].

An alteration of the parallel methodology is found in a few designs, in which the two nozzles are really moved far removed from the printing area when not being used. This is explained by lifting the idle nozzle , at times by a shifting instrument that can shift to connect either nozzle. This methodology is advantageous to the above mentioned parallel methodology, yet at the same time can experience the ill effects of dribbles and energy challenges. Nonetheless, a few systems utilize a bowden extruder way to deal with and overcome this issue.

3) Mixing

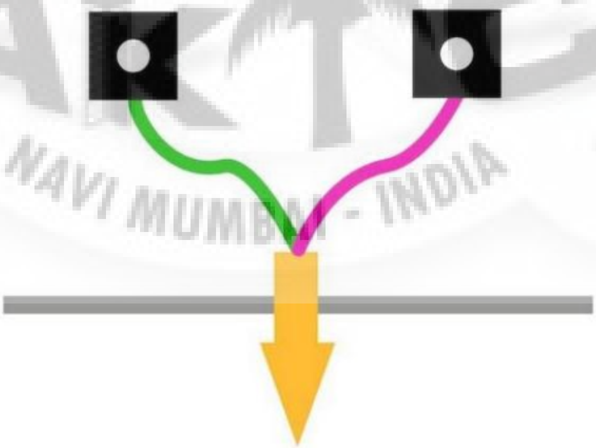


Figure 2.4 Mixing Arrangement of Dual Heads[12].

This methodology is quite straightforward. This "mixing" hot end has all the properties of being a single hot end and nozzle and even designed in such a shape that permits more than one filament to enter it. Advanced slicing software deals with the exactness developments of the two extruders to take care of material into the mixing nozzle. It is feasible to extrude one material by taking care of it at 100% speed, with the other extruder at 0%, or the other way around. It's additionally conceivable to mix materials, for example by running each extruder at 50% speed.

4) Independent

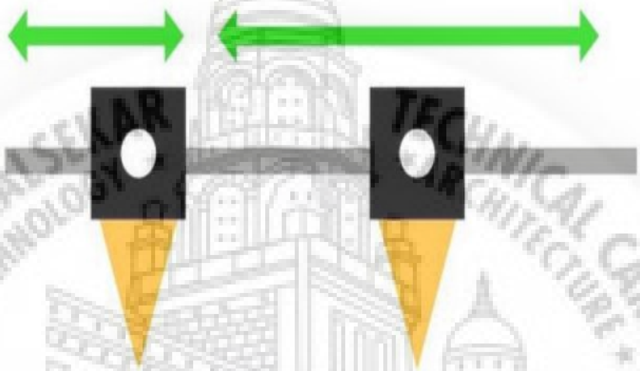


Figure 2.5 Independent Arrangement of Dual Heads[12].

A new methodology is to utilize dual independent toolheads. Basically this is equivalent to the parallel methodology, with the difference being that the two toolheads can move freely. Frequently they are mounted on the X-axis, so "independent" signifies just on that axis; they move circumstantially on the Y-axis. This methodology is truly very complex in construction and programming but with this, one could hypothetically print two distinct objects simultaneously, or have two toolheads work on a similar object simultaneously in parallel , as long as they don't interfere with each others' developments. One of the important disadvantages of this methodology is that it is commonly very much expensive compared to the other techniques. Maybe this will change later on.

5) Custom Filament

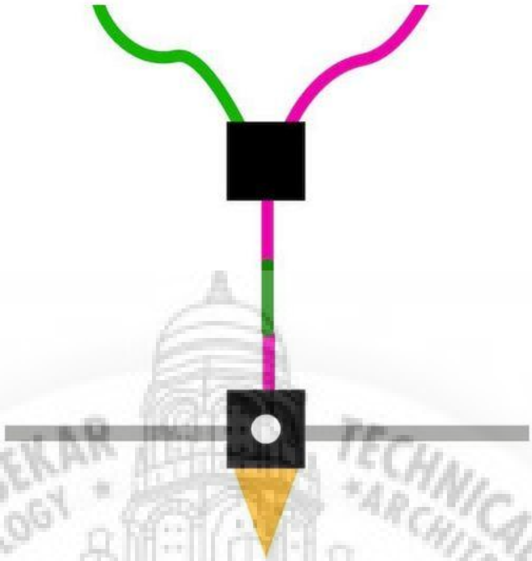


Figure 2.6 Custom Arrangement[12].

One organization has an interesting way to deal with double extrusion: Mosaic Manufacturing's Palette creates a custom filament dependent on the necessities of the different materials required. Their product identifies the device changes needed for a print and afterward in a real sense cuts fragments of filaments to fitting length and bonds them together. This method provides the custom filament reasonable depending on the size just for that specific print, however it could in fact convey newly made changes that are basically double extrusion or however many various materials as one would like to include. This methodology is exceptional to this current organization's items, however it faces one challenge: in the event that a print fails, especially close to the start of the print, the rest of the custom filament is pointless and should be disposed of. One will then need to reproduce the whole custom filament, which could be very time consuming. This could be rectified in later future designs however in the event that things work one can get a decent multi material print, including dissolvable support material.

2.4 COMPONENTS USED IN FDM PRINTER

2.4.1 FRAME

The frame of a 3D printer is a very important part in a 3D Printer. It may look very simple, but the design can actually be quite complex. This is due to the various design possibilities. The importance of the 3D printer frame is attributed to the following:

- It supports all the electrical and mechanical parts that carry out printing.
- It gives a brief idea of the build volume of the printer.
- It gives the printer a robust look and good aesthetic appearance.

While picking a 3D printer frame, one needs to think about the expense, simplicity of gathering, strength and toughness, just as the application as far as desired volume. Style might be an extraordinary thought to architects and organizations who may need their printer to look great and adequate to people in general. However, this may not be an issue to the printers that are just utilized for experimentation or fundamental prototyping.

1. JOINT AND MEMBER CONSTRUCTION

A Joint and Member Construction is the least complex and most common development of a 3D printer frame. Primary individuals can be as bars or bars and associated by joints in a manner like supports. The individuals are either strung bars or extrusions (aluminum or smooth metal rods). The design is straightforward, modest and simple to build. In light of its effortlessness, it is additionally simple to 3D print a portion of the parts for development. For instance, Reprap offers directions on what parts of a Prusa i3 3D printer can be 3D printed, just as connections to the documents required. Although the frame being basic and simple to develop is an incredible advantage, this frame development has its drawback too. This frame leaves the printer parts uncovered. This causes safety issues for both the client and the printer. Articles can impede the belt and pulleys, while a few materials or items can be pulled in to the hot end nozzle. Another drawback is the appearance – it isn't the most appealing casing. Such printers are ideal for prototyping and analyses.

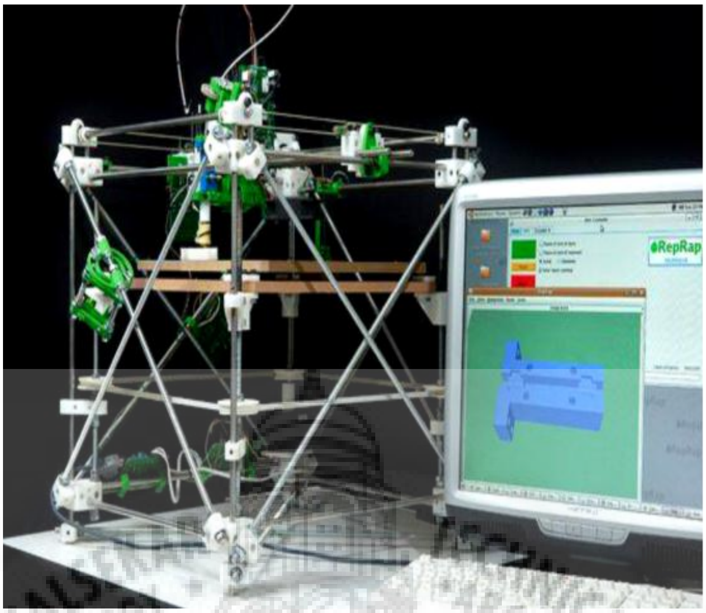


Figure 2.7 Joint and Member Construction[13].

2. LASER CUT/CNC CUT FRAME

A laser cut/CNC cut frame is another simplest alternative for 3D printer outline development. Materials like pressed wood, acrylic or plastic are cut into boards by a laser or CNC machining. The boards are then joined together to produce the last casing structure. There is no extraordinary programming needed as the pieces are cut in 2D. Ease development and simplicity of configuration is an advantage to this kind of frame. Like all the other things, laser cut/CNC cut 3D printer outlines have their disadvantages. The boards are hard to gather because of their structure and shape and tight assembling resiliences. Due to the openness of this frame to stickiness and mechanical components weight, there are chances of the wood being twisted. These frames are also prone to scratching, particularly when worked from acrylic or plastic material.

Figure 2.8 Laser Cut/CNC Frame[13].

3. METAL FRAMING AND INJECTION MOLDING

Metal 3D printer frames can be utilized but not for end users which are using this 3D Printer at their own homes. These frames are made through infusion forming. This technique is ideal for creating 3D printer outlines in enormous amounts. In this manner, these metal casings are most appropriate for the business area and top of the line end users. The advantages of this is that this printer will be tough, and for the most part there is no set-up required. The significant downside of this method is that metal casings are hard to change with time since this requires further machining.

Figure 2.9 Metal Frame and Injection Moulding[14].

2.4.2 3D PRINTER LINEAR MOTION SYSTEM

1. LEAD SCREW

The component to provide translation from a turning motion to linear motion and used as a screw linkage in machines is known as a Lead Screw which is also called Power Screws. Since the lead screw threads have a large area of sliding contact between their male and female members, they have larger frictional energy loss as compared to various other linkages available. These power screws are fundamentally used to carry high power. They are, however, used in lower power based positioner and actuator mechanisms. Commonly found applications of Lead Screws include linear actuators, machine slides, vises, presses, jacks, electronic linear actuators, etc. Manufacturing process of Lead Screws is the same as that of other thread forms. For the need of disengagement to make axial movement independent of screw's rotation, the Lead Screw is sometimes used in conjunction with a split nut (commonly known as half nut). To compensate for wear, a split nut can also be used by compressing the parts of the nut. Many disadvantages of the normal Lead Screw are overcome with the use of a Hydrostatic Lead Screw which has high positional accuracy, very less amount of friction, and low wear. However, these Hydrostatic Lead Screw has a requirement of continuous supply of high pressure fluid and high precision manufacture causing a significant increase in cost comparative to other linear motion linkages.

TYPES OF LEAD SCREWS

Power screws are arranged with respect to the geometry of their threads. V-threads are less appropriate for lead screws than others, for example, Acme since they have high friction between the threads. Their threads are intended to prompt this contact to hold the fastener from extricating. Lead screws, then again, are intended to limit friction. Therefore, in general business and mechanical use, V-threads are maintained a strategic distance for lead screw use. All things considered, V-threads are in some cases effectively utilized as lead screws, for instance on micro lathes and micromills.

- Square Threads: These threads are named directly after their geometrical shape of square. These threads have the least amount of friction and are most efficient, hence often used as screws for carrying high power. However, they are the most expensive being the most difficult to manufacture compared to others.

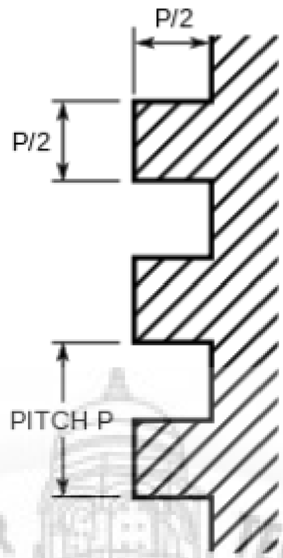


Figure 2.10 Lead Screw[15].

- Acme Thread/Trapezoidal Thread: Being easier to machine compared to square threads, these Acme Threads have a thread angle of 29˚ and a thread height which is half of the pitch size. Having an increased amount of friction due to the induced thread angle, the Acme Thread is the most efficient. Because of having trapezoidal thread profiles, Acme Thread provides greater load bearing capacity making them stronger than square threads. As the wear can be easily compensated for, the Acme Thread wears better than square threads.

Figure 2.11 Acme Threaded Lead Screw[15].

- Buttress Thread: Buttress Threads are of a triangular shape. These threads are easier to manufacture as opposed to square threads and are as efficient as square thread. They are applied wherein the load force on the screw is only to be in one direction.

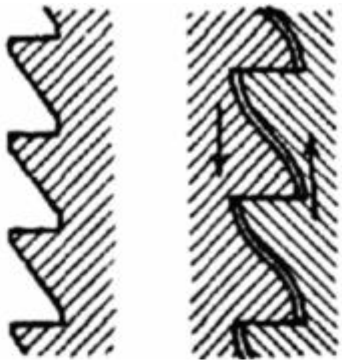


Figure 2.12 Buttress Thread[15].

Alternatives to lead screw are Ball Screws and Roller Screws, Fluid Power, Gear Trains, Electromagnetic Actuation, Piezoelectric Actuation, etc.

Hence after careful analysis, it was established that the lead screws having square threads are the most efficient and most feasible solution to use for our 3D Printer. We decided that using square threads on the lead screw will provide the most efficiency and is the most suitable one in comparison to other types of thread profiles. High loads can be easily lifted using square thread profiles. Vertical movement of bed can be easily performed and applied with the use of square thread profiles and hence it was established that the use of square threads for lifting and lowering the bed coupled through stepper motors via flexible couplings and the provision of third dimensional was achieved via Z axis provided by bed moving vertically. The other two dimensions X and Y were achieved via motor/extruder movement. The lead screws used in our project were carefully cut and were of 8mm threaded pitch profile. The lead screw has several advantages such as mechanical advantage, self-locking, etc. The disadvantages of such lead screws are that they require lubrication periodically, have more wear as compared to linear motion systems, due to being metal-on-metal contact they are quite noisy and they are prone to backlash. Suffering from backslash is the major reason for not using this type of power transmission in the X and Y axes as these axes are subject to frequent changes in directions. Every time the lead screw changes its direction the positional accuracy of lead screw decreases causing it to become a problem in the long run affecting life of the printer. Technically speaking threaded rods are not at all the same as that of lead screws because their main purpose is to attach things and not perform linear motion. They may have the advantage of being readily available and very much inexpensive but they also have disadvantages such as large amount of backlash, quick wear, requirement of periodic lubrication, and are inefficient having efficiency as low as 20-30% due to most of the energy loss occurring on overcoming friction. ACME thread profile lead screws are designed for linear motion, are more accurate than threaded rods, and have a smaller amount of wear. Due to being trapezoidal shaped, it is more resistant to wear. This may be the case but they are still very much efficient and require continuous/periodic lubrication. But these are more expensive than threaded rods and its nut is also very much more expensive than regular nut and hence use of these threads is not feasible. Ball Screws are by far the most efficient, have less wear due to less power consumption, are more accurate than threaded rods, and have small backlash. They are about 70% more efficient than threaded rods or ACME Threads. But they also require periodic lubrication and are very much expensive as compared to the above two. Hence the most feasible option was to use square thread based lead screw or threaded rods[15].

2. LINEAR RODS

The option in contrast to utilizing rails for direct movement is Linear Rods. Linear Rod arrives in a wide range of lengths and measurements, yet a regular bar with a breadth of 8mm is utilized in 3D printer assemblies. Usually produced using steel and chromed for improved hardness, Linear Rod is more affordable to fabricate. The effortlessness of rod means less resistance issues contrasted with linear rails, particularly when buying modest imported straight movement frameworks. Straight metal rollers (otherwise called ball bushings) ride on the Linear Rod to give the genuine movement. These bushings are likewise generally accessible and cost fundamentally not exactly the carriages that ride on Linear Rails. These are the smooth poles utilized for 3D printer units. They give smooth, predictable movement when combined with straight direction. These Linear Rods also called smooth bars are produced for use in 3D printers, Hydraulics just as in CNC/straight movement applications, are raised up to frequent use without an issue. In the advanced mechanics field, these Linear Rods or smooth metal poles are normally utilized on the hub for 3D printers or CNC etching machines to slide on. This bar comes in different lengths and body measurements. After thorough investigation, the last significant thing is protected pressing. Hostile to rust oil is to be splashed on the bar surface and every rod is to be stuffed in a paper sleeve and afterward in the wooden box.

Two or three years prior it seemed like each 3D printer depended on bars for direct movement. Yet, today, the pattern is to utilize direct rails for new printer fabricates. While linear rails give unobtrusive enhancements to print quality, which relying upon who you ask is or does not merit the additional cash, the explanation most DIYers are rushing to linear rails is the capacity to make less difficult and lighter printers. Linear Rods make a bulkier get together in light of the fact that the bars require thick braces to be connected to the casing and all the more critically, two rods should be utilized per pivot to confine the movement to one level of opportunity. The direct orientation can push ahead, in reverse, and twirl around its hub of movement. Assuming you appended an extruder to just a single direct bearing, the extruder could twirl around the rod, which is inadmissible. This can be fixed by appending the extruder to a course on a second equal rod, however obviously, this is a bulkier arrangement contrasted with the single guide prerequisite for linear rails.

Interestingly, carbon fiber has arisen as another material for Linear Rods. Weight for weight, carbon fiber is stiffer then both aluminum and steel. Consequently, empty carbon fiber rods are very light while as yet being adequately solid for direct movement. Carbon filaments are new to the market and the ones with adequate resiliency for 3D printers cost a chunk of change. Modest carbon fiber rods that can be found on amazon have a conflicting external measurement along the length of the rod, requiring sanding to accomplish smooth movement of the bearing. However, it must be noted that carbon fiber dust generated from cutting or sanding is easily inhaled and very toxic.

In the case of our project, we have utilized Linear Rods instead of Linear Rails due to above mentioned advantages. We tried to avoid use of Carbon Fiber as it would increase the cost of the total project and would contradict our goal to make an economically feasible yet efficient 3D Printer. There are a total two sized rods which we used, one is of 8mm diameter and other of 12mm diameter. The 8mm diameter rod is used for the X movement supporting the extruder and the 12mm rod provides lateral movement in the Y direction through belt drive. The 8mm diameter sized linear rods also provide the support via bearings for the bed movement in vertical Z direction and provides smooth movement as well as ensures that the bed travels vertically straight and does not wobble causing misprint and reducing danger of damaging any extruder or the hot end.

Figure 2.13 Linear Rods[16].

2.4.3 BEARING AND BUSHING

1. BEARINGS

A bearing is a machine component that obliges relative movement to just the ideal movement, and decreases friction between moving parts. The plan of the bearing may, for instance, accommodate free straight development of the moving part or with the expectation of complementary pivot around a fixed hub; or, it might forestall a movement by controlling the vectors of ordinary powers that bear on the moving parts. Most bearings encourage the ideal movement by limiting contact. Courses are arranged comprehensively as per the sort of activity, the movements permitted, or to the bearings of the heaps (powers) applied to the parts. Rotating components such as shafts or axles within mechanical systems are held by Rotary Bearings thereby helping transfer axial and radial loads from the source of the load to the structure which supports it. Plain Bearing, the simplest form of bearing, has a shaft rotating inside a hole. Friction is reduced by means of lubrication. To reduce sliding friction in ball bearing and roller bearing, rolling elements such as balls or rollers between races or journals of the bearing assembly having circular cross-sections. To meet the demands of the application for maximum efficiency, reliability, durability and performance, a wide variety of bearing designs exists.

TYPES OF BEARINGS

There are mainly 6 common types of bearing, each operating on different principles:

- Plain Bearing, made up of a shaft rotating in a hole. Bushing, journal bearing, sleeve bearing, rifle bearing, composite bearing are some specific styles of plain bearing.
- Rolling-Element Bearing, rolling elements are placed in between stationary and turning races to prevent sliding friction. These are available in two main types; Ball Bearing having rolling elements as balls and Roller Bearing having rolling elements as rollers of spherical, cylindrical or taper shaped.
- Jewel Bearing is a type of Plain Bearing having one of the bearing surfaces as ultra hard glassy jewel material such as sapphire for reduction in friction and wear.
- Fluid Bearing is a type of bearing having a load supporting member as gas or liquid. Also known as air bearing.
- Magnetic Bearing supports the load by means of a magnetic field.
- Flexure Bearing supports the motion by means of a bending load element.

Motions permitted by bearings are Radial Motion that is the shaft rotation, Linear Motion example being drawer, Spherical Rotation e.g. ball and socket joint, Hinge Motion e.g. door, elbow, knee.

For our project, we have selected two types of bearings; a linear ball bearing and a thrust bearing is used. The linear ball bearings are used on linear rods on X axis direction movement for extruder. As bearings are known for being friction-less, these bearings provide smooth movement with very little power loss thereby increasing the efficiency. This linear ball bearings is of the specific LM8UU and LM12UU wherein the number 8 and 12 signifies the inside diameter size of the bearing. These LM8UU 8 MM Linear Motion Bearing closed type ball bushing has an 8mm bore and 15mm outer diameter and LM12UU 12 MM has a 12mm bore and 21mm outer diameter and both are suitable for use in a mounted slide unit to carry components. These Bearings have various standardized parts which are interchangeable, so there is not any need to worry about replacement of any worn parts.

The linear motion ball bushing employs a high-carbon chromium steel case for strength and rigidity, a synthetic resin retainer plate for accurate ball guidance and low noise. The universal Ball Bearings is great for one to replace the damaged Ball Bearings in one's devices for improving the efficiency and saving the energy. Balls in the cage loop run along a smooth ball guide surface to ensure low noise even in the high-speed operation. These linear ball bearings have several advantages over bushings. First is that these bearings are smoother than bushings since instead of sliding, they perform rolling motion. The other benefit of using these bearings is that they can be used for tighter and close tolerances as compared to the bushings. Thus having less slop and less backlash are the benefits of having tighter fitz and hence linear ball bearings are advantageous. There are several disadvantages of using such bearings, major is the cost. Since Linear Motion bearings slide along the Linear Rods, for the reliable and smooth motion the rods must be lubricated. The quality of the rods directly influences the quality of linear motion we get. So, using chrome plated and hardened rods would serve beneficial otherwise the balls will eventually cut the shaft over-time thus increasing backlash.

The thrust bearings used are for support on the 8mm linear rods which provide smooth movement of bed in the vertical direction upwards as well as downwards. Using these bearings provide advantages such as the load on the bed movement is reduced and also the friction-less bearing reduces power loss causing less work for the motor. Meaning the motor will not waste power in overcoming the friction. Thus efficiency is increased[17].

2. BUSHINGS

The bushings which are also known as sleeve bearings are also supporting members which provide sliding motion over smooth rods and extremely low friction motion thereby reducing wear, noise and power consumption. The bushings also known as bush is the most common form of a plain bearing providing a bearing surface for rotary applications by being inserted into a housing. The most common designs include solid (sleeve and flanged), split and clenched bushings. Having an inner diameter (ID), outer diameter (OD), and length, the sleeve, split or clenched bushings is only a sleeve of material. A cut along its length of the split bushing, solid all the way round of a solid sleeve bushing and for the clenched bearing, is similar to a split bushing but with a clinch or clench across the cut connecting the parts are the notable differences between these three. A flange at one extending radially outward from the OD is for a flanged bushing. In order to provide a thrust bearing surface or to positively locate the bushing when it is installed is the most probable use of flange. SAE numbering system is almost exclusively used for Sleeve bearings of inch dimension. Thrust washers are the other name of the thrust form of bearing conventionally. Secured with radial features, the linear bearing is not pressed into a housing. Matching with the groove in the housing two retaining rings or a ring is molded onto the OD of the bushing. The main difference between bearings and bushings is that bushings is a type of bearing. Generally, bushing is a term used to define a thing that allows motion between two components and bushings are specific pieces of equipment. They are designed as a single part. Bushings find common applications in drill jigs for drilling, hydraulic external gear pumps and motors. Other types of bushings are for cars, trucks and SUVs. Thus, in simple terms, bushings are somewhat similar to thin tubes and are most commonly used for machinery with rotating or sliding shafts in order to improve efficiency and reduce vibration and noise. Bushings typically rely on soft metal or plastic and an oil film to support the rotating shaft on the hardened shaft journal. Self-lubrication, low cost, quiet in operation, can be used on both hardened or non-hardened shafts, less maintenance are some of the commonly known yet important to note advantages of bushings over linear ball bearings. However, disadvantages such as needing to overcome static friction forces before moving and slightly worse fit on smooth rods due to wider tolerances, elimination of the use of bushings is more advantageous and in place of bushings, bearings are used. Our project uses bearings only to provide support, carry loads, reduce friction to minimum thus increasing efficiency and reducing the power pull of the motor in overcoming friction thus reducing power input and safe-guarding the board without damaging due to overload.

Figure 2.14 Bearings[17].

2.4.4 NOZZLE

A 3D printer nozzle is an integral part of the hot end. It is the most important component of the machine as it is the reason for the primary layers of a print to expel from. One of the extraordinary adaptations in work area 3D printing is the provision to trade out nozzles depending on the printing reason. There is a deficiency of nozzle sizes and materials which is basically an advantage to the nozzle design because when printing with extraordinary materials or incrementing the detail and paces at the requirement, the nozzle is simply a single element which can do all these tasks effectively[18].

WHAT HAPPENS IN THE NOZZLE?

Basically, there's little to understand about the 3D printer nozzle. Screwed into the hot end, a small chamber exists which is the nozzle. The filament simply travels to the hot end from the cold end and through the heat break finally reaching the nozzle. Here, the heater block is the place where the filament liquidizes. After heating, the filament finally passes through the 3D printer nozzle and transforms into a shape in accordance with the nozzle opening. It must be noted that two parameters of the 3D printer nozzle must always be kept into consideration viz., the diameter of the opening and the material of the nozzle[18].

NOZZLE MATERIAL

The most basic yet important part is actually the material with which the nozzle is manufactured from. Market research shows that the nozzle is usually found with a diameter of 0.4mm and made up of Brass. Brass material is most commonly found to be used in conjunction with the filament material such as PLA and ABS. However, during the long run and to use advanced materials such as glow-in-the-dark PLA, brass is not commonly suited as it is a soft material. During operation, there is a continuous extrusion of material from the nozzle which causes the nozzle to get eroded. This causes distortion and change in the accurate dimensions of the nozzle and its opening. Over a period of time, these distortions are increased thus reducing print quality and hence usage of a harder material for the construction of nozzles is preferred. Following are some of the commonly found and used available materials of nozzle:

1. BRASS 3D PRINTER NOZZLE

The most commonly found and used material for the nozzle is Brass. Compared to the other 3D printer nozzle materials, it is the softest one available. Brass nozzles are cheap, easily available and are easily machined thus making it the ideal choice for beginners as well as for industrial usage. Possessing excellent thermal conductivity, makes brass the most commonly used material as compared to the rival materials.

Figure 2.15 Brass Nozzle[18].

CHARACTERISTICS

- High thermal conductivity.
- Corrosion resistant.
- Softer in nature.
- Low abrasion resistance.

Best uses: "Soft" plastic filaments such as PLA and ABS and PETG

2. STAINLESS/HARDENED STEEL 3D PRINTER NOZZLE

Overcoming the disadvantage of brass being a soft material, metals like stainless steel or hardened steel are very much suited and are found in use for 3D Printing technologies. These stainless or hardened steels solve the issue of less life of nozzle as in case of brass which gets eroded quickly thus improving overall life of the nozzle and the 3D Printer. Provision of printing of filaments enhanced with hard particles like carbon fiber and metal without the danger of the 3D printer nozzle eroding and print execution lacking is also possible with the use of stainless steel.

This material (stainless steel or hardened steel) being advantageous over brass, however, suffers from poor thermal conductivity as compared with brass. This means inconsistent flow performance, particularly so at larger nozzle sizes.

Figure 2.16 Stainless Steel Nozzle[18].

CHARACTERISTICS

- Low thermal conductivity.
- More harder.
- Corrosion resistant.
- High abrasion resistant.

Best uses: Filaments used with hard additives such as metal, carbon fiber, and glass.

3. TUNGSTEN CARBIDE 3D PRINTER NOZZLE

A newly introduced to the 3D printer nozzle market is the Tungsten Carbide nozzle. The use of this material is based on hefty mining ventures and their utilization of the ceramics for cutting metals and drilling rocks. This Tungsten Carbide is a perfect balance of hardness, thermal conductivity and abrasion resistance making it superior to stainless steel and even brass. Since as of now this material still remains as a Kickstarter fixed at late 2018 and delivering, real world testing is still to be carried out by Tungsten Carbide.

Figure 2.17 Tungsten Carbide Nozzle[18].

CHARACTERISTICS

- High thermal conductivity.
- More harder.
- Corrosion resistant.
- High abrasion resistant.

Best Uses: Charged as the best "all-rounder", a Tungsten Carbide 3D printer nozzle would more than serenely manage the rough fibers that demand an intense nozzle.

4. RUBY 3D PRINTER NOZZLE

The Olsson Ruby as nozzle was first created in Sweden. Requirement of a specific experiment in 3D Printing a filament blend containing Boron Carbide is the inspiration for it being used. Steel and brass nozzles wore down quickly after suffering from unusability due to distortions occurring from the use of as less as almost about 1KG of this filament containing Boron Carbide. This triggered the creation of the Olsson Ruby named after Anders Olsson. Body of brass nozzle and having a ruby tip provides with the thermal conductivity of brass and the superior abrasion resistance (specifically aluminum oxide).

There are arguments regarding the Olsson Ruby having a low thermal conductivity, however these claims are not much backed up as this is still in under development stages.

Figure 2.18 Ruby Nozzle[18].

CHARACTERISTICS

- High thermal conductivity.
- Corrosion resistant.
- High abrasion resistant.

Best Uses: Likewise with steel, profoundly abrasive filaments are the excellent use case for a nozzle like the Ruby. The one distinction here is that it was explicitly intended to print the third hardest material on the planet, without surrendering the phantom after a couple hundred grams of material.

NOZZLE SIZES

The nozzle diameter is an important parameter that affects the required degree of details in a print as per the end users, thus influencing not just on how wide the line widths are, also the recommended and commonly used layer heights, as well. First off when printing with a 0.15mm 3D printer nozzle versus a standard 0.4mm nozzle there is the benefit of having the option to hypothetically accomplish higher X-and Y-axis resolution. Better lines can mean more honed corners, however this increase is likely just reachable on an all around kept up, well maintained and tuned 3D printer. As a free dependable guideline the 3D printer nozzle distance across should direct the layer statues you focus on. Mean to print layer statues around 25-50% of the nozzle's diameter. This (alongside an appropriately aligned bed) guarantees better attachment between the lines you set down. For instance with a stock 0.4mm 3D printer nozzle, you should mean to print with a 0.1 – 0.2mm layer height. Thus, to have a superior possibility of effectively printing superfine layer height underneath 0.05mm, you may be better off selecting a 0.2mm 3D printer nozzle.

Figure 2.19 Different Sizes of Nozzle[18].

2.4.5 STEPPER MOTOR

Figure 2.20 NEMA-17 Stepper Motor[19].

The most commonly used and implemented in this 3D Printer also is the stepper motor named "NEMA 17". Having a genuinely huge measure of force and a helpful size, these motors are seen on pretty much every 3D printer pack one can purchase today. The 40-45 N· cm torque yield motors are viewed as standard since they have a lot of force for moving generally enormous parts at fair speeds, making them a reasonable decision for most applications. This incorporates Bowden extruders, complex belt frameworks like those of a Core XY printer, and practically everything. For most 3D printing applications, the 40-45 N· cm motors are very adequate, and their low value contrasted with elective frameworks makes them quite possibly the most well known decisions for both DIY creators and modern makers of 3D printers[19].

2.4.6 STEPPER MOTOR DRIVER

A NEMA-17 Stepper motor is controlled by means of a Pololu Stepper Driver which is specified as A4988 Stepper Motor Driver. This comes with an additional heat sink to remove the heat generated during operation. Unipolar Stepper Drivers are much easier to control but with the same motor size the torque output given by Unipolar Stepper Driver is less. Hence a Bipolar Stepper Driver such as A4988 is used. It has an output capacity of around 35V and +-2A letting the user control a bipolar stepper motor each with one stepper driver. This driver has a built-in translator for ease in operation. There are about 5 different operational steps which are full step, half step, quarter step, eighth step and sixteenth step. There are actually only two control pins viz., one for step control and other for directional control. Below is a labeled diagram showing the pin-out of this Stepper Driver:

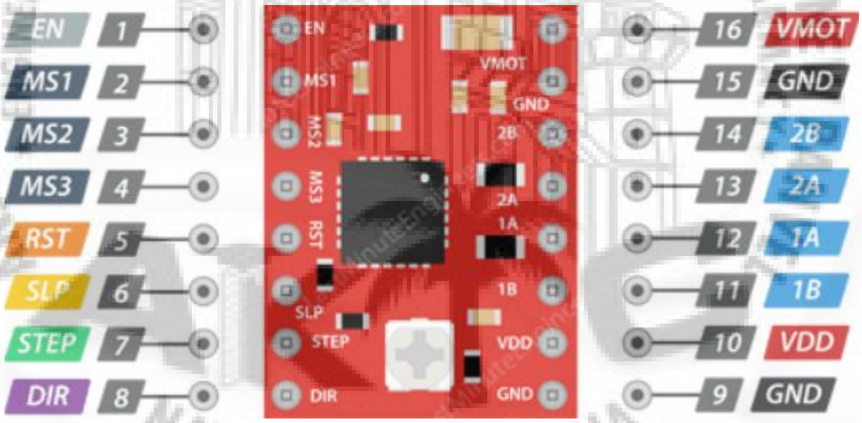


Figure 2.21 A4988 Pin-Out Diagram[20].

The heat sink provides good heat dissipation capacity generated with the operation of the stepper driver. Exorbitant power dissipation of the A4988 driver IC outcomes in the ascent of temperature that can go past the limit of IC, likely harming itself. Regardless of whether the A4988 driver IC has a maximum current rating of 2A per coil, the chip can just stock roughly 1A per coil without getting overheated. Below shows the Stepper Driver with incorporated Heat Sink:

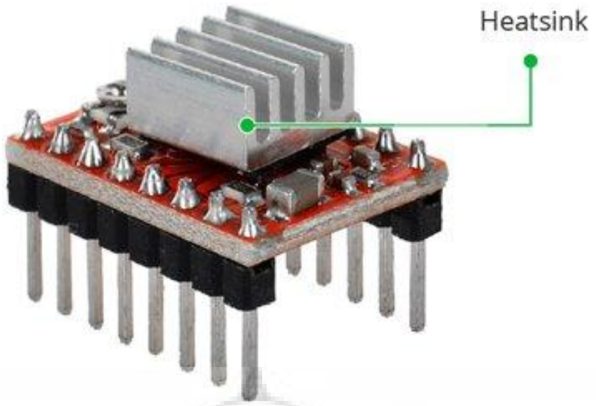


Figure 2.22 Heat Sink for A4988 Stepper Driver[20].

2.4.7 EXTRUDER AND HOT END

1. EXTRUDER

The 3D extruder is the piece of the 3D printer that ejects material in fluid or semi-fluid structure to deposit it in progressive layers inside the 3D printing volume. At times, the extruder serves only to deposit a bonding agent used to solidify a material that is originally in powder form. More or less, FDM includes a thread of plastic material being taken care of into a heated metal block with a nozzle, which at that point melts and is extruded in a predetermined format. This traced path is repeated till the stacking gradually until a solid 3D object is formed. Found in 3D Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF) printers, the extruder is additionally needed for legitimate activity of machines utilizing Binder Jetting or Polyjet innovations, and surprisingly 3D Systems' CPX machines. These are added substance producing machines that need to store material prior to changing it either by adding a Bolding specialist to it (Binder Jetting) or by changing the synthetic properties (Polyjet and CPX).

Figure 2.23 Extruder[20].

2. HOT END

Inside the gathering known as the hot end the filament passes into a hot chamber, where it advances from solid to fluid. Sounds very much straightforward, and it for the most part is. Despite the fact that there is a great deal proceeding to permit the filament to smoothly expel onto the build plate.

Figure 2.24 (a) Figure 2.24 (b)

Figure 2.24a: Hot-End, Figure 2.24b: Labeled Exploded View of Hot- End[21].

From the through and through, a regular 3D printer hot end contains a specific series of parts. There is a slight difference in the event of utilization of a PTFE/PEEK or all-metal hot end.

To clarify the all-metal hot end, differences between PEEK/PTFE and all-metal hot finishes are as such:

First and foremost there is the filament feed tube. In both the Bowden and direct drive 3D printer extruder this will just be the PTFE tube running from your cold end. However, it must be noted that not all immediate drive 3D printer extruders include this[21].

2.4.8 ENDSTOP SWITCHES

Figure 2.25 Endstop Switch[22].

Endstop switches, also known as mechanical endstops, are contact-based manual switches (or buttons) that decide when an object is toward the finish of its axis. Endstop switches work by utilizing a simple touch sensor that is incorporated as a switch. At the point when the switch is moved by an object, it signals the mainboard that the object is toward the finish of the way. Unlike optical endstops, endstop switches are truly reached by the object, meaning that they must be very sturdy. Endstop switches are exact, however not as exact as optical endstops. This is because they are hit by the object moving again and again, which can make them displaced over a period of time. Endstop switches thus have low precision outcomes when examined for precision and consistency. Mechanical endstops are not just utilized for axis endstops they are also utilized as bed-leveling sensors. For instance, the mainstream BLTouch (just as other nearness bed-leveling sensors) is basically a mechanical endstop mounted on a hot end carriage. Mechanical endstops are utilized a great deal in 3D printing, as seen on Creality, MakerBot, Ultimaker, Anycubic, and numerous other FDM printers. This innovation is so regularly utilized due to it being very much simple.

1. OPTICAL ENDSTOPS

Figure 2.26 Optical Endstop[22].

Optical endstops are a new kind of endstop, utilizing light to decide when an object is toward the finish of its axis path. Optical endstops comprise of a U-formed device, called a photograph interrupter, with a light producer on one arm of the U and a light sensor on the other. Optical endstops work by detecting when the light beam, cast by the light emitter, is disturbed. The object, regularly the print head on a 3D printer, utilizes a very thin edge or a flag to hinder the light between the producer and the sensor. When the sensor cannot at this point identify the light beam from the emitter, it signals the motherboard to stop the movement on the axis as the object has arrived at its' end position. For 3D printers, this implies the item has arrived at the finish of the belt, rail, or Z-axis bar. This endstop type does not particularly require any contact between the item moving and the endstop. Optical endstops are exact, reliably halting an object at an exact distance. Optical endstops can, however, run into certain blunders when utilized in zones with variable measures of light. For instance, if a 3D printer utilizing optical endstops is close to a window, the print may fizzle if the sensor recognizes daylight which it is not supposed to do. Along these lines, on the off chance, while utilizing this kind of endstop, it must be ensured that the printer is in an area with consistent lighting or that the endstops are safeguarded from light changes. Optical endstops are not that much sturdy, which they are not even required to be, as they are never expected to be hit by the object. They are additionally extremely delicate to development, so it is important to shield them from being moved or contacted.

2. MAGNETIC ENDSTOPS

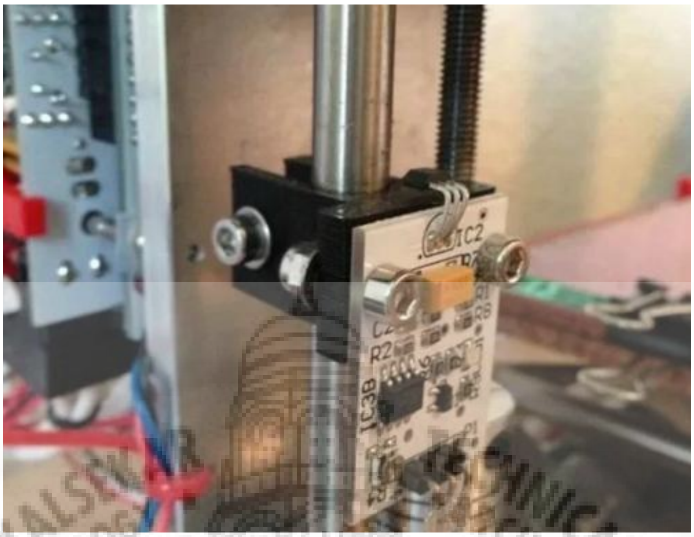


Figure 2.27 Magnetic Endstop[22].

Magnetic endstops, also known as Hall effect sensors, utilize magnetic fields to detect when an object is surrounding the endstop. These endstops use magnets to determine whether an object has arrived at its end position. Magnetic endstops utilize two parts: a Hall effect sensor and a magnet. The Hall effect sensor is joined to the end limit of an axis and detects the magnetic field of the magnet, which is attached to the moving object. The Hall effect sensor detects the magnetic field when the item draws near to the sensor, sending a signal to the mainboard to stop the movement of the object along that axis. This kind of endstop is extremely exact, with a precision inside 0.01 mm. However, certainty of the printer not being close to anything that radiates a magnetic field must be ensured as this may interfere with the operation of the sensor. Magnetic endstops are not that strong, however similar to a non-contact endstop, they are not made to be resilient to impacts like mechanical endstops are[22].

2.4.9 SENSORS

There are various definitions concerning what a sensor is, nevertheless we might want to characterize a Sensor as an information device which gives a yield (signal) regarding a particular actual amount (input).

The expression "input device" in the meaning of a Sensor implies that it is essential for a greater framework which gives contribution to a primary control framework (like a Processor or a Microcontroller).

1. INDUCTIVE SENSOR

An Inductive sensor is utilized to gauge position .They are normally utilized inside unforgiving conditions as they are for the most part strong and can convey stable signals even in threatening conditions. They utilize a contactless rule which gives them longer life and makes them profoundly dependable. Inductive sensors work on a transformer guideline utilizing a physical phenomenon dependent on rotating electrical currents[23].

Benefits of using inductive sensors:

Inductive Sensors are generally utilized in view of their touch less position discovery and limitless mechanical life expectancy. Different advantages of Inductive Sensors are:

- High Resolution.
- High Repeatability.
- High linearity.
- High Accuracy.
- Robust.
- Easy to install.
- High resilience to foreign matters.
- Unaffected by magnetic fields.
- Low thermal drift.
- Maintenance free.
- Wear free - long life[23].

2. CAPACITIVE INDUCTIVE SENSORS

The capacitive proximity sensors are utilized for estimating an item's position, removal, or vicinity are regularly utilized in a scope of assembling plant control applications. They can be applied for examining and observing items and apparatuses, controlling machine frameworks, and situating moving parts.

Capacitive proximity sensors are comparable in capacity to inductive sensors yet have certain extraordinary plan particulars and working boundaries. They depend on the standard of capacitance to recognize little articles and can deal with both conductive (metallic) and non-metallic material, including ill-equipped mechanical surfaces and things moving along a transport. The typical bundle style is as a little chamber with cathodes and wiring at the finishes. The capacitive proximity sensor yield is commonly sent as a contact conclusion or a heartbeat that is actuated when an article arrives at a particular distance limit[23].

Benefits of Capacitive Inductive type Sensors:

- The ability to detect non-metallic objects.
- The ability to detect small lightweight objects that cannot be picked up by mechanical limit switches.
- A high switching rate that provides quick reaction in object counting applications.
- The ability to detect liquid targets through certain barriers.
- A long operational lifespan.
- Contactless detection.
- A wide array of materials can be detected.
- Able to detect objects through non-metallic walls with its wide sensitivity band.
- Well-suited to be used in an industrial environment.
- Contains potentiometer that allows users to adjust sensor sensitivity, such that only wanted objects will be sensed.
- No moving parts, ensuring a longer service life.

Demerits of Capacitive Inductive type Sensors:

- Relative low range, though incremental increase from inductive sensors
- Higher price as compared to inductive sensors[23].

3. HALL EFFECT SENSORS

Hall Effect sensors use the "Hall effect" to gauge the size of a proximal magnetic field. All the more unequivocally, Hall effect sensors measure "magnetic flux "which is the absolute magnetic field, going through a given area,(where An is the territory of the detecting unit ordinary to the magnetic field). While inductive sensors respond to changing magnetic fields, one advantage of Hall Effect sensors is that they work with static (non-evolving) fields. In this way, a Hall Effect sensor can react to a magnet regardless of whether it's not moving.

The Hall Effect gives data with respect to the kind of magnetic shaft and extent of the magnetic field. For instance, a south pole would make the gadget produce a voltage yield while a north pole would have no effect. By and large, Hall Effect sensors and switches are intended to be in the "OFF", (open circuit condition) when there is no magnetic field present. They just turn "ON", (shut circuit condition) when exposed to a magnetic field of adequate strength and extremity.

The yield voltage, called the Hall voltage, (VH) of the fundamental Hall Element is straightforwardly relative to the strength of the magnetic field going through the semiconductor material. This yield voltage can be minuscule, a couple of microvolts in any event, when exposed to solid magnetic fields so most economically accessible Hall effect gadgets are made with worked DC intensifiers, rationale changing circuits and voltage controllers to improve the sensors affectability and yield voltage. This additionally permits the Hall Effect sensor to work over a more extensive scope of force supplies and magnetic field conditions[23].

2.4.10 COMPARISON

Capacitive Sensor:

Figure 2.28 Capacitive Sensor[23].

A non-contact sensor that can detect both metallic and non-metallic surfaces. This sensor works by checking the capacitance (how much energy the on-board capacitor can hold) which changes when an item is set close to its sensing face. It can identify any surface that has a bite the dust electric constant more noteworthy than air which should cover each form surface being used (counting glass). Another benefit of this sensor type is that it can test amazingly quickly, saving time during each print. The following is an essential chart of how the sensor functions.

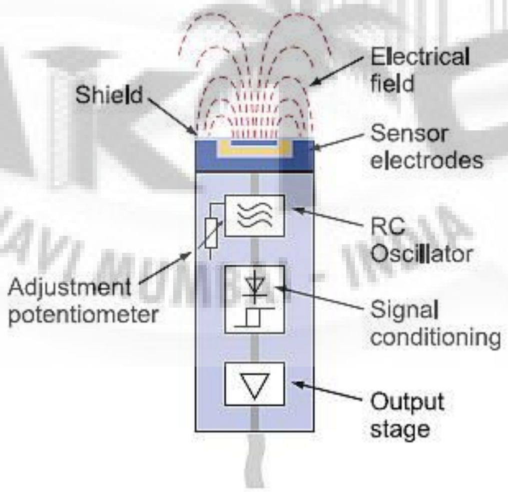


Figure 2.29 Components of Capacitive Sensor[23].

One disadvantage is that while it can detect practically any surface, the distance at which it pursues it will change contingent upon fabricate surface sort, temperature, and mugginess[23].

Inductive Sensor:

Figure 2.30 Inductive Sensor[23].

This is another non-contact sensor, be that as it may, this sort can just recognize metallic surfaces. Assuming somebody who likes to print on glass, garolite, or polypropylene they might need to search for another choice as these materials won't be identified. Albeit these sensors look fundamentally the same as a capacitive sensor, they work dependent on a totally unique guideline. They utilize the electrical chief called inductance. More or less, an inductor curl in the sensor makes an attractive field that changes when a metallic article is inside its sensing distance. Non-metallic surfaces don't influence the attractive field which is the reason the surface should be metallic.

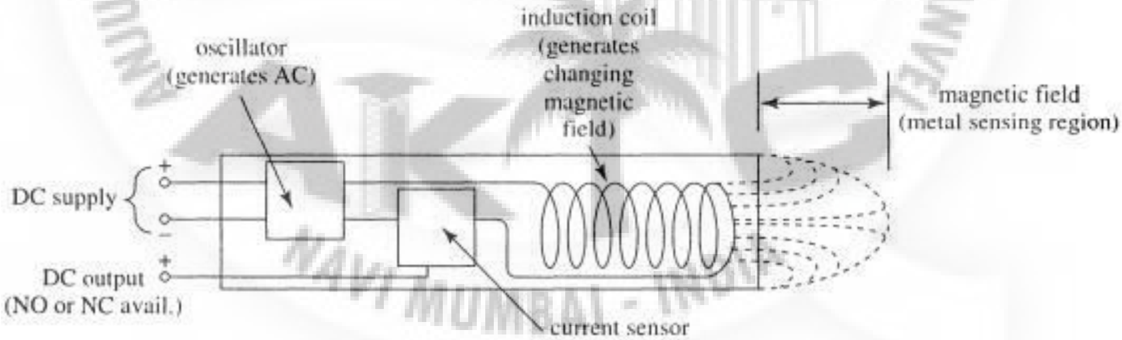


Figure 2.31 Working Principle of Inductive Sensor[23].

Like the capacitive sensors, their readings are influenced by temperature and dampness changes.

Physical Hall-Effect Sensor (e.g.: BL-Touch Sensor):

Figure 2.32 Hall Effect Sensor[23].

This is the solitary sensor on the rundown that really connects with the bed as a method for identification. Along these lines, it is unaffected by temperature and moistness changes like the other two competitors. It capacities by utilizing a plastic plunger (pin) and a Hall Effect sensor to distinguish fabricate plates. When the plastic pin connects with the bed, it is withdrawn and enlisted by the Hall Effect sensor. Likewise, there is an underlying solenoid that permits to broaden and withdraw the test through g-code which gives a lot of freedom while printing. The following is a chart of how an essential Hall Effect sensor functions. If it's not too much trouble, note, the plastic plunger has a magnet installed towards the top which is the thing that the Hall Effect sensor is really observing[23].

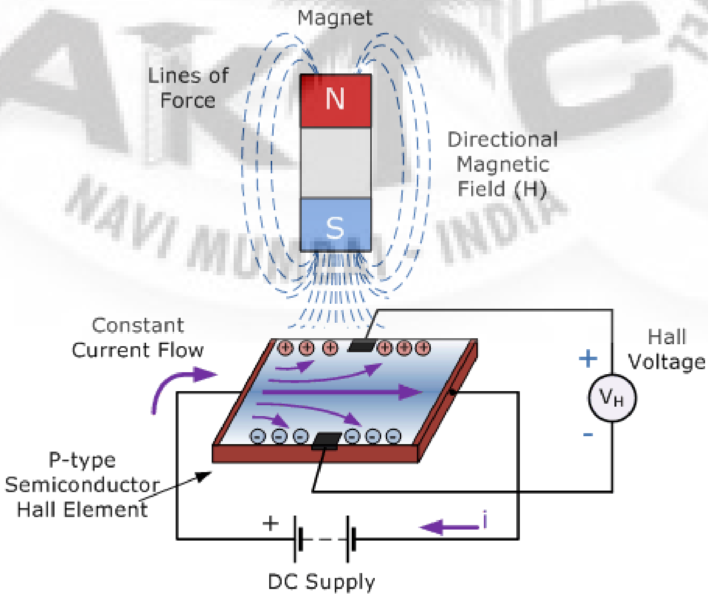


Figure 2.33 Working Principle of Hall Effect Sensor[23].

The fundamental downside of this sensor type is that it is more slow contrasted with the other non-contact types. The following issue is that it contains moving parts along these lines, in principle, there is more that can break on the sensor. Fortunately, the instrument is very straightforward so there is practically zero chance of it really fizzling. The new plastic test tips are additionally made to twist so on the off chance that we incidentally crash it, can essentially twist the plunger once again into the right spot and return to printing[23].

2.4.11 HARDWARE

1. MICROCONTROLLER RAMPS 1.4

Figure 2.34 RAMPS 1.4 Board[24].

RepRap Arduino Mega Pololu Shield, or RAMPS 1.4, is a board that provides the interface between the Arduino Mega the regulator PC and the electronic components on a RepRap 3D printer. The PC extracts data from documents containing information about the article required to be printed and makes an interpretation of it into advanced conditions, such as providing a voltage to a particular pin. It takes many, numerous such pins turning on and off to guide a printer. The Mega needs more ability to really work the printer's equipment. That is the place where the RAMPS board comes in. It puts together and intensifies the data coming from the Mega so that they are appropriately coordinated down the right channels. For instance, if the hot end carriage needs to move one side to the other side, the RAMPS board courses the signs from the Mega to the X-axis stepper engine through the suitable pins and wires.

RAMPS 1.4 emerged from advancement by the RepRap project. It fulfilled the requirement for a simple regulator board that utilized the Arduino Mega and Pololu stepper drivers to deal with every one of the elements of a 3D printer. In the case of RepRap, it was initially intended to permit printing at home. Before long, it turned out to be too complex and the plan changed to support business sheets. The fundamental design of the board began with RAMPS 1.2 and has proceeded to (at any rate) 1.7. In any case, the most well known variant has stayed 1.4 (with through openings or surface mount segments). This board has been broadly replicated and can be gotten and collected for under $10 from Asian producers.

BENEFITS

- **Open and dependable**: The load up is modest, promptly accessible, and makes some impenetrable memories. Ongoing admonitions have been posted on the RepRap site about some extremely modest RAMPS sheets that spot force and ground follows exceptionally near one another. Nonetheless, this isn't essential for the default RAMPS configuration, so sheets bought from respectable providers ought not have this issue.
- **Versatile**: The board is accessible as a collected board, a unit, an exposed board, and as records to ship off business circuit board producers. The schematic of the board is broadly accessible.
- **Measured**: The Pololu stepper drivers fit into attachments so they can be effortlessly supplanted.
- **Open**: The plan is open-source.
- **Coordinated**: The Arduino Mega runs Marlin firmware, a profoundly advanced middleware that is not difficult to change, is continually developing, and permits the RAMPS 1.4 board to run almost any sort of 3D printer[24].

2. ARDUINO MEGA 2560

The Arduino Mega 2560 Rev3 (R3) is one of the numerous choices to consider in case of a microcontroller board. Microcontrollers can be utilized for little, DIY ventures like robots and smaller than normal PCs. For 3D printing, it can be utilized as a distant 3D printer worker (for example with OctoPrint) or even as a control board for a printer.

Figure 2.35 Arduino Mega 2560 Board[25].

Table 2.1 Arduino Mega 2560 Specifications[25].

Operating Voltage:	5V
Input Voltage (recommended):	7-12V
Input Voltage (limits):	6-20V
Digital I/O Pins:	54 (of which 15 provide PWM output)
Analog Input Pins:	16
DC Current per I/O Pin:	20 mA
DC Current for 3.3V Pin:	50 mA
Flash Memory:	256 KB of which 8 KB used by bootloader
SRAM :	8 KB
EEPROM:	4 KB
Clock Speed:	16 MHz
LEDs:	13

3. GRAPHICS CONTROLLER

A REES52 LCD 12864 Graphics Smart Display Controller Module is used in this 3D Printer. This has an in built potentiometer and a SD Card Reader. It is specified as a 128 x 64 bit dot matrix LCD Display with an included adapter which has an additional adaption to the SD Card for RAMPS 1.4 Shield. This SD Card is used for saving the G Code in it for printing. The LCD Display is connected with the adapter to the RAMPS 1.4 board and is powered through it. Running it with Marlin firmware 2.0 reads the SD Card and displays it on the LCD Display from where the controller provided below the LCD Display to change the setting and select the option from the menu displayed on the LCD Screen. With the implementation of a LCD Display, the need of connecting the RAMPS 1.4 Shield and Arduino to a computer every time a print is to be carried out. The G-Code generated from the Slic3r software can be directly copied to the SD Card and added into the adapter of the LCD Display directly and the settings can be also manipulated in the various options provided in the Marlin Firmware 2.0 such as bed temperature, printing time, part to be printed, etc. Thus use of an LCD Graphics Controller provides ease of use of the 3D Printer saving the end user his/her time by just selecting the given option in the menu list without doing any tedious tasks. Functions such as Bed Leveling, Bed Heating, etc are shown and are carried out automatically.

Figure 2.36 Graphics Controller LCD 128*64[26].

4. ELECTROMAGNET

A DC 12V KK-P25/20 Lifting Solenoid Electromagnet is used on the two print heads for dual extrusion. It is simply a coil of wire and wound around an Iron Core but if it is wound around an air core (in this case) it is called a Solenoid Electromagnet. When connected to a DC Supply it gets energized creating a magnetic field just like a permanent magnet. In case of operation, the Electromagnet is placed on one printer head and a magnetic substance is placed on the other. While printing is being carried out the electromagnet activates and one print head gets attached to the other temporarily to cover an additional distance due to space being limited with incorporation of dual extrusion heads. The capacity of this Electromagnet is around 8KG which means it can create such a strong magnetic field which can pull around 8KG of load. After use the magnet is so designed that it can release the residual magnetic force.

Figure 2.37 Electromagnets[27].

2.5 STEPS INVOLVED IN 3D PRINTING

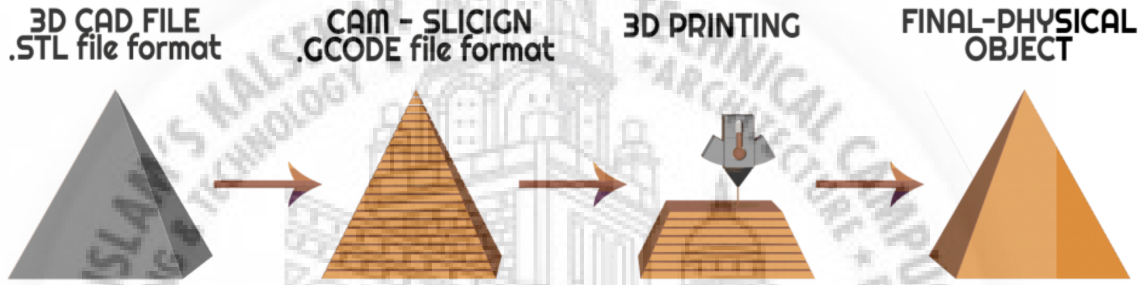


Figure 2.38 Steps in 3D Printing[28].

1. Part Geometry / CAD File Generation

The most initial step in 3D Printing any object is to determine how it looks, the shape and size of the required part or object or model/prototype. Individual or the user requirement can be fulfilled by creating a 3D model or simply known as a CAD file by means of various software available viz., SolidWorks, AutoDesk Inventor, Catia, Creo, etc. For ease, most shapes and parts are available on the internet freely on websites such as Thingiverse from where one can search for the shape or model as per requirements and download freely from the same website saving time. However, it must be noted that not 'everything' is available to download or available sometimes one has to manually model it.

2. CAD File Conversion / STL File Generation

Now that the 3D CAD Model is created and is ready, the next step is to convert this CAD file format into a 3D Printer-readable, .STL file which is read as Standard Tessellation Language or Stereolithography or Standard Triangle Language. This is done by means of another software known as Slic3r. The 3D printer can only read .STL file format and hence this is a necessary part. This file format includes the data that describes the layout / surface and the triangular mesh (polygons) of the 3D Object.

3. Slicing or CAM

The Slicing process is the most important step in the process of 3D Printing any object. This is done by another software which is used by this printer known as Pronterface. This software, after reading the .STL file generated by means of the Slic3r software, generates a layer-by-layer sliced geometry. In other words, the object is 'sliced' or cut in regular intervals or steps generally of a height of 0.1mm thickness per layer each. The Pronterface actually connects to the 3D Printer by means of RAMPS 1.4 and Arduino Mega 2560. This software can actually control the motors of the 3D Printer manually, heat the bed, set home position, and much more. After slicing the files, the new file format is generated known as G-code which is the actual set of instructions for the printer to start or stop movement, move the stepper motors, etc. This software Pronterface is so user-friendly that one can manually turn on or off the endstop, give movements to motors to test check and much more.

4. Print

After performing the above steps, the next step is the main printing process. After correct calibration and maintenance, the G-code is then transferred and run to the printer to perform the function of 3D Printing finally. The bed is first heated and the heads are moved to their home position. After attaining required temperature of bed and the extruder hot end, the spool then pushes the thermoplastic PLA material slowly and the first layer is added. The bed lowers and another layer of material is added thus the object is created.

5. Post-Processing

The final object is then removed from the bed and then cleaned by removing the additional support materials through means of a knife or sandpaper. Thus the object is then finally created and built by means of 3D Printing process[28].

CHAPTER 3

SPECIFICATIONS, MATERIAL AND DESIGN

3.1 SPECIFICATIONS

Specifications are the designations of a 3D Printer which states its fundamental requirements in the real world. Hence, before design of the printer we first need to understand its nature or rather its specifications. Following are the specifications of the 3D Printer:

Table 3.1 Specifications of 3D Printer.

Part	Parameters	Specifications
1. Nozzle Supported	Nozzle Diameter	0.1mm, 0.2mm, 0.35mm, 0.4mm, 0.6mm
	Printing Mode	Dual/Single Color, Dual/Single Material depending on use.
	Head and Extrusion	Dual/Single Head, Dual/Single Extrusion depending on use.
2. Material	Filament Diameter	1.75mm
	Supported Material	ABS, PLA, HIPS, PVA, NYLON
3. Machine Accuracy	XY positioning accuracy	Within 100 microns
	Z Positioning Accuracy	Within 50 microns
	Repeatability Accuracy	Within 100 microns
4. Build	Build Surface	Aluminium Bed
	Volume	180mm X 180mm X 180mm
	Environment	Room Temperature

5.Print Accuracy/Resolution	Wall Thickness	Depends upon nozzle diameter
	3D Printer Part Accuracy	+/- 0.5mm
	Layer Resolution	50 microns to 600 microns
6. Command	Graphical Controller	From Memory Card
	Computer	From Pronterface or Cura
7. Bed Leveling with the use of Auto-Bed Leveling Sensor	Detection Mode	Capacitive Type
	Detection Distance	8mm
8. Temperature	Nozzle Temperature	30-300°C(PLA)
	Bed Temperature	30-80°C for heated bed

3.2 MATERIAL

3.2.1 ABS (ACRYLONITRILE BUTADIENE STYRENE)

ABS implies Acrylonitrile Butadiene Styrene (ABS). ABS (Acrylonitrile Butadiene Styrene) is important for the thermoplastic polymers family. As its name suggests, ABS is made from Acrylonitrile, Butadiene and Styrene polymers. It is a material generally utilized in close to home or family 3D printing, which is finished utilizing basically FDM or FFF 3D printers. This regular thermoplastic material is well known on the grounds that it is not difficult to use with a work area 3D printer, yet in addition since it has some incredible material properties. ABS is lightweight and has great effect strength; it is abrasion resistant and available at reasonable cost. Also, ABS polymers withstand a great deal of chemical formulas. The glass transition temperature of ABS plastic is 105°C (221°F), making it ideal for use in generally safe machines that are not difficult to work. ABS material has a low melting point[29].

3.2.2 PLA (POLYLACTIC ACID)

Polylactic Acid, well known as PLA, is one of the most popular materials used in desktop 3D printing.Conversely, PLA will be less tough, more delicate, and more sensitive to heat than ABS. PLA has a glass transition temperature of 65 °C and a melting temperature of 178 °C. PLA isn't the most heat resistant material, this is the reason it is especially appropriate for decorating objects with no mechanical limitations. PLA material has various benefits, and that is why this is the most utilized plastic material for work area 3D printers. PLA filaments arrive in a variety of shades, styles, that can fit various applications. When cooling, PLA material contracts less than ABS material , which gives it good stability during the manufacturing process[29].

3.2.3 MATERIAL PROPERTIES

Table 3.2 Properties of Printing Material[29].

Material Property	**ABS (Acrylonitrile Butadiene Styrene)**	**PLA (Polylactic Acid)**
Young’s Modulus E (GPa)	1.1-2.9	3.5
Shear Modulus G (GPa)		2.4
Density ρ (Mg/m^3)	1.01-1.21	1.25
Yield Stress σ_y (MPa)	18.5-51	
Elongation at Break (%)	3-75	6
Melting (softening) temperature T_m (˚C)	88-128	160
Glass Transition Temperature (˚C)	100	60
Fracture Toughness (Plane Strain) K_{IC} (MPa√m)	1.19-4.3	
Tensile Strength σ_{ts} (MPa)	25-50	36-55
Ultimate Tensile Strength UTS (MPa)	33-110	35
Strength to Weight Ratio (kN-m/kg)	31-80	40
Thermal Expansion (µm/mK)	83-95	

3.3 DESIGN

3.3.1 SELECTION OF DRIVING MECHANISM

1. For X and Y Axis

The X and Y Axes are loaded with the important task to hold, move and support the Extruder Hot End and Sensor, and also to support the incoming material filament for printing purpose. Thus moving the printing head of the 3D Printer from one end to another overcoming the load of the printing head and the friction generated with the help of the torque provided by the motor is the task of the X and Y Axes. This load carried by both the Axes is around 300-600 grams which is of the dual printing head. Rapid movement from one position to another, jerk and immediate change in direction are some of the requirements of the Axes during operation. Belt drive is used and is more suitable to use in this area because of the following:

1. Lubrication is not required.
2. High speed operability.
3. High breaking strength.
4. Immediate direction change can be incorporated easily.
5. Backlash is eliminated.

2. For Z-Axis

Straight vertical movement of bed is carried out in the Z Direction and must be moved precisely and with an accuracy of approximately 10 microns. There is not much of any sudden changes in the direction the Z Axis movement also compared to the X and Y Axes movements the Z Axis is not to be moved rapidly but moves slowly to incorporate addition of each layer of material filament addition precisely. As the objects start to build, the load on the bed or the platform as material gets added step by step in layers. Z-Axis movement is carried out by use of a Lead Screw because of the following advantages:

1. No need to adjust tension.
2. Highly accurate, precise and fine movement is obtained.
3. High Load Carrying Capacity.
4. Long Life.
5. Self-Locking property is provided by a lead screw which holds the bed in position.

3.3.2 BED ARRANGEMENT & DESIGN OF PLATFORM ELEMENTS

1. BED ARRANGEMENT

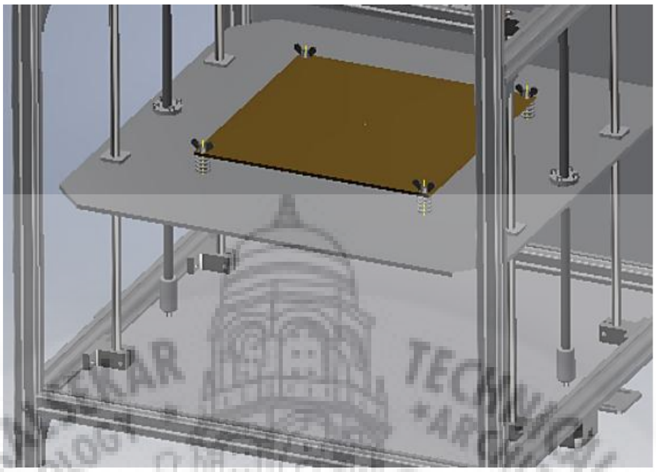


Figure 3.1 Bed Arrangement in CAD.

2. DESIGN

I. Maximum Printing Volume

Length: 180mm

Width: 180mm

Height: 180mm

Volume =180*180*180 = 583200 mm^2

= $5.832*10^{-3}m^2$

II. Max. weight of printed object:

Weight = density * volume

=1250 * 5.72 * 10^{-3}

=7.29 kg = 72.9 N ≈ 73 N

I. Design of MK3b heat Bed

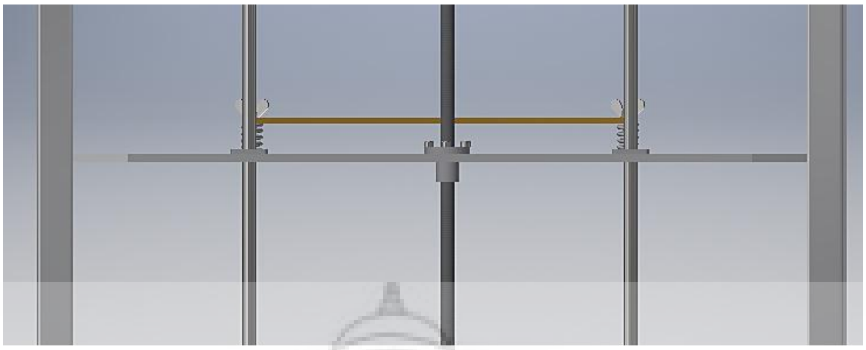


Figure 3.2 MK3b Bed CAD Drawing.

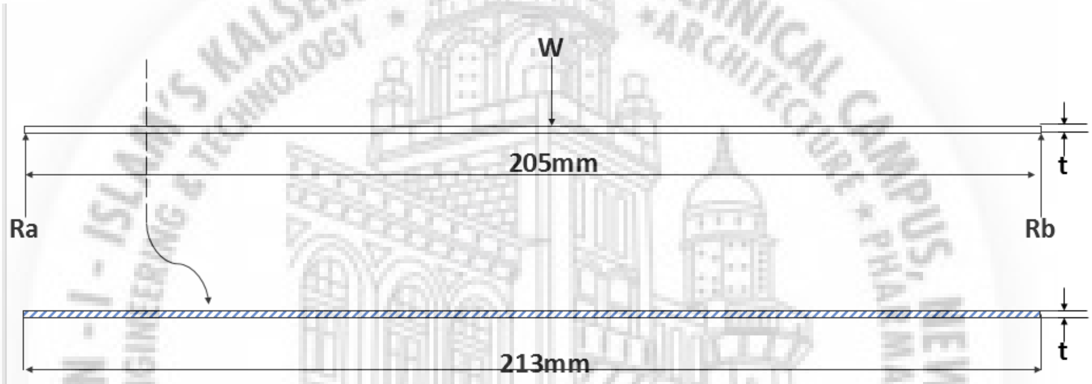


Figure 3.3 Loading Diagram of MK3b Bed.

W= 73 N

R_A = R_B =73 * (205/2) =7380 N-mm

By flexural formula:

BM/I = [σ_b]/y

For Aluminium 6065:

σ_u= 310MPa σ_y= 276MPa ρ= 2700Kg/m^3

Taking FOS = 4

[σ_t] = 69 MPa

[σ_b] = 0.72*[σ_t] = 49.68 MPa   [τ_s] = 0.5*[σ_t]= 0.5*69= 34.5 MPa

$7380/(bt^3/12) = 66.24/(t/2)$

B= 213 mm

$(7380 * 12)/213 = t_2 * 2 * 69$

t = 1.7357 mm

We have an available thickness of 3mm.

II Design of Spring

Material: Alloy Steel 37Mn2

σ_y =700MPa FOS =4

$[\sigma_y]$ =175MPa

τ_s = 87MPa

Now taking C = 6

K_s = 1.2525

$\tau_s = K_S 8PC/\pi d^2$ ………………………………………………………………… Equation 3.1

$= (1.2525 * 8 * 36.5 * 6)/\pi d^2 = 87.5.$

D= 1.826 ≈ 2 mm

Stiffness = 50 N/mm

$q = Gd/8C^3n$ ………………………………………………………………….. Equation 3.2

$50 = 210*103*2/8*6^3*n$

n =7.298 ≈ 7

For square & ground end n'= 9

Solid length = n'*d = 9 * 2 = 18 mm

Free length = 30 mm

Lf = P n + 2d

30= P * 7 + 2 * 2

P = 3.71 mm

3.3.3 DESIGN OF LEAD SCREW AND NUT FOR BED

1. STRENGTH CHECKING OF LEAD SCREW

Material: stainless steel S- 303

FOS = 3

- δ_{ut} = 510MPa, [δ_t] = 170Mpa
- δ_{uc} = 510MPa, [δ_c] = 170MPa
- δus = 510MPa, [δ_s] = 170MPa

Compressive stress

$\sigma_c = w/ (\pi/4 * d_c) = 73 /(\pi/4) * 6.2^2 = 2.418$MPa

For torsional stress

$\tau = 16\ T / \pi d_c^3$ ………………………………………………………………………. Equation 3.3

$= 16 * 550 / \pi * 6.2^3 = 11.75$MPa

Maximum Shear Stress = $[(\sigma_C)^2 + (\tau)^2]^{0.5}$ ……………………………………….. Equation 3.4

$= [(2.418/2)^2 + 11.75^2]^{0.5}$

$= 11.817$ MPa < [δ_{us}]

Bulking Wer= $\pi/4\ dc^2\ \delta yc\ \{1- [\delta yc\ (L/K)_2/4\ C\pi^2 E]\}$ ……………………………. Equation 3.5

$= \pi/4 * 6.2^2 * 170 * \{1- [170 * (300/1.55)^2] / 4 * 0.25\pi^2 * 210 * 10^3\ ]\}$

[C= 0.25 for one end fix & another free, X= 0.25 dc =1.55 mm] 48

W_{er} = 3250 N > f

Hence safe

2. STRENGTH CHECKING FOR THE BRONZE NUT

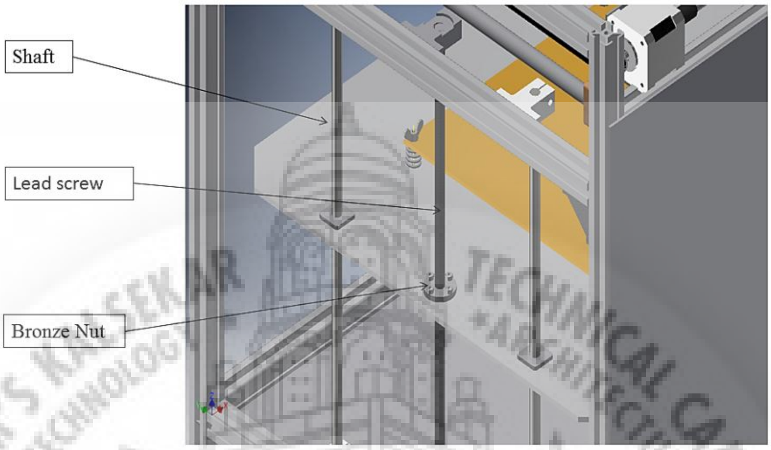


Figure 3.4 Bronze Nut Location CAD Drawing.

δut = 450MPa

Taking FOS = 4

[δut] = 112.5 MPa, [τs] = 56.25 MPa

Bearing pressure for the bronze nut Pb= 160MPa

Shear induced in the nut.

τ_s= w/ $\pi d_{cn}pn$ ……………………………………………………………………….. Equation 3.6

Taking n=3

= 73/ [π * 8.3 *2 * 3] = 0.466 MPa < $[\tau s]_{nut}$

3.3.4 DESIGN OF CHROME PLATED HARDENED SHAFT (FOR Z AXIS)

σ_y= 700 MPa taking FOS = 3

[σ_t] = 233.33MPa

M/I = σ_b/y …………………………………………………………………….... Equation 3.7

(5475) / (π/64) * d^4 = 233.33/(d/2)

d= 6.205 mm ≈ 8mm

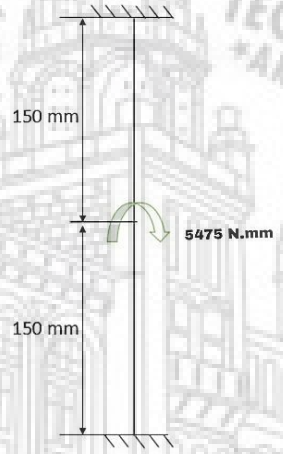


Figure 3.5 Chrome Plated Hardened Shaft.

3.3.5 DESIGN OF 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

3.3.6 DESIGN OF CHROME PLATED SHAFT FOR X AND Y AXIS

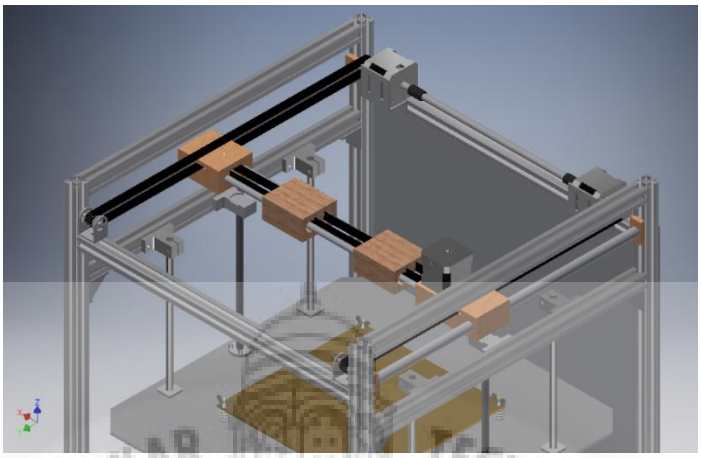


Figure 3.6 Chrome Plated Shaft Arrangement in CAD.

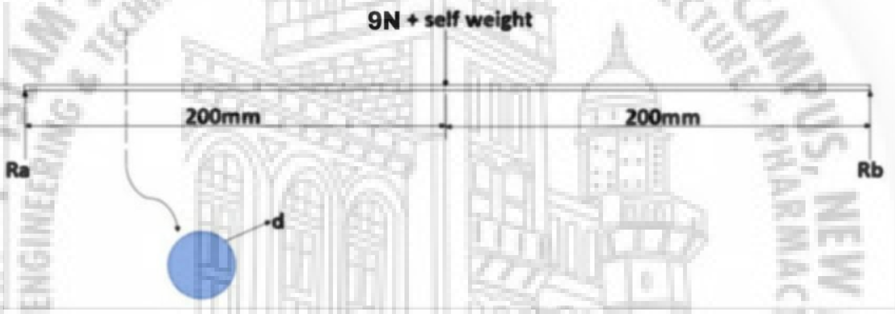


Figure 3.7 Loading Diagram for Chrome Plated Shaft.

$R_A = R_B = (\delta + 3N)/2$

$= (9 + 3N)/2$

$R_A = R_B = 6$ N

BM= 6 * 200 = 1200 N-mm

$1200/ (\pi/64 * d^4) = 233.33/(d/2)$

d = 3.741 mm

taking 8 mm

3.3.7 MOTOR SELECTION FOR X AND Y AXIS

Force to move F = 9N

Diameter of pulley D= 16mm.

Torque required T = F*r

= F*(D/2)

= 9*(16/2)

= 72 N-mm=0.72 kg-cm.

Therefore, selecting NEMA 17 with holding torque of 4.2 kg-cm.

3.3.8 CALCULATION OF MOTOR TORQUE (FOR Z- AXIS)

Force = 73 N

Taking lead screw of diameter 8 mm

& D_m= 7.183, P = 2

$\boldsymbol{\alpha} = \tan^{-1} (p/\pi * D_m)$ …………………………………………………………………….. Equation 3.8

$= \tan^{-1} (2/ \pi * 7.183) = 5.1^{\circ}$

$\Phi = \tan^{-1} \mu = \tan^{-1}(0.25) = 14.03^{\circ}$

Torque required to raise the load $T_{raise} = (F / 2) * D_m * \tan (\boldsymbol{\alpha} + \Phi)$…....……………… Equation 3.9

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

= 90.94 N/mm

= 0.09094 Nm = 0.9094 kg.cm

There is some extra load acting on the motor due to the machining error or misalignment by considering all these aspects.

We are selecting NEMA–17 motors with holding torque of 5.5 kg-cm.

3.3.9 DESIGN OF ALUMINIUM T SLOT SECTION FOR FRAME

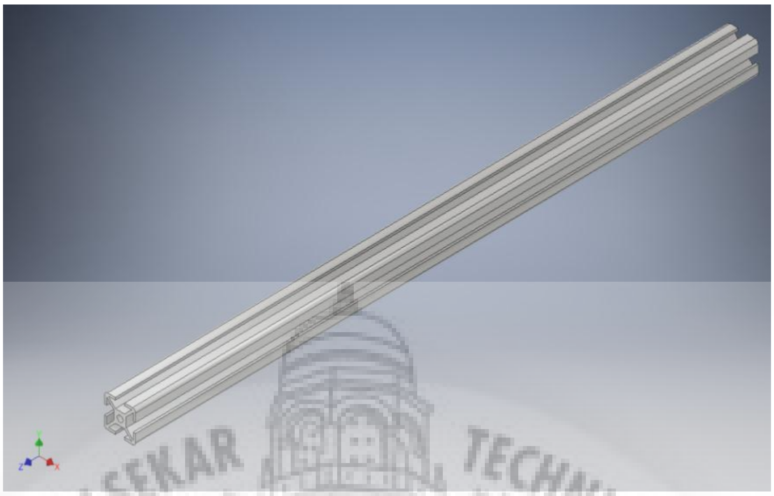


Figure 3.8 Aluminium T-Slot Extrusion CAD Drawing.

Aluminium-6065

σ_{yt} = 380MPa

F.O.S= 2 $R_a=R_b$

$[\sigma_{yt}]$ = 190MPa

$[\sigma_b]$ =0.72 $[\sigma_{yt}]$ =136.8MPa

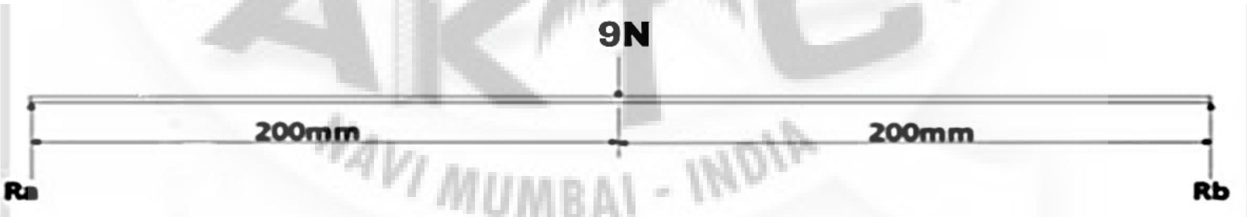


Figure 3.9 Loading Diagram of Aluminium Extrusion.

$R_a=R_b$= W/2 = 9/2

$R_a=R_b$= 4.5 N

Checking of bending strength

$M/I = \delta_b/y$ …………………………………… Equation 3.10

$BM_{max} = (WL)/8$

$BM_{MAX} = (9*400)/8$

$BM_{MAX} = 450$ N.mm

$y = 10$mm $I = 6659.70\ mm^4$

$450/6659.70 = \sigma_b/10$

$\sigma_b = 0.675$ MPa $< [\sigma_b]$

CHAPTER 4

FABRICATION

4.1 FRAME

A structure which supports all the components from a simple mechanical motor to the electronic driver which drives the motor through the electronic board known as RAMPS 1.4 and Arduino Mega 2560 is the actual frame of the printer.

4.2 MATERIAL AND DIMENSIONS

The 3D Printer must be easily able to be moved from one place to another whenever required without much effort thus making it portable and easily accessible. To make this possible, material used for the frame should be easily accessible, good strength, less weight, easy to be able to cut for manufacturing, less maintenance, should appear attractive, must be adaptable to changes, etc. One such possible material for this application is Aluminium. Thus square or box sections of aluminium having T-Slots are used. As per the calculation, Aluminium of 2020 series T-Slot extruded of grade material 6065T is used for the design and structure. This 3D Printer is actually based on the previously made 3D Printer in the institute by the previous batches. Thus most of the maximum materials used are as per the previous batch with some modifications to suit the current requirements.

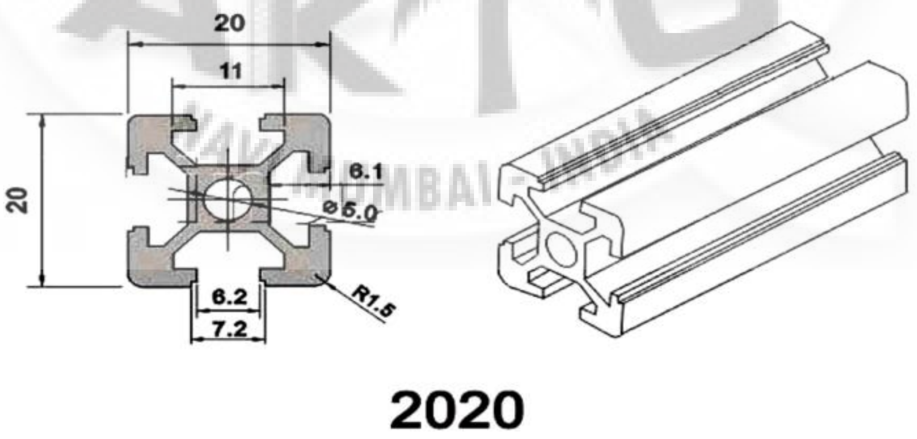


Figure 4.1 T-Slot Aluminium Extrusion[13].

4.3 STEPS IN CONSTRUCTION OF FRAME

Step 1 Cutting, Grinding and Polishing

The first and foremost step in construction of the frame is to cut the Aluminium frame which is acquired from the market directly at a length of 10 feet as a whole. Cutting the long section into required length as per requirement and then ground from the sides with a smooth file then polished to get a clean look. The final product from this process is:

Table 4.1 Quantity of Aluminium Cut Extrusions.

Sr. No.	Length (mm)	Quantity
1	500	4
2	400	9

This was actually carried out by the previous batch. Dismantling, Polishing was done.

Step 2 Assembly of all the sections or members

After performing the required operations above, the next step is to assemble all the members to construct a strong structure capable of supporting the total load of the 3D Printer during running as well as idle condition. For this process, four accessories are used for fastening the members to one another viz., T-Slot Nuts, Allen Bolts, Brackets and L-Shaped Aluminium strips for increased fastening strength.

The T-Slot Nuts are perfect to be used as fasteners for the T-Slot sections of Aluminium. They have a special type of trapezoidal shaped section with a threaded hole in the centre for the allen bolt. They easily slide in the slot of Aluminium sections when placed and can be locked in a position easily just by revolving it around its threaded hole when matched with the hole in the Aluminium section.

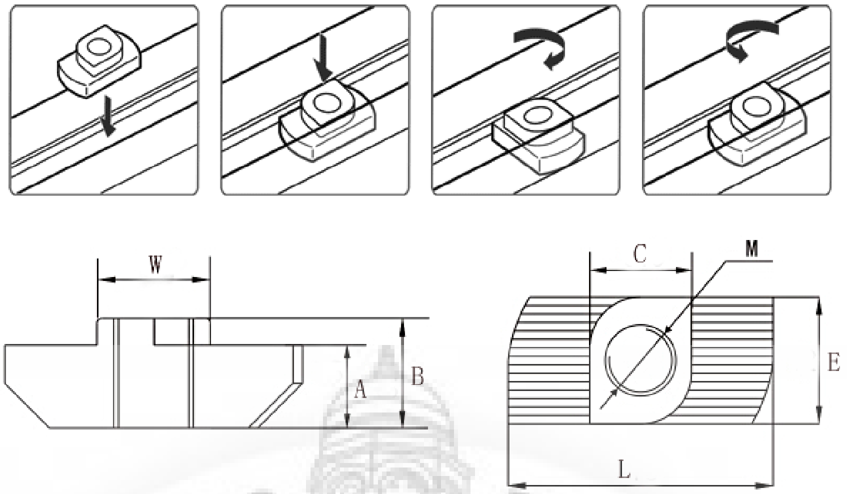


Figure 4.2 T-Nut Placing and its dimensions.

Allen Bolt: Ease of access, removal and assembly as per requirements and to allow for compensation of constrained radial space around bolt are granted with the use of Allen Bolt.

Brackets and L-Shaped Aluminium Strips: To strengthen the structure, the brackets and L-Shaped Aluminium strips are added to the construct.

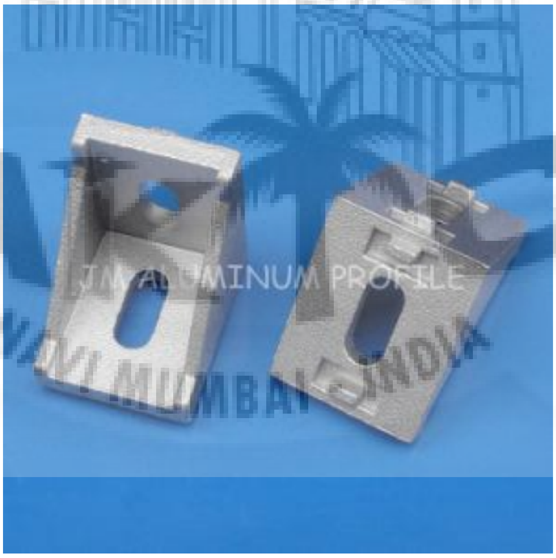


Figure 4.3 Brackets used for frame construction.

Finally, assembling all parts with accessories and maintaining distance throughout the vertical length of the sections with the use of a level bottle, below is the frame created:

Figure 4.4 Frame Construction.

4.4 BED

4.4.1 BED ASSEMBLY AND MOUNTING

The Bed Assembly consists of two parts:

1. Heat Bed - An Aluminium plate with a heating coil on its back side is called the Heating Bed of the 3D Printer. This is basically the stage on which the printing is carried out. The bed used in this 3D printer is MK3B Heat Bed as per the design.

2. Supporting Bed - The platform on which the object is 3D Printed that is the Heat Bed, rests on another platform which is the supporting bed. This is driven by lead screw for the vertical movement and supported by chrome plated linear rods. This supporting bed is heated by wing nuts and bolts/screws and in between them are four springs to support the load of the object to be printed and the incoming material.

Bed Mounting: The X and Y axis motion is given to the extruder and the Z-Axis motion is given to the bed. This vertical motion thus helps add material layer by layer creating the desired object. The total bed assembly is carried out as follows:

Lead Screw is attached with the motors for the vertical movement supported by the base frame. Chromium plated linear rods with bearing attachment provides smooth and true vertical movement with support without any lag and wobble. Thus, lead screw and chrome plated shafts provide motion for the vertical up and down movement of bed without any slight wobble.

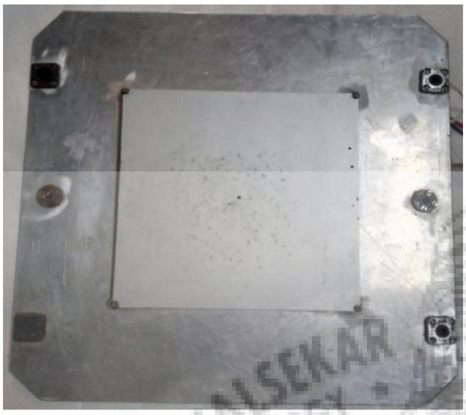


Figure 4.5 (a)

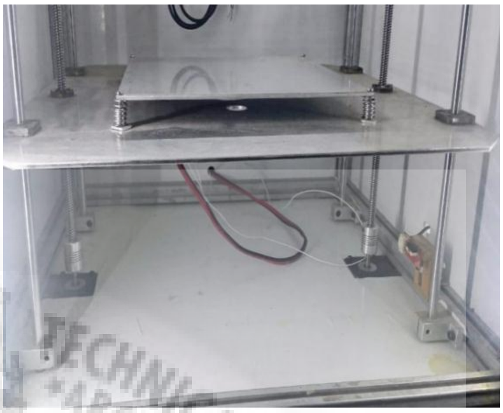


Figure 4.5 (b)

Figure 4.5 (a): MK3B Heated Bed, Figure 4.5 (b): MK3B Heated Bed with supporting bed attached to the frame.

4.5 MOVING BLOCKS

Moving blocks are the wooden blocks that provide the support for the bearings, pulley and the chromium plated shafts for their movements. There are total of 4 wooden blocks they are categorized as:

4.5.1 SIDE BLOCKS

They are two in number and are used for the movement in Y-Direction over the chromium plated linear rods. It is made in two halves for each block having drilled holes for supporting the linear rods and contains a pulley bearing a double belt for the drive.

Fabrication Procedure:

1. Marking is done on a Wooden Plywood as per the required dimensions.
2. Cutting of the marked portion by the saw mill.
3. Marking for Drilling.
4. Drilling.
5. Polishing.

6. The bearings are then press fitted in the drilled holes.

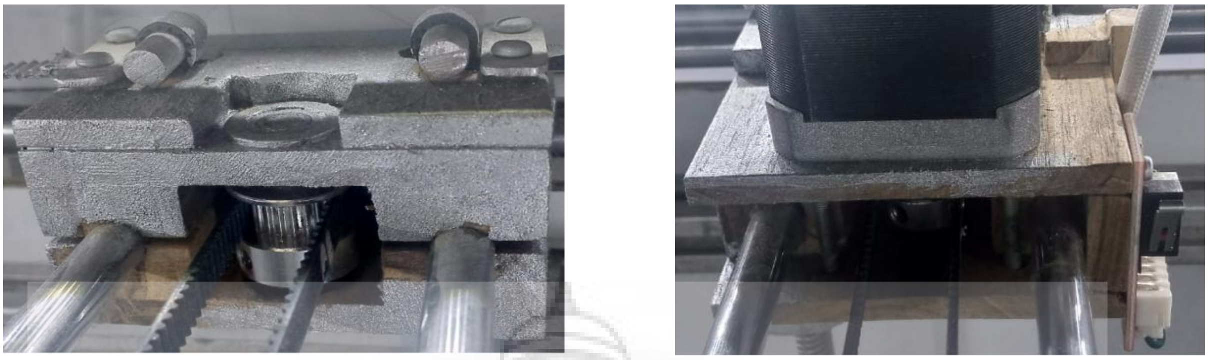


Figure 4.6 Two side moving blocks on either side with pulley.

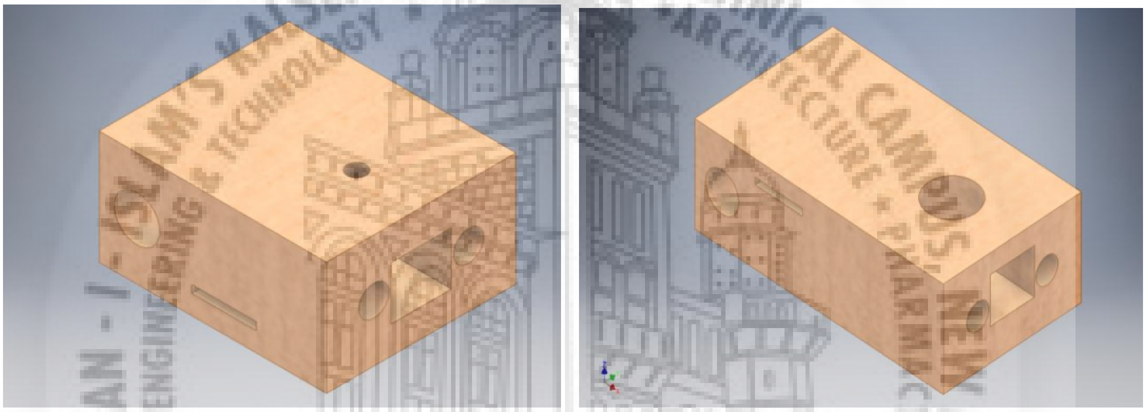


Figure 4.7 CAD Model Depiction of Side Moving Blocks.

4.5.2 CENTRE BLOCKS

They are also two in number and are used for supporting the print head or the hot end extruder. As this printer is based on dual extrusion, two wooden blocks are used. These wooden blocks are also made in two halves each and have drilled holes to support the motion as well as carry the load of the extruder and the sensor for Auto-Bed Leveling.

Fabrication Procedure:

1. Marking is done on a Wooden Plywood as per the required dimensions.
2. Cutting of the marked portion by the saw mill.
3. Marking for Drilling.
4. Drilling.
5. Polishing.

6. The bearings are then press fitted in the drilled holes.

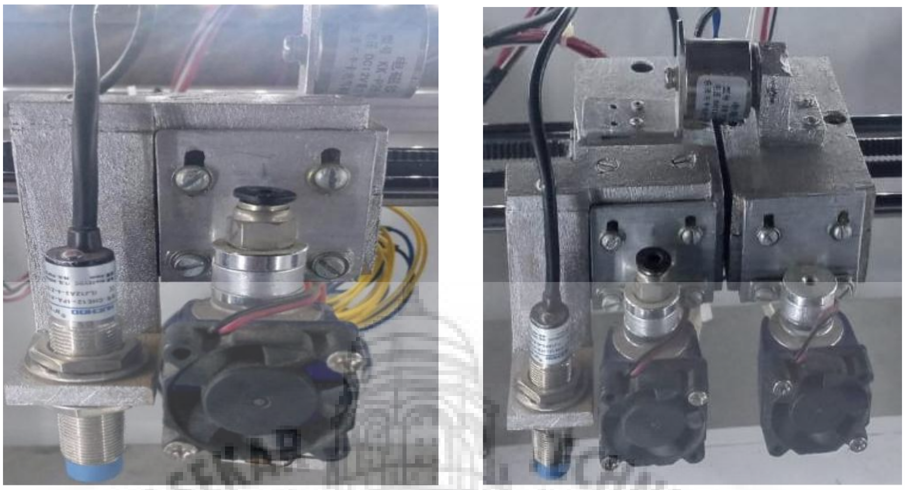


Figure 4.8 Two centre blocks with Hot End and sensor attached.

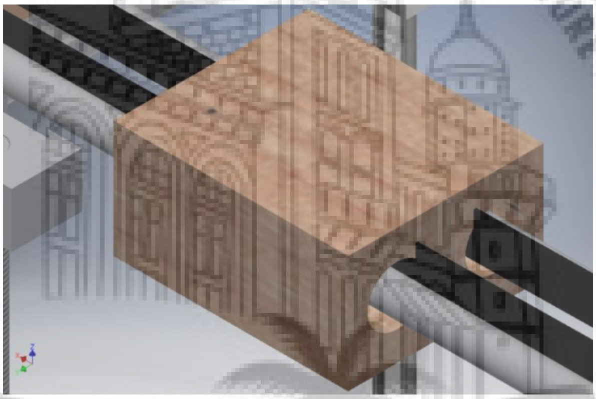


Figure 4.9 CAD Model Depiction of Centre Block.

4.5.3 PREPARATION OF CHROME PLATED LINEAR SHAFT

Supporting load, reduce wobbling, provision of guide ways for X, Y and Z axes movements in both directions. This is achieved by following procedure:

The linear rods obtained are of two sizes viz, 12mm diameter and 8mm diameter. Both rods are obtained from the market at a full size of 12 inches. They are then cut to the required dimensions and then the corners of each piece of rods are filled with the means of a roughing file. The 12mm rods are used for the movement of the extruder head in the Y-Direction and the 8mm rods are used for the movement in the X and Z Directions. Since, most of the load is supported on the bed and as the movement of bed has to be done sometimes in the direction of gravity and sometimes against gravity and hence power required by the motor and eventually support and guide ways are provided by the linear rods, hence material used for linear rods for the Z-Direction is Hardened and Chromium Plated whereas the other two axes use just Chromium Plated.

Figure 4.10 (a)

Figure 4.10 (b)

Figure 4.10 (c)

Figure 4.10 (a): Steel Rod, Figure 4.10 (b): Steel Rod for Z Axis, Figure 4.10 (c): Steel Rod for X Axis.

4.6 MOUNTING OF X-Y AXIS

4.6.1 BRACKETS TO SUPPORT THE LINEAR RODS

A customized bracket composed of Aluminium material was made for incorporating and supporting the shafts in the X and Y directional axes as there were practical difficulties in employing the available SK Type bracket.

4.6.2 ASSEMBLY OF X, Y AND Z AXIS AND EXTRUDER ASSEMBLY

Here, the first and foremost step is to provide an attachment or a resting for motors which will make the motors fixed with respect to the frame. This is done with the incorporation of a metal bracket. All motors and extruders are provided with a bracket each. These are of L-Shaped or a straight type depending on the requirement. Straight brackets are used for extruders and for Z-Axis motors whereas L-Shaped Brackets are used for Y-Axis motors. Next step is to mount the Linear Rods in the centre blocks, side blocks and the four corners of the supporting bed. The linear rods acting as guideways for the Z-Axis movement are supported by bearings and the two Lead Screws are coupled to the bottom placed Nema-17 Single Shaft Motors by means of a 8mm to 5mm Flexible Coupling. After mounting the 12mm rods on the side for the Y-Axis Movement. Two Nema-17 Dual Shafts are coupled together via two 12mm to 5mm Rigid Couplings on a 12mm shaft on either side. Other side of the motor or the opposite shaft are coupled to pulleys on a belt arrangement thus providing Y-Axis Motion. The centre block and side blocks contain pulley tightening arrangements to increase tension in the belts. Each centre block has a hot-end and a sensor. Out of the two side blocks, one has a Nema-17 Single Shaft Motor attached to it to rotate the pulley inside the side block for the linear motion in X-Direction. The belt pulls the centre block of the whole assembly in either the left or the right direction, that is in other words, the positive X or the negative X Direction. This motion is supported by means of guide ways created by 8mm Linear Rods. These rods are two in number and reduce the overall wobble during motion and to also achieve a stand still position when not in working. To provide smooth motion without any friction, the centre block is also incorporated with two bearings named as LM8UU. After all this is set and achieved, the extruder assembly is added to the motor which pulls the filament from the spool and pushes it to the hot-end. Main components of the Extruder Assembly are the main body, idler pulley, feeding gear and spring arrangement. As the 3D Printer is to be designed with the Dual-Extrusion function, there are two Extruder Assemblies used which are added to the motor itself and this total block is then attached to vertical straight metal brackets and fixed to the sides of the frame of the 3D Printer.

Figure 4.11 (a)

Figure 4.11 (b)

Figure 4.11 (a): Total Frame Constructed with added X, Y and Z Axis movements, Figure 4.11 (b): Extruder Assembly.

4.7 MOUNTING OF BELT AND PULLEY

As the motor will rotate the pulley in contrast will also rotate as the belt is mounted upon the pulley the rotary motion of the motor is converted into linear motion of the respective axis. It consists mainly of motor, pulley, belt and wooden blocks.

4.7.1 MOTOR MOUNTING

The Motors are mounted on frame using a special type of a bracket. This bracket allows tensioning of belts which ensure a smooth motion of belt and pulley.

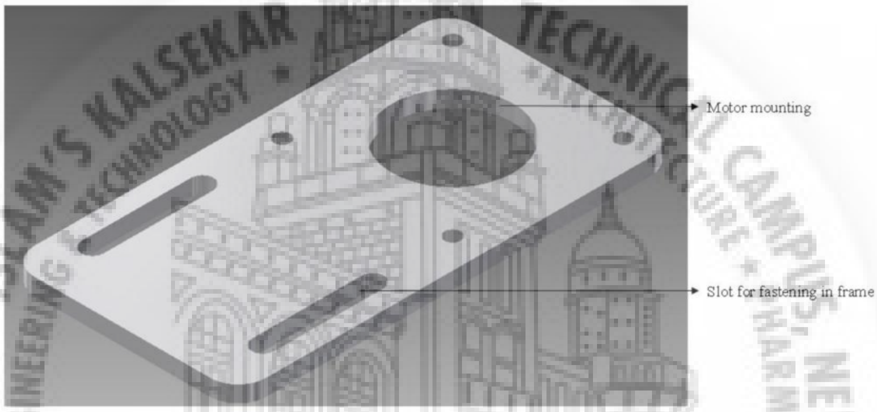


Figure 4.12 CAD Model Depiction of Motor Mounting.

4.7.2 PULLEY

Pulley are mounted on motor shaft and on other side it is mounted on C bracket

Figure 4.13 Pulley with belt attached and mounted on Frame.

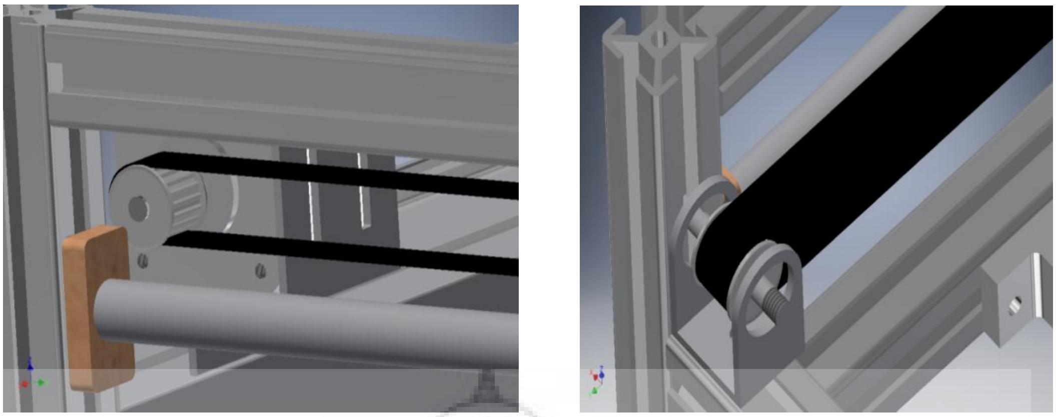


Figure 4.14 CAD Model Depiction of Pulley and Belt.

4.7.3 BELT

Belts are mounted on both the pulleys on motor shaft and on other side it is mounted on C bracket so in order to move the wooden block with very smooth motion

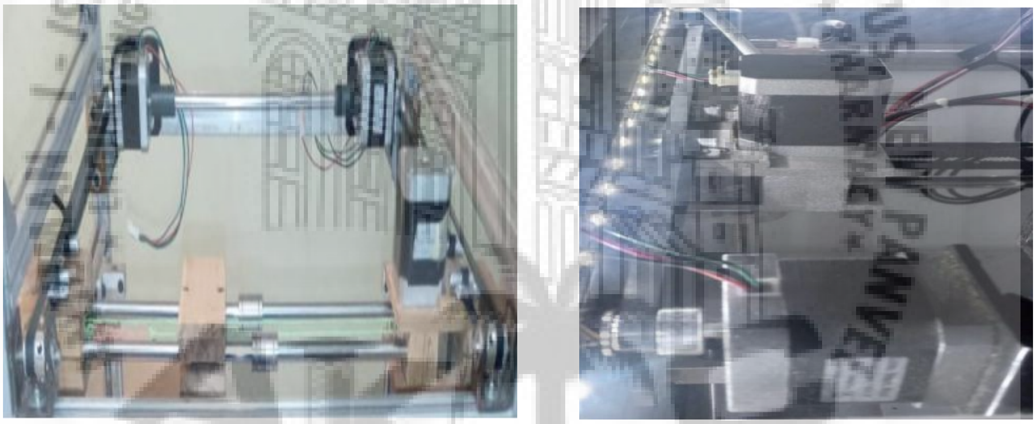


Figure 4.15 Belt and Pulley combined attachment.

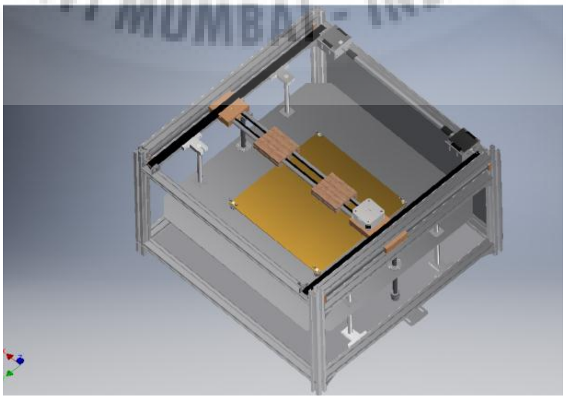


Figure 4.16 CAD Model Depiction Belt and Pulley combined attachment.

4.8 AESTHETICS

After all is said and done, the most final step is to perform the improvement in the overall looks of the 3D Printer. As per the frame and design fabrication carried out above the 3D Printer is basically now just a structure supported from all four corners and across them. Mechanically, and structure wise the design is safe and there are probably very low chances of failure except due to excessive usage and for a long period of time. Typically, this may be the final product, but in order to make the 3D Printer aesthetically appealing and attractive to the user rather than just being a skeleton, it is covered from all sides with wooden panels. First, a wooden plank or a ply is bought from the market and markings are made to the size of the 3D Printer. Then pieces are cut to the required dimensions with respect to all sides of the 3D Printer and then planning is done with the help of a hand planer. With this, all three sides of the printer are covered. A window arrangement is made with the help of the wood and glass is added for transparency and a handle is also provided. Hinges are used for the window / door movement. Thus the 3D Printer can be viewed from the front side, the door can be used to open for removing the finished object and for carrying out the maintenance thus improving the ergonomics and making the 3D Printer more appealing. The insides of the 3D Printer, which are all the four sides and the bottom base are covered with white background to give it a clean attire improving overall aesthetics. In order to further improve the handling of the 3D Printer components, a drawer type system is made below the base in the gap between the support bed and the floor on which the 3D Printer rests. This drawer can be drawn out and put back easily and is too made up of wood. The purpose of providing this drawer is to place the Switch Mode Power Supply (SMPS) on it so that the 3D Printer as a whole is confined in a single rectangular area without creating a mess of the components being loitered. The RAMPS 1.4 Shield and Arduino Mega 2560 are placed on the back side of the 3D Printer. This back side is a whole different story as a slot made in the previously created wooden frame covering and a box covering of plastic is made to cover it. Both the boards that are the Arduino Mega 2560 and the RAMPS 1.4 Shield are kept in the slot and the plastic cover is placed on it to cover thus further making the 3D Printer more confined and keeping the components aesthetically assembled, reducing mess and making it more appealing to the end user. All the wires and cables are too arranged properly keeping in mind not to create a hanging wire from any side so as to reduce any inconvenience and to make the 3D Printer more clean and more appealing. Next and the final step in the aesthetic improvement is to incorporate LED and attach the LED Light Strip on the 3D Printer to make the inner part more visible. The LED Light color chosen is of white too which is in resemblance with the background and thus solving any visibility issues faced during operation in night time. Thus as a whole, the 3D Printer now looks more appealing, use of wood in most work causes light weight thus being easy to transport, operation during night time is now also possible without any issues and is now aesthetically and ergonomically very much more confident.

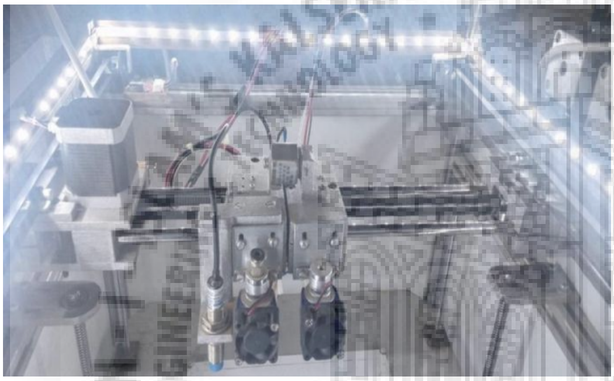


Figure 4.17 (a)

Figure 4.17 (b)

Figure 4.17 (a): LED Lights attached, Figure 4.17 (b): Final 3D Printer with all aesthetic improvements.

CHAPTER 5

INTERFACING AND COST REPORT

5.1 INTERFACING

As discussed above, all the Mechanical related components were thoroughly sought out, and as per the design, were cut to the required dimensions and carefully assembled. Now, the next task is to actually and carefully interface and integrate the Mechanical components with the Electronic and Electrical components to combine them and thus creating a required easily controllable 3D Printer.

5.1.1 RAMPS 1.4

As this 3D Printer is based on RepRap Machines, the most widely used Electronic board in these machines is the RAMPS 1.4 integrated with an Arduino Mega 2560 board and maximum of 5 Pololu Stepper Drivers (A4988, to be precise). This board works on a 12V Power Supply Unit or sometimes even 24V Power Supply Units may be used with appropriate changes. This RAMPS 1.4 is capable of handling upto 5 Stepper Motors interfaced with a HotEnd and with a precision of approximately 1/16, can support Dual Extrusion and hence can incorporate another HotEnd, a fan, a LCD Controller, upto six End Stoppers, and upto three thermistors.

Below is a detailed and a picturized step by step explanation of Interfacing:

1. JUMPER CONNECTIONS TO RAMPS 1.4

Three Jumpers in each of the slots are inserted as shown below in the RAMPS 1.4 board to get the highest precision this board can supply that is of 1/16. These slots are marked as orange in the image shown below. These jumpers are actually components which control the precision of the motor movement and thus is an important step to incorporate it so as to get a highly precise and smooth operated 3D Printer.

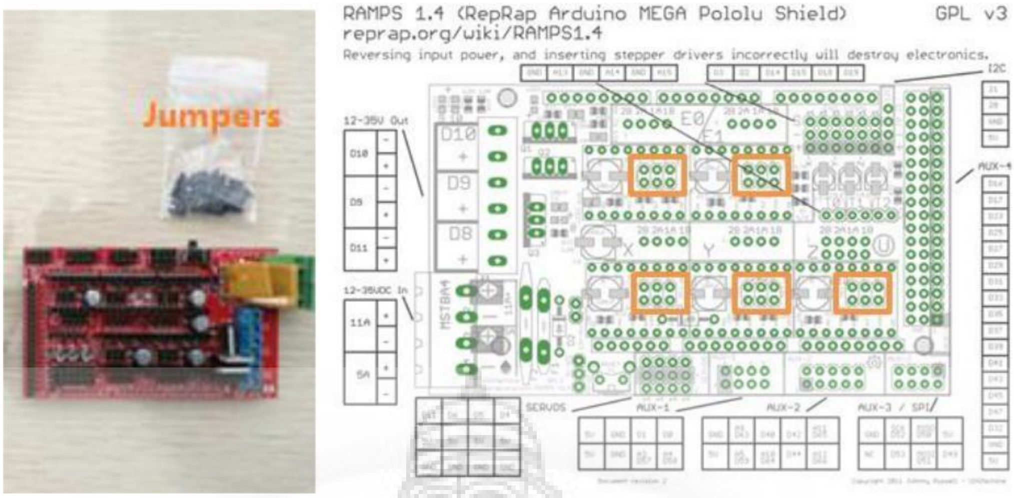


Figure 5.1 Jumper Connections[24].

2. BOARDS CONNECTIONS:

Integration of RAMPS 1.4 shield with Arduino Mega 2560 can be done very easily. The RAMPS 1.4 shield is matched to the top of the Arduino Mega 2560 board and pressed to be connected but done carefully so as not to damage any pins causing failure. Alignment is done by matching the corners of the board. For instance, the side of the Arduino Mega 2560 board containing the USB Port and the power supply port must be directly below the side of the RAMPS 1.4 shield containing the power supply and the D8, D9, and D10 ports as shown below.

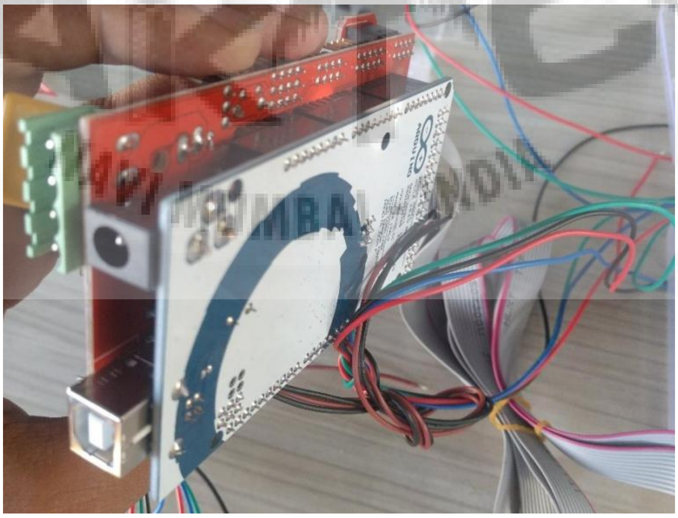


Figure 5.2 Arduino Mega 2560 integrated with RAMPS 1.4[24].

Now the next part is to add the Pololu Stepper Drivers A4988 as shown below. To ensure correct orientation, the Stepper Drivers must be interfaced correctly as there may be an issue of the Stepper Drivers getting burnt and becoming inoperable. This is done by ensuring that the potentiometer shown as red in the image below on the right side face directly away from the D10, D9, D8 ports side of the RAMPS 1.4 shield. After this, add heat sink elements where the Pololu Stepper Drivers are connected to ensure there is proper heat loss during operation as the board may get heated. However this too must be done carefully ensuring that the heat sink elements do not touch the various components of the Stepper Driver.

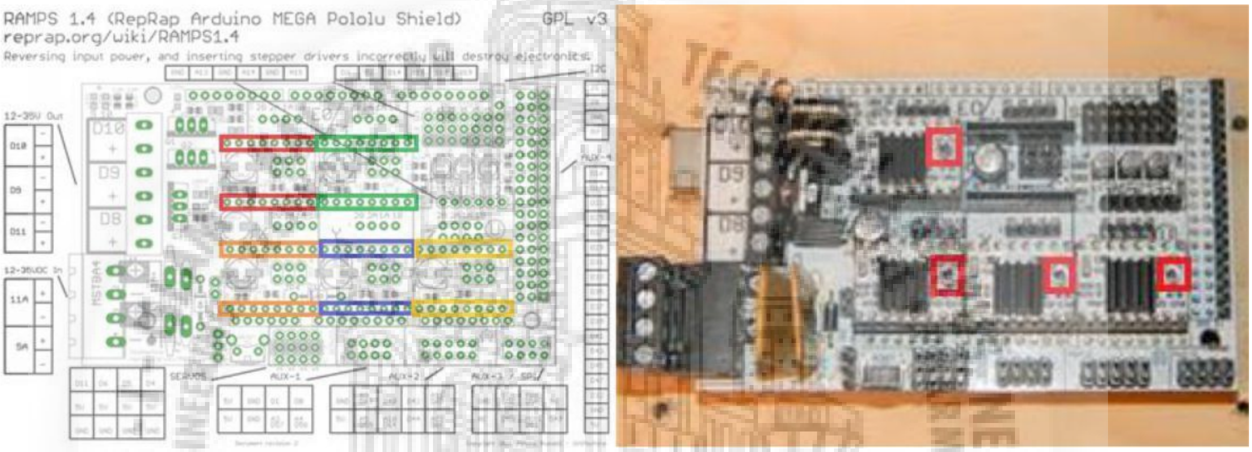


Figure 5.3 Installation of the Stepper Drivers[24].

3. CONNECT THE POWER SUPPLY:

Every Electronic and Electrical component requires Power Supply for operation. Same is true for this 3D Printer too which also contains these components. This 3D Printer requires a power supplying unit to supply it with a 12V and 10A Power. The Power Supply Unit (PSU), is directly given an input from the wall outlet of any room, office, etc. Which is at 100-265V 50Hz A/C supply and this PSU converts it into a 12V D.C. Constant Supply. It is an SMPS (Switch Mode Power Supply) and its output is directly connected to RAMPS 1.4 Shield. The output cables are connected to four pins containing alternating Positive and Negative outputs. The green ports in the RAMPS 1.4 Shield shown below is the input supply to the board and is connected to the output supply from the SMPS.

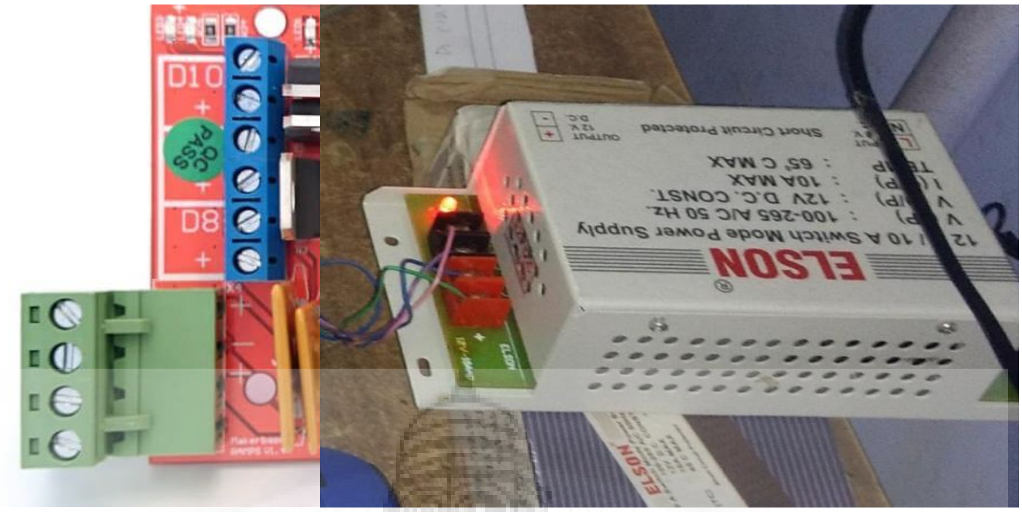


Figure 5.4 (a) Figure 5.4 (b)

Figure 5.4 (a): Power Supply Module RAMPS 1.4, Figure 5.4 (b): Power Supply Unit / SMPS[24].

4. Connections of Motors, Thermistors, HotEnd, Heat Bed and Fans:

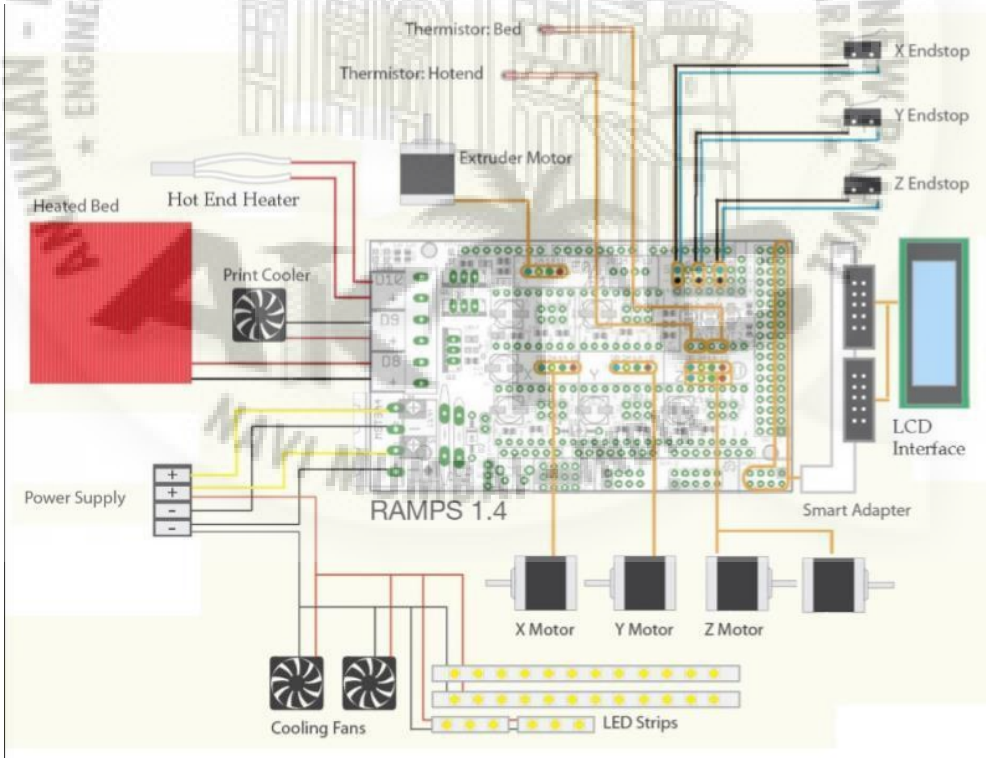


Figure 5.5 Connections of Motors, Thermistors, HotEnd, Heat Bed and Fans[24].

A. NEMA 17 STEPPER MOTOR CONNECTION:

Another important connection is to connect the Stepper Motor. The RAMPS 1.4 Shield contains X, Y and Z Ports and is connected with the wire drawn from the Motors of X, Y and Z Directions respectively and carefully so as to not damage the ports causing board failure. There are four ports / slots in each axis direction on the RAMPS 1.4 shield and similarly there are four wires drawn from each motor which are colored as Blue, Red, Green and Black. There are two slots for Z-Axis Motors as most of the cases of RepRap Machines (including ours) use two motors for Z-Directional operation. This connection is polarity sensitive which means that if a motor spins in the opposite direction than desired, then the same motor's wired connections must be flipped from the board to get the motor moving in the right direction. Below is a labeled diagram shown:

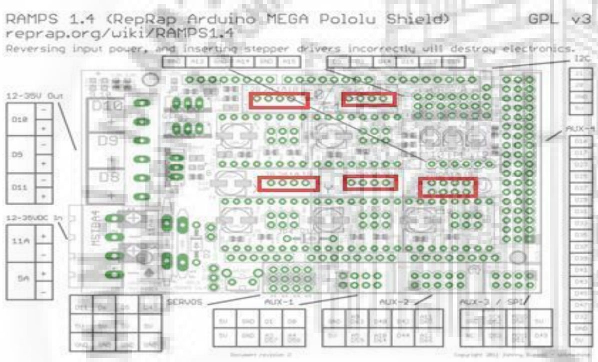


Figure 5.6 (a)

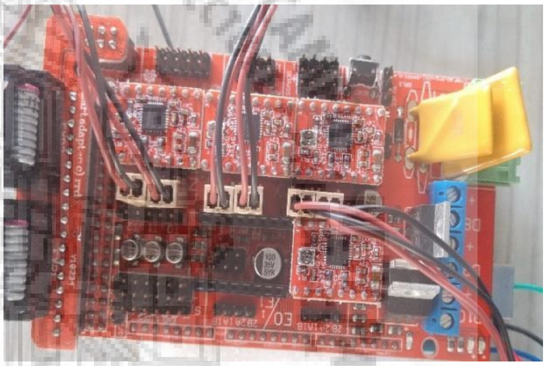
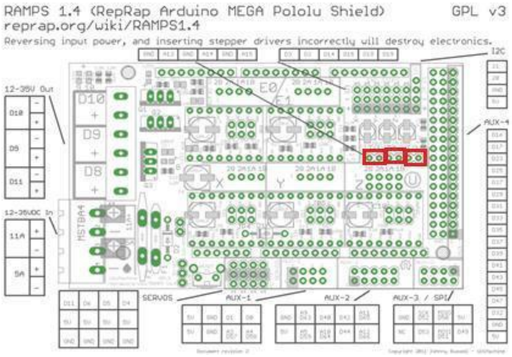


Figure 5.6 (b)

Figure 5.6 (a): Line Diagram of RAMPS 1.4 with marking for Stepper Motor, Figure 5.6 (b): Actual Connections[24].

B. THERMISTOR CONNECTIONS:

Next task is to connect the three thermistors in the 3D Printer. The RAMPS 1.4 Shield also has three thermistor ports for operational use. As shown in the labeled diagram below the thermistors are marked from left to right as Extruder 1, Heat Bed and Extruder 2. In contrast to the NEMA 17 Stepper Motor Connections shown above these connections are not polarity sensitive.



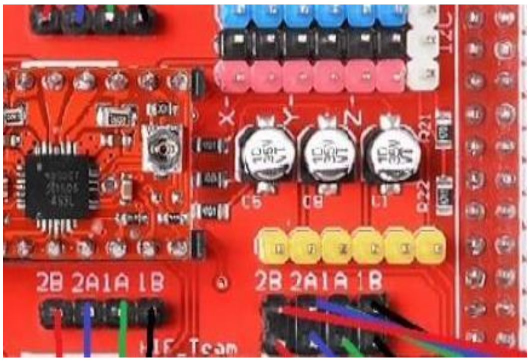


Figure 5.7 (a) Figure 5.7 (b)

Figure 5.7 (a): Line Diagram of Thermistor Connections, Figure 5.7 (b): Actual Connections of Thermistor Connections[24].

C. EXTRUDER HEATER (HOTEND), HEAT BED CONNECTION AND FAN CONNECTIONS:

The Extruder Heater or the HotEnd, Heat Bed and Fan are connected to the D10, D8 and D9 ports respectively on the RAMPS 1.4 Shield board. The fan connection is replaced with another Extruder Heater / HotEnd to provide Dual Extrusion. Here in this connection, only the Fan is polarity sensitive. Below shown is a labeled figure highlighted in red to show the extruder from top to bottom as Extruder Heater 1 / HotEnd 1, Fan or Extruder Heater 2 and Heat Bed Heater.

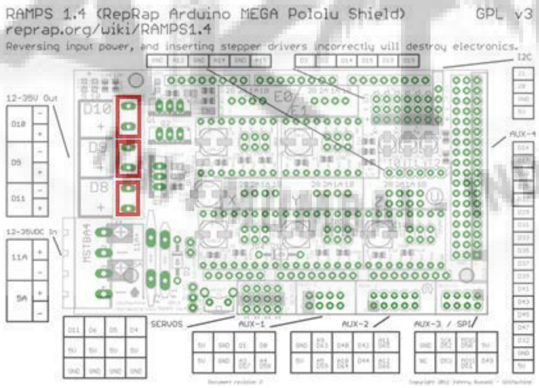


Figure 5.8 (a) Figure 5.8 (b)

Figure 5.8 (a): Line Diagram of Extruder Heater (HotEnd), Heat Bed Connection and Fan Connections, Figure 5.8 (b): Actual Connections of Extruder Heater (HotEnd), Heat Bed Connection and Fan Connections[24].

D. MECHANICAL END STOPPERS CONNECTIONS:

Now the next task is to connect the EndStoppers for motors. These are Mechanically based End Stops and are Polarity Sensitive. These End Stops have three wires Green, Black and Red and there are three slots on the RAMPS 1.4 Shield and are connected from top to bottom as Green, Black and Red respectively as shown in the orientation below where if viewed from the top the Power Supply port would be at the left. As per this orientation, the labeled slots are for the End Stops wherein each column corresponds to Xmin, Xmax, Ymin, Ymax, Zmin, Zmax from the left to right respectively.

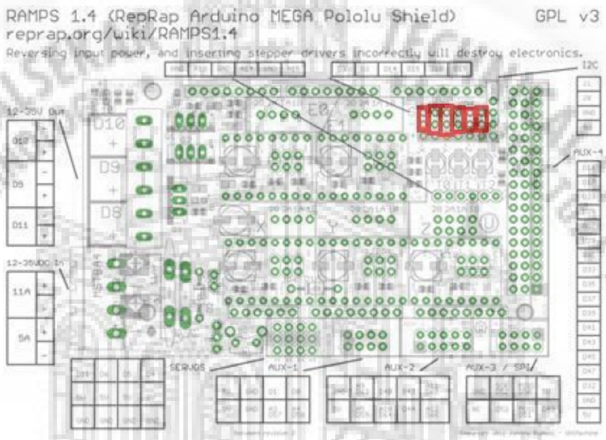


Figure 5.9 Line Diagram of Mechanical End stoppers Connections[24].

E. LCD CONNECTION:

A REES52 LCD 12864 Graphics Smart Display Controller Module is used in this 3D Printer. This LCD comes with Connector Adapter and cables for direct connection with RAMPS 1.4 Shield. The LCD with its components and the connection of this LCD with RAMPS 1.4 Shield is as shown below side by side respectively. The L-Shaped Connector Adapter is directly connected upon the RAMPS 1.4 Shield with its shorter side being on the direct opposite to the Power Supply port as shown. The cables are then connected to the adapter and its other end is connected to the LCD.

Figure 5.10 LCD Connection With RAMPS 1.4.

5.2 FINAL CONNECTIONS

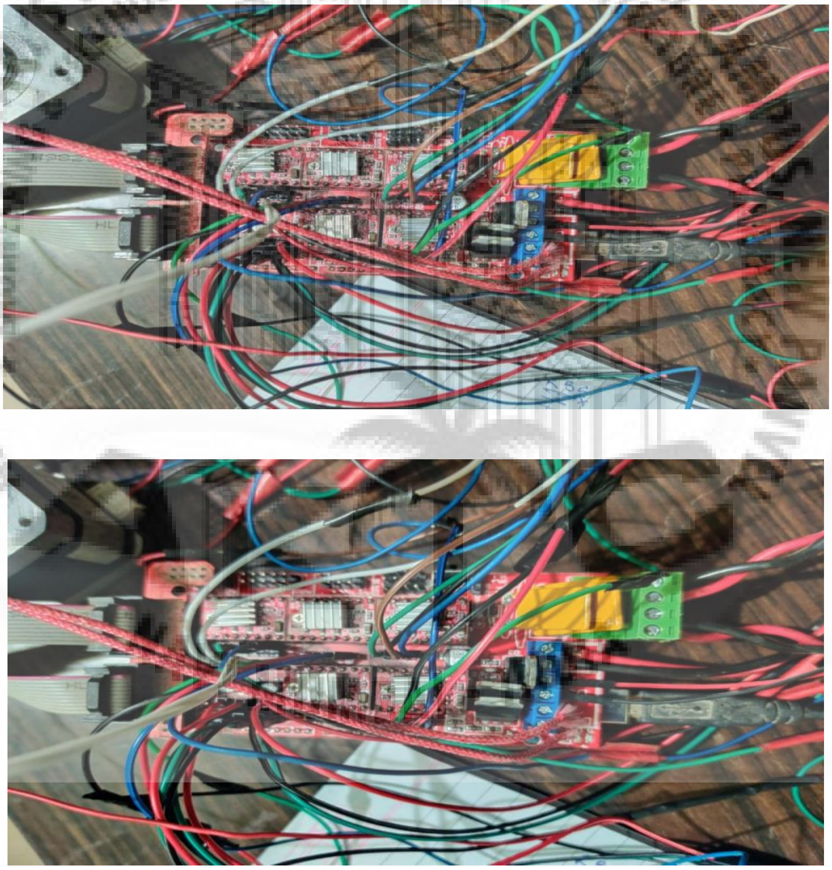


Figure 5.11 Final Connections.

5.2 COST REPORT

Table 5.1 Cost Report.

Sr. No.	COMPONENTS OR PARTS	AMOUNT
1.	5x NEMA17 Stepper motor 0.4 N-m 1.7A	3500
2.	Arduino Mega 2560 or compatible	1000
3.	10x 6mm GT2 belt pulley 20 teeth 8mm bore	1200
4.	2x NEMA17 Dual Shaft Stepper motor 0.4 N-m 1.7A	800
5.	2x Rigid Couplings	190
6.	8x Angle Plates	64
7.	2x M8 Nuts "for extending All thread"	400
8.	5 meters 6mm GT2 belt	799
9.	10x 100k high temp NTC Thermistors	320
10.	RAMPS 1.4 + 6x A4988 Stepper drivers	1780
11.	5x End stops on PCB	500
12.	Graphical LCD / control for RAMPS	600
13.	DC 12 V Electromagnet	295
14.	Nozzle	80
15.	25x M4x5mm set screws	200
16.	20x M3x20 Bolts or Allen screws	120
17.	4x 158 teeth closed loop 6mm GT2 belts	600
18.	M4 Nuts (T-Nut)	80
19.	3D Printer filament	1500
20.	Aluminium for extruder and brackets	400
21.	LED Lights	150
22.	Wood Ply	260
23.	Wires and clips	205
24.	Teflon Sheet	240
25.	12ft. Chrome Plated Linear Rod 8mm	200
26.	12ft. Chrome Plated Linear Rod 12mm	330
25.	Miscellaneous Cost	5000
	APPROXIMATE TOTAL	**20813**

CHAPTER 6

EMERGING TECHNOLOGIES

6.1 AUGMENTED REALITY

6.1.1 BACKGROUND OF AUGMENTED REALITY

In 1990 Tom Caudell, a Boeing analyst, authored the term 'enlarged reality'.

In 1992 Louis Rosenburg, a researcher in the USAF Armstrong's Research Lab, created ‘Virtual Fixtures’, which was one of the first fully functional augmented reality systems.

In 1994 Julie Martin, a writer and producer, brought augmented reality to the entertainment industry for the first time with the theater production titled Dancing in Cyberspace.

In 1999 NASA made a cross breed manufactured vision arrangement of their X-38 rocket. The framework utilized AR innovation to help with giving better routes during their experimental drills.

In 2000 Hirokazu Kato built up an open-source programming library called the ARToolKit. This bundle helps different engineers fabricate increased reality programming programs. The library utilizes video following to overlay virtual illustrations on top of this present reality.

In 2003 Sportvision upgraded the first and Ten realistic to remember the element for the new Skycam framework – giving watchers a flying shot of the field with illustrations overlaid on top of it.

In 2009 Esquire Magazine utilized enlarged reality on paper media without precedent for an endeavor to make the pages wake up.

In 2014 Google divulged its Google Glass gadgets, a couple of enlarged reality glasses that clients could wear for vivid encounters.

In 2016 Microsoft began delivering its rendition of wearable AR innovation called the HoloLens, which is further developed than the Google Glass, however accompanied by a powerful sticker price. It's certainly not an ordinary sort of embellishment.

In 2017 IKEA delivered its expanded reality application considered IKEA Place that changed the retail business for eternity[30].

6.1.2 DEFINITION OF AUGMENTED REALITY

Augmented Reality (AR), otherwise called Mixed Reality, expects to join virtual and real scenes together to accomplish that virtual ones have a place with this present reality. Being normal for the combination of virtual and real scene, numerous uses of Augmented Reality are arising, such as in the field of education, clinical treatment and entertainment. Expanded the truth is the conveying of intelligent advanced components over the encompassing genuine articles. This innovation is going to improve this present reality with the utilization of virtual components through a visual gadget. AR virtual items are overlaid on and followed at the same time with the information obtained from a camera in a perspective on this present reality. This makes a virtual figment that viably connects with clients in a virtual world[31].

Goals of Augmented Reality

- To challenge the impossible.
- To create a virtual environment for a more rich user experience.
- To integrate it into daily lives to help the masses.
- To achieve feats which are limited in the real world.
- To enhance the imagination of youths[31].

6.1.3 TYPES OF AUGMENTED REALITY

There are two types of simple augmented reality: markerbased which uses cameras and visual cues, and marker less which uses positional data such as a mobile's GPS and compass.

Various kinds of Augmented Reality (AR) markers are pictures that can be recognized by a camera furthermore, utilized with software as the area for virtual resources put in a scene. Most are dark and white, however tones can be utilized as long as the differentiation between them can be appropriately perceived by a camera. Straightforward increased reality markers can consist of at least one fundamental shape of dark squares against a white foundation. More intricate markers can be made utilizing straightforward pictures that are as yet perused appropriately by a camera. A camera is utilized with AR software to identify increased reality markers as the area for virtual items. The outcome is that a picture can be seen, even live, on a screen and advanced resources are put into the scene at the area of the markers.

1. MARKER BASED AUGMENTED REALITY

A marker based AR searches for a particular picture design in the climate and superimposes the virtual article on top of it. So the camera of the AR gadget will continually check the information and do markers — picture design acknowledgment and afterward make it's math and spot virtual item. The math of the virtual item will be administered by calculation and position of marker. On the off chance that the camera dismisses the marker the virtual item is lost and when it comes in see once more, the article is set once more.

Figure 6.1 Marker Based Augmented Reality[32].

2. MARKER LESS AUGMENTED REALITY

In markerless AR, the virtual object is placed in the geometry created by something called SLAM (Simultaneous Localization and Mapping) which takes in the camera feed and creates a 3 mesh of the environment. So the software remembers the environment as a 3d model. Hence when a virtual object is placed in an environment it is positioned in its 3d model. So even if the camera loses it’s sight on coming back the virtual object will still be found at the same location.

Figure 6.2 Markerless Augmented Reality[32].

6.1.4 APPLICATIONS OF AUGMENTED REALITY

1. MEDICAL TRAINING

From working MRI gear to doing complex medical procedures, AR tech holds the possibility to support the profundity and adequacy of clinical preparation in numerous territories. Understudies at the Cleveland Clinic at Case Western Reserve University, for instance, will currently learn life systems using an AR headset permitting them to dig into the human body in an intuitive 3D arrangement.

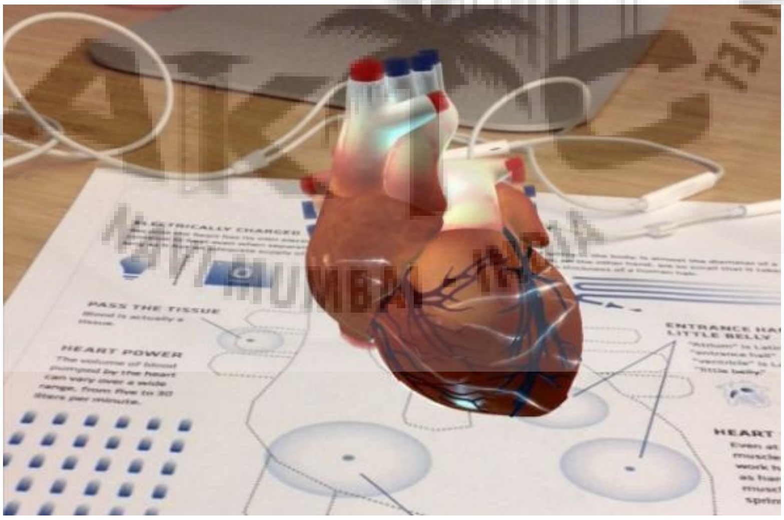


Figure 6.3 Medical Application of A.R.[33]

2. CLASSROOM EDUCATION

While innovations like tablets have gotten widespread in numerous schools and homerooms, instructors and teachers are presently increasing understudy's learning experience with AR. The Aurasma application, for instance, is now being utilized in study halls so students can see their classes by means of a cell phone or tablet for a more rich learning climate. Understudies finding out about stargazing may see a full guide of the close planetary system, or those in a music class could possibly consider melodic to be continuous as they figure out how to play an instrument.

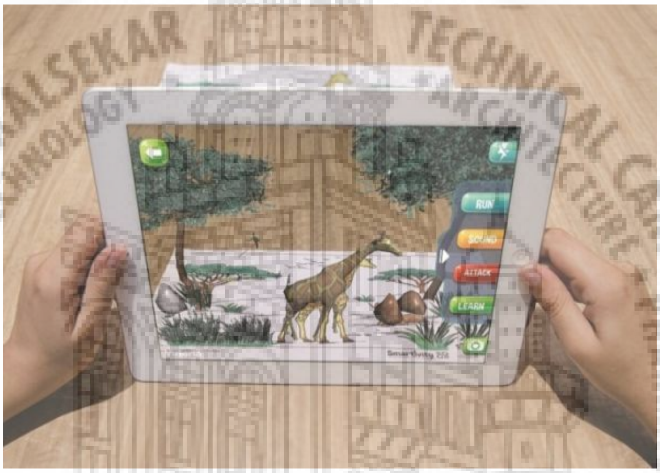


Figure 6.4 Educational Application of A.R.[33]

3. DESIGN & MODELING

From inside plan to engineering and development, AR is assisting experts with imagining their end results during the innovative interaction. Utilization of headsets empowers modelers, architects, and plan experts to step straightforwardly into their structures and spaces to perceive how their plans may look, and even make virtual on the spot changes. Metropolitan organizers can even model how whole city formats may look utilizing AR headset perception. Any plan or demonstrating occupations that include spatial connections are an ideal use case for AR tech.

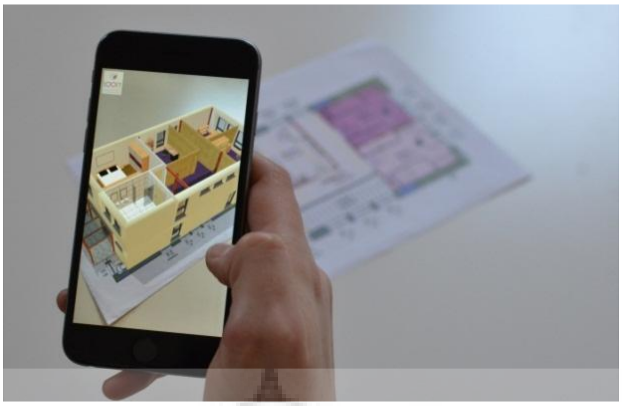


Figure 6.5 Design Application of A.R.[33]

4. RETAIL

In the present actual retail climate, customers are utilizing their cell phones like never before to analyze costs or look into extra data on items they're perusing. World celebrated cruiser brand Harley Davidson is one extraordinary occurrence of a brand taking advantage of this pattern, by building up an AR application that customers can use. Clients can see a bike they may be fascinated in purchasing in the display area, and redo it utilizing the application to see which tones and highlights they may like.

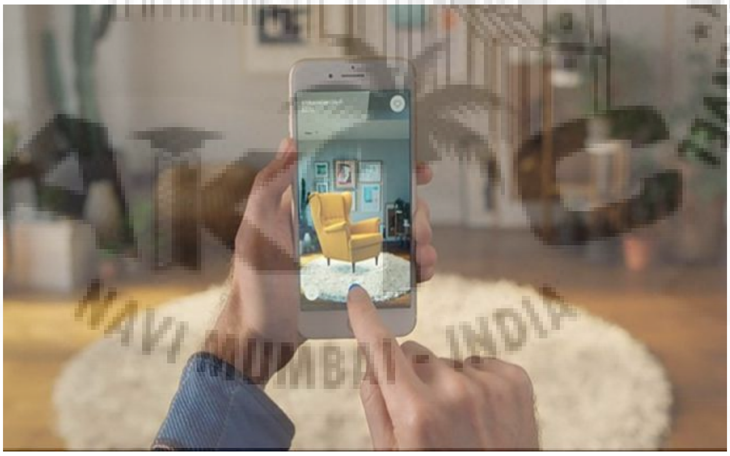


Figure 6.6 Retail Application of A.R.[33]

6.1.5 HOW DOES A MARKER BASED AUGMENTED REALITY SYSTEM WORKS?

1. CAMERA

A true live video is fed as a contribution from the PC camera to the Camera module.Showing this live feed from the PC camera is the truth in Augmented reality. This live video transfer is given as an input to the Image Capturing Module.

2. IMAGE CAPTURING MODULE

The input to the Image Capturing Module is the live video feed from the camera of a cell phone. This module investigates the camera feed, by dissecting each edge in the video. This module creates binary images for example an digital image that has just two potential values for every pixel. Normally the two shadings utilized for a binary image are black and white. These binary images are provided as an input to the image processing module.

3. IMAGE PROCESSING MODULE

Input to the Image Processing Module are the Binary pictures from Image Capturing Module. These binary pictures are prepared utilizing a picture handling technique to recognize the AR Marker. Identification of AR Marker is fundamental to decide the position, where to put the virtual article. When the AR Marker is distinguished, its area is given as an input to the Tracking Module.

4. MARKER TRACKING MODULE

The following module is the "heart" of the Augmented reality system, it calculates the overall posture of the camera continuously. The term presents six levels of opportunity (DOF) position, i.e the 3D area and the 3D direction of an object. The determined posture is given as a contribution to the Rendering Module.

5. RENDERING MODULE

There are two inputs to the Rendering Module. First is the figure present from the following module also, other is the Virtual Object to be enlarged. The rendering module combines the first picture and the virtual segments utilizing the determined posture and delivers the increased posture on the presentation screen of the cell phone.

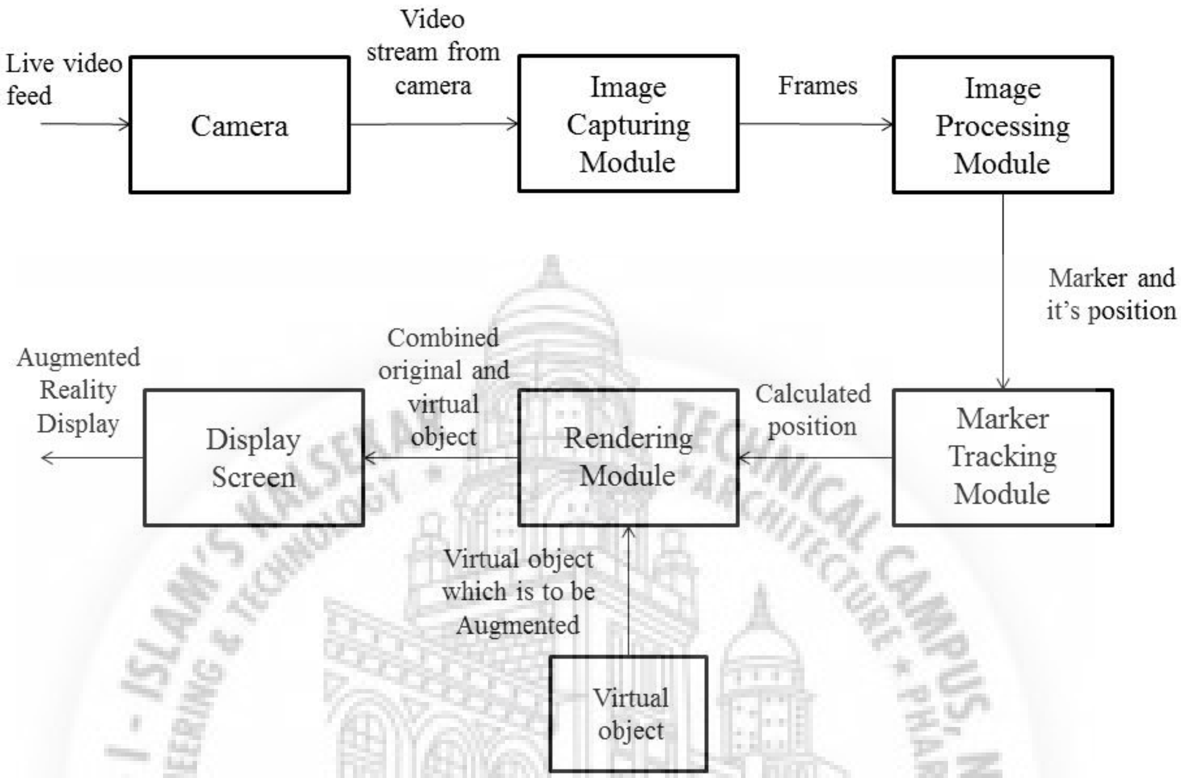


Figure 6.7 Working of Marker Based A.R. Technology[34].

6.1.6 IMPLEMENTATION OF AUGMENTED REALITY

Steps To Be Followed In Marker Based Augmented Reality

1. Making a model in any 3D modeling software.
2. Importing the model into the unity software.
3. Deciding the marker to be used.
4. Creating the marker using the Vuforia website and getting the license key.
5. Checking the rating of marker for enhanced detection
6. Downloading the created database from Vuforia.
7. Import the database into the unity software.
8. Placing the marker at the appropriate position into the software.
9. Placing the model above the marker.
10. Adding license and database data into unity.
11. Setting up the world anchor.

12. Setting up the deployment methods.
13. Building the apk for android.
14. Installing and running the application on mobile[35].

As mentioned earlier, we are using Marker Based Augmented Reality as mentioned in above steps firstly we have to create a 3D model of an object which is to be virtually represented that can be made on any 3D modeling software like Autodesk Inventor ,Catia ,Solidworks.After completion of the 3D model and saving it in required format. The next step to be followed is the importing the created 3D model into the unity software. In parallel to that we have to first create our marker which will be used as base to represent our object. To create the marker we have to first visit the Vuforia website where we have to manually select a marker either from your computer or by default option so that a license key is generated for the selected marker at the end. The figure below shows the marker which has been used and uploaded to generate the license key.

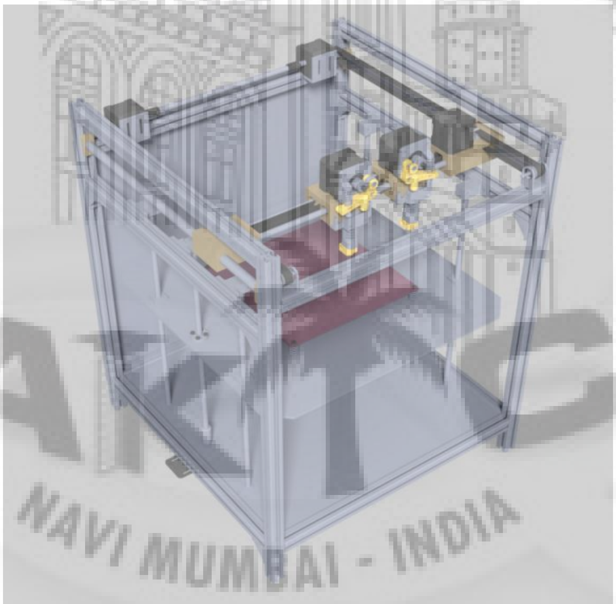


Figure 6.8 Final Marker for A.R.

We can also check how efficient our marker is through the vuforia website as there is a specific window for that. After completion of this step we can download the data of markers from the vuforia website. This database is used in order to obtain the license key and add it to the unity software. The marker which was generated is properly placed in the software. Next to the addition of the marker the 3D model which we are using as the object to be represented virtually is properly placed onto the marker with proper anchor and deployment methods.

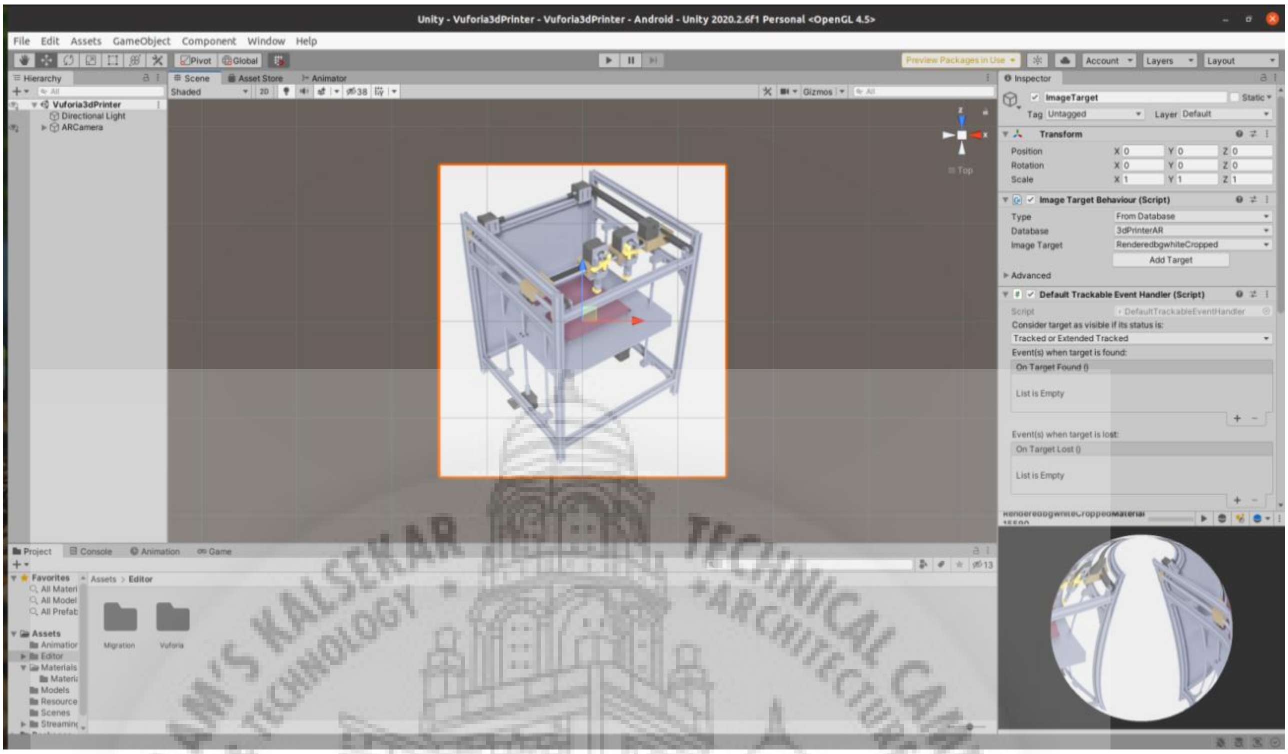


Figure 6.9 Vuforia Application Interface.

The above fig. shows the user interface of the software in which marker which we have created. After doing all the settings we can finally build an apk of our object to be represented. And it is ready to install. We have named it as Vuforia3dPriner.apk

Figure 6.10 Vuforia APK File.

The above image depicts the apk which we have built for Our Project. After running the application we were able to obtain the following result for Marker Based Augmented Reality.

Figure 6.11 Final A.R. Model Depiction.

6.2 CHATBOT

6.2.1 WHAT IS A CHATBOT ?

Chatbots are computer programs built to simulate human conversations, whether that's on an internet site, a messaging app or a virtual assistant. With today's customers expecting more reach and engagements in their interactions with brands, the addition of chatbots as a channel has become essential to business growth.

In its simplest form, chatbots are often programmed to answer specific, commonly asked questions, offering a simple thanks to engage with visitors. On the other hand, AI (AI) - powered chatbots can research from person conduct and previous agent interactions to are expecting tourist conduct and provide applicable information.

Using chatbots will facilitate change interactions and supply instant accessibility across sales, marketing, and client service functions.

6.2.2 TYPES OF CHATBOT

Chatbots have evolved dynamically. Currently chatbots are subdivided into three categories according to their technical aspects such as

1. Simple Chatbots
2. Smart Chatbots
3. Hybrid chatbots

1. SIMPLE CHATBOTS

Simple chatbots have restricted capabilities, and are typically referred to as rule-based chatbots, they are task-specific. consider them as IVRS on chat. This implies the bot poses queries supporting planned options and therefore the client will choose between the choices till they get answers to their query. The chatbot won't build any inferences from its previous interactions. These chatbots are best suited to easy dialogues. they're terribly simple to make and train.

Example: Ordering a pizza

When a client interacts with a chatbot to order pizza, the flow of the speech is set. a bit like an associate degree operator asks for your order over the phone, the chatbot will create the queries within the same way. ranging from the dimensions of the pizza, to the crust, toppings and quantity of cheese. it'll then request the address and payment method. The steps are logical and solely need the customer to click through to finish their order.

2. SMART CHATBOTS

AI-enabled chatbots are designed to simulate near-human interactions with customers. they will have free-flowing conversations and perceive intent, language, and sentiment. These chatbots need programming to assist it understand the context of interactions. They're abundant, more durable to implement and execute and want tons of information to learn.

Example: Virtual Assistants

Virtual assistants are a changed version of smart chatbots. Siri, for instance, learns from each human interaction. It may have interaction in confabulation that is another advantage of smart chatbots. whereas smart chatbots are trained to administer the foremost relevant response with the assistance of an open domain resource, they learn best by collecting info in real-time. Note that companies are nevertheless to create a larva to the extent that virtual assistants work as a result of it needing large data. However theoretically, good chat bots would work like virtual assistants on internet apps.

3. HYBRID CHAT BOTS

They are a mixture of simple and good chatbots. Each simple and smart chatbot are extremes within the chatbot spectrum. there'll perpetually be a requirement for straightforward chatbots to be smarter and smart chatbots to be simpler. Hybrid chatbots meet that middle ground. Hybrid chatbots have some rule-based tasks, and also they can perceive intent and context. This makes them a balanced tool for businesses to act with customers.

Example: Medical Diagnosis

Chatbots that facilitate a diagnosis mix the capabilities of each simple and smart chatbot. Guests are ready to voice their health-related queries and the bot will slender down possible conditions by inquiring for symptoms in an exceedingly rule-based format. Guests are able to come back and forth, opt for completely different choices and provide a lot of details till the bot narrows down on their condition and prescribes remedies for the same.

6.2.3 BENEFITS OF CHATBOTS

a) 24-hour accessibility

According to studies, over 50% of clients/consumer shoppers} expect a business to be obtainable 24/7. Watching for future available operators for minutes isn't a resolved downside yet, however chatbots are the nearest candidates to ending this problem. Maintaining a 24/7 response system brings continuous communication between the vendor and also the customer. Of course, this profit is proportional to however well the bots are. Bots that are unable to serve straightforward customer queries fail to feature worth even though they're 24/7 available. The biggest issue at this time is how well the chatbots can perceive and solve customer problems. Finally, highlighting 24/7 accessibility will produce backlash once bots are down thanks to security problems or maintenance.

b) Instant answers

An operator will focus on one client at a time and answer one question. However, a chatbot can answer thousands of queries at a similar time. Because of the speed of the cloud, internet, and software system mechanisms, responses are provided instantly.

c) Consistent answers

Talking to a client service rep, a customer has no assurance that alternative reps also are providing similar, consistent responses. If a customer service rep isn't helpful, a customer might be tempted to undertake occupation once more to examine if consequent rep is better.

d) Endless persistence

While purchaser reps and clients generally lose their persistence, that’s one element bots are but incapable of. The impatience of the consultant and additionally the client in the course of the solution of a retardant is one among the human-associated failures. The consultant is expected to be loads of affected persons in the most quantity as practicable simply so the company will maintain client pleasure high. Chatbots can display the persistence that no human can provide. At this point, a human-sourced client provider trouble is frequently resolved directly.

6.2.4 ACTUAL IMPLEMENTATION OF CHATBOT

Below are the screenshot images of the chatbot created and implemented with the 3D Printer:

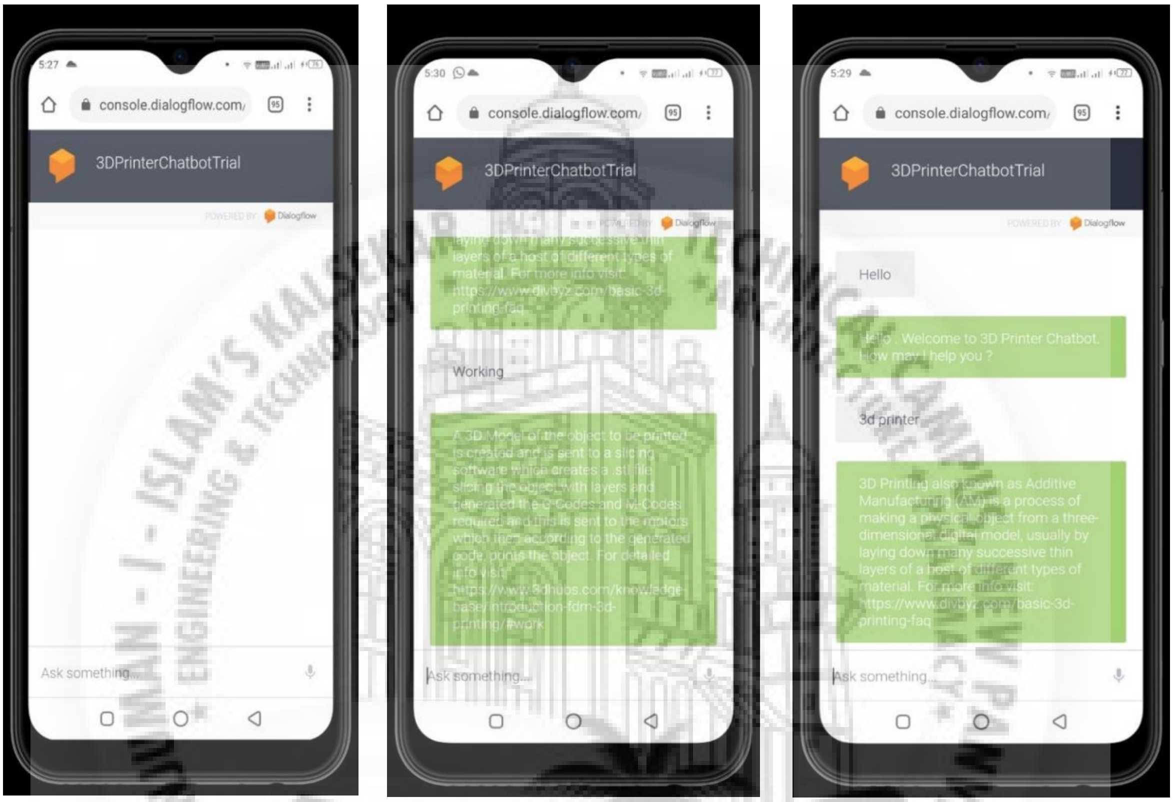


Figure 6.12 Implementation of Chat Bot.

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