3D PRINTER USING FUSED DEPOSITION MODELING

A Project report submitted in partial fulfillment of requirements

for the award of the Degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

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(*Permanently Affiliated to AU, Approved by AICTE and Accredited by NBA & NAAC with ‘A’ Grade*)

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(2019-23)

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CERTIFICATE

This is to certify that the project report entitled **"3D PRINTER USING FUSED DEPOSITION MODELING"** submitted by **D. SUPRIYA (320126512L13), K. JAYANTH (319126512091), K.H.V.S.SAI MADHU (319126512093), CH.SAI KRISHNA (320126512L09)** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics and Communication Engineering** of Andhra University, Visakhapatnam is a bonafied work carried out under my guidance and supervision.

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ACKNOWLEDGEMENT

We would like to express our deep gratitude to our project guide **MRS G. GAYATRI**, Assistant Professor, Department of Electronics and Communication Engineering, ANITS, for her guidance with unsurpassed knowledge and immense encouragement. We are grateful to **DR.B.JAGADEESH,** Professor, Head of the Department, Electronics and Communication Engineering, for providing us with the required facilities for the completion of the project work.

We are very much thankful to **Principal and Management, ANITS, Sangivalasa,** for their encouragement and cooperation to carry out this work.

We express our thanks to all **teaching faculty** of Department of ECE, whose suggestions during reviews helped us in accomplishment of our project. We would like to thank all **non-teaching staff** of the Department of ECE, ANITS for providing great assistance in accomplishment of our project.

We would like to thank our parents, friends, and classmates for their encouragement throughout the project period. At last, we thank everyone for supporting us directly or indirectly in completing this project successfully.

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ABSTRACT

3DA new technology known as an additive manufacturing technology, or 3D printer, is used to print 3D things of any shape from a provided 3D model or other electronic data sources by combining the processes in which additional material is added while being guided by a computer. It makes use of ceramics, metals, resin, and polymers. Jewelry, shoes, industrial design, building and construction, automotive, aerospace, the dentistry and medical professions, education, and consumer goods are just a few of the sectors that employ it.

By heating and extruding thermoplastic filament in various colors, a 3D printer that uses FDM (Fused Deposition Modeling) technology builds the pieces layer by layer from the bottom up. We are using biodegradable thermoplastic aliphatic polyester called poly lactic acid (PLA) or polylactide (Poly) as the 3D printing filament in this particular 3D printer. By doing away with the need to design, print, and assemble individual model elements, this technique for making 3D models using "INKJET" technology saves time and money. Therefore, we are developing a 3D printer that uses computer commands to produce 3D things of any shape.

Keywords: Additive Manufacturing Technology, Fused Deposition Modeling, inkjet technology.

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CHAPTER 1

INTRODUCTION

CHAPTER 1

1.1 INTRODUCTION

A 3D printer uses the additive manufacturing process to create three-dimensional objects such as sculptures and parts from numerous layers of material. Rapid prototyping is a common name for it. By linking a machine to a computer that contains the blueprints for any object, it is possible to rapidly create 3D objects of any size using this mechanical technology.

A three-dimensional model or other electronic data sources can be used to create a three-dimensional object of any shape using additive processes, in which subsequent layers of material are applied while being controlled by a computer. This technique is referred to as additive manufacturing (AM) or 3D printing. The first person to print a tangible product from a computer design is largely regarded to be Hideo Kodama of the Nagoya Municipal Industrial Research Institute. However, Charles Hull, who created the first 3D printer in 1984 while working for the company he founded, 3D Systems Corp. The stereo-lithography technique and the STL (stereo-lithographic) file format, which is still the most widely used format in 3D printing today, were invented by Charles Hull. Along with pioneering 3D printing, he is credited with starting the commercial fast prototyping industry. He originally used photopolymers heated by UV light to create the melting and solidification action. The first 3D printer was created and commercialized in 1984 by Charles Hall of 3D Systems Corp. As technology advanced, these devices became more and more useful while also becoming more and more affordable.

Rapid prototyping is now used widely in a variety of industries, including engineering, medicine, the service sector, construction, armature, fashion, education, computer science, and countless more. Fused deposit modeling, the plastic extrusion technology most commonly associated with the term "3D printing," was invented by Stratasys in 1990. (FDM). The number of 3D printing companies has significantly increased, and their prices have gradually decreased, since the turn of the century. Early in the 2010s, the terms "3D printing" and "cumulative manufacturing" had developed into different marquee terms for additive manufacturing (AM) technologies, with the former being used informally by consumer-maker communities and the media and the latter being used formally by artificial AM end use part directors, AM machine manufacturers, and international specialized norms organizations. Both phrases emphasize the fact that all technologies share the same notion of succession—sub caste material addition—and joining—under automated control—within the 3D work envelope. Additionally, the names desktop manufacturing, rapid-fire manufacturing, and nimble tooling on-demand manufacturing had been used as antonyms for AM. The 2010s marked the first decade in which work products will be grown (either before or rather after machining) in essence end use corridor akin to machine classes and huge nuts rather than having to be machined from bar stock or plate.

The subtractive system, in contrast to the cumulative system, involves the removal of a block's material through drilling or cutting. The main goals of using a 3D printer are to maximize resource use, lengthen product lifecycle, and produce lighter, stronger objects. A number of sectors, including construction, aerospace, automotive, medicine, and the manufacture of several consumer goods, are successfully utilizing 3D printing.

1.2 GENERAL PRINCIPLES

1.2.1 MODELING

The printed object or model must first be drawn or modelled in a CAD (computer assisted drawing) application such as solid works, etc. This 3D printed model was created with the use of CAD, which reduces the number of flaws found and potentially repaired before printing. 3D modelling is the process of assessing and obtaining data on the geometry and appearance of an object. This data can be used to construct the scanned object's 3D model.

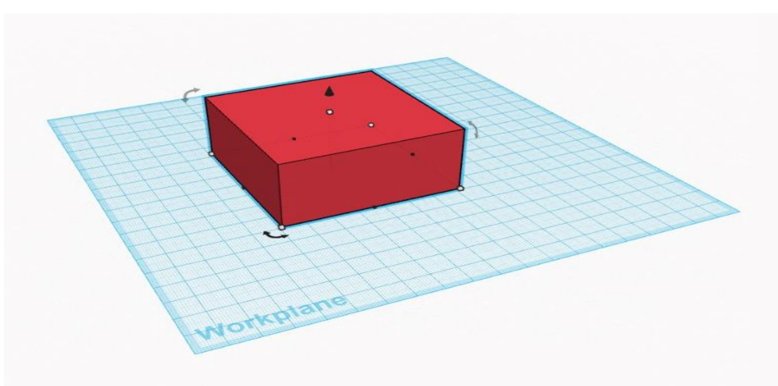


Fig 1.1: Modeling of the 3D object

The above figure1.1 shows the modeling of the 3D object. The method of creating geometric data for 3D computer plates in home modelling is comparable to plastic arts like sculpture. 3-dimensional models of the examined object can be created based on the data. The modeling stage ends once the final 3D model has been" published." The most popular are shape ways, YouMagine, thingverse, 3D CAD cybersurfer, Sketchfab.

1.2.2 PRINTING

The model has been turned into a series of layers and a G-code file with instructions once the file has been converted to .STL Format by software known as a "SLICER." This G-code file will be produced via 3D client software. (Which loads the G-code and uses it to instruct the 3D printer during printing). The 3D printer used G-code instructions to lay down every subsequent layer that eventually created the model from a series of nozzle cross sections. These layers, which represent the virtual cross sections of the CAD model, are joined or automatically melted to create the final shape. The process could take minutes or hours, depending on what the printer is generating.

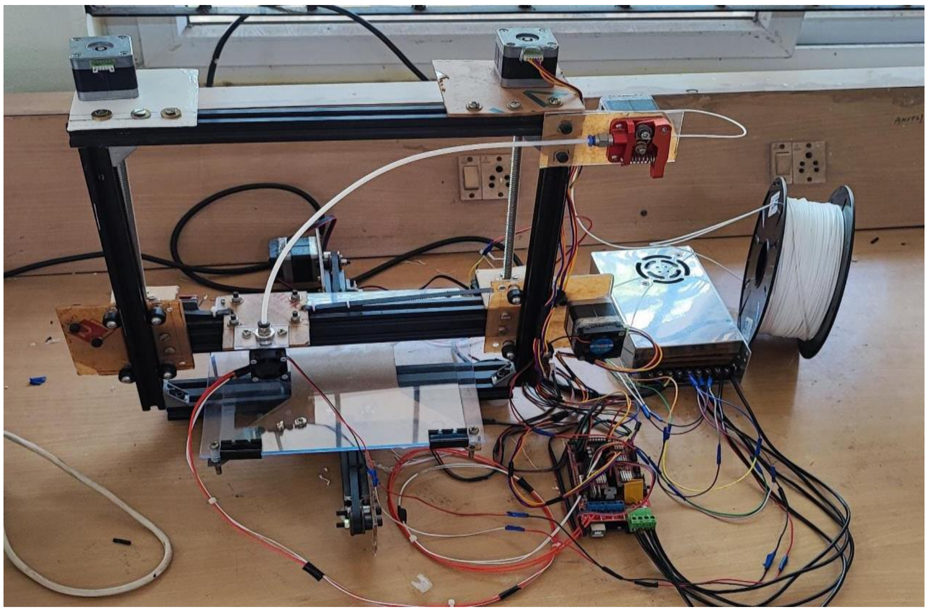


Fig 1.2: Printing a 3D model

An example of printing a 3D model is shown in image 1.2 above. This time can often be cut down to a matter of hours using additive techniques, while exact reductions depend greatly on the machine type, size, and quantity of models being made. Depending on the size, method, printing speed, and intricacy of the model, model construction could take several hours to several days. The period of time can typically be cut down to a few hours, depending on the size and type of machine.

1.2.3 FINISHING

For numerous reasons, the resolution produced by the printer is more than adequate; nonetheless, printing will produce a slightly wider interpretation of the needed items compared to the normal resolution, and the process of material barring can offer even better perfection. Using chemical vapour methodologies, several reported polymers provide a smoother and better face finish. These methods of part fabrication allow for the use of colourful accessories in some cumulative manufacturing processes. These methods enable simultaneous publication of numerous colour schemes. For overhanging elements, several printing processes require the placement of internal supports. These supports need to be mechanically removed or dissolved after printing is complete. The capitalized essence 3D printers are definitely much more likely to be used for cutting the essence components of the essence substrate after deposit. International Manufacturing Technology demonstrates how some cumulative manufacturing processes can utilize a variety of tools while constructing a corridor.

1.3 PROCESSES OF 3D PRINTING

A range of techniques, tools, and materials are employed in the additive manufacturing of a three-dimensional object. The bulk of 3D printing techniques are additive in nature, with a few noticeable distinctions in the technology and materials utilized in the process. This is because 3D printing is also known as active manufacturing. Since the late 1970s, numerous cutting-edge 3D printing methods and technologies have been developed. Printers were initially bulky and expensive in relation to their production capabilities. There are numerous additive manufacturing methods accessible today. In some technologies, such selective laser melting (SLM), selective laser sintering (SLS), and fused deposition modelling (FDM), the material is melted or softened to build the layers, whilst other technologies use a range of procedures to cure liquid materials.

1.3.1 SELECTIVE LASER SINTERING

Picky ray sintering (SLS), which was developed and brevetted by Dr. Carl Deckard and his academic advisor Dr. Joe Beaman at the University of Texas in the middle of the 1980s with assistance from DARPA. Deckard was a founding member of the famous start-up DTM, which was established to design and create the notoriously challenging ray sintering machines. In 2001, DTM was acquired by 3D Systems, DTM's primary rivals. The latest fashion patent from Deckard for fickle ray sintering was granted in January 1997 and will expire in January 2014.

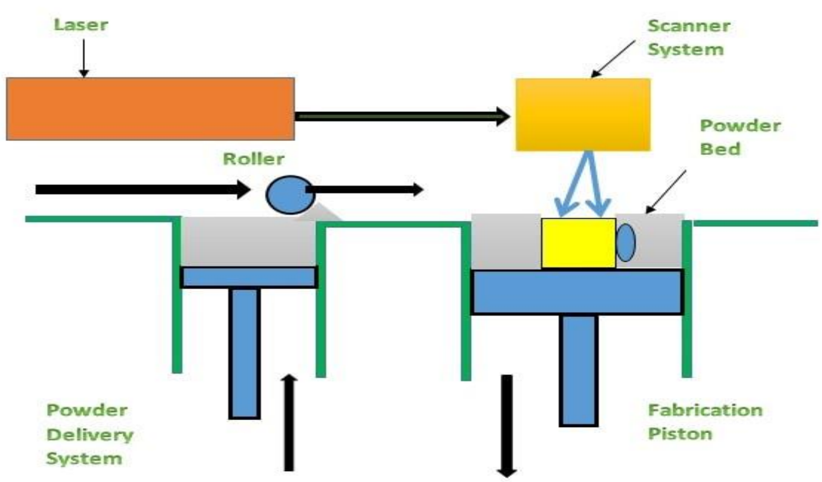


Fig 1.3: Selective Laser Sintering (SLS)

SLS, a relatively new technology that has thus far been mostly utilized for advanced manufacturing and low-volume part production, is depicted in Fig. 1.1. is a kind of additive manufacturing (AM) that sinters microscopic particles of polymer powder into a solid structure based on a model by autonomously focusing the laser at spots in space defined by the 3D model and fusing the material to form a solid structure.

1.3.2 FUSED DEPOSITION MODELING

The fused deposition modelling (FDM) method was initially created by S. Scott Crump in the late 1980s, and Stratasys designed it in 1990. This kind of 3D printer became attainable when the invention's patent was published.

Unwinding is taking place on a coil of thermoplastic wire or filament that provides material to an extrusion nozzle head. The nozzle head, which also modulates the flow, heats the material to a particular temperature. The extrusion head is often controlled in the z-direction by stepper motors, which can also adjust the flow as appropriate. The mechanism that moves the head in both horizontal and vertical directions is managed by a computer-aided manufacturing (CAM) software programme operating on a microcontroller.

Layer thickness, infill pattern, infill density, raster angle, raster width, printing speed, build orientation, printing, and bed temperature are a few factors that are employed in the FDM process. Mechanical and anisotropic qualities are severely hampered in FDM-produced parts.

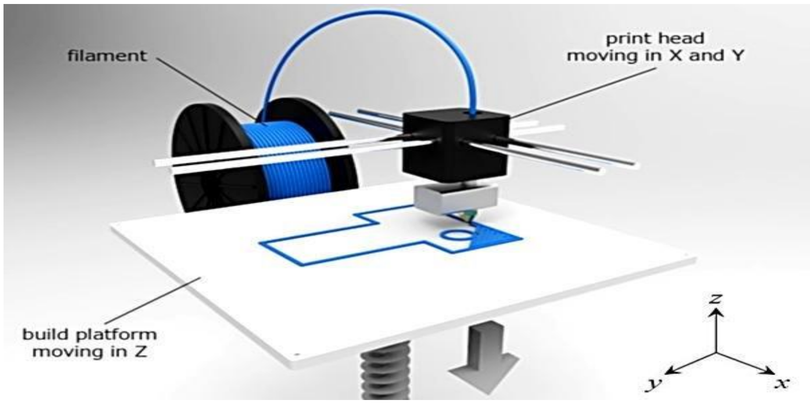


Fig 1.4: Fused Deposition modeling (FDM)

Fig 1.2 shows modelling of fused deposition. A continuous thermoplastic or composite material thread in the form of filament is used in the technique of additive manufacturing termed fused deposition illustrating to generate 3D components. The plastic filament is fed through an extruder, melted at the extruding nozzle, and then layer by layer, naturally, is deposited onto the build platform.

1.3.3 STEREOLITHOGRAPHY

Stereolithography (SLA) is an industrial 3D printing process used to create concept models, cosmetic prototypes, and complex parts with intricate geometries in as fast as 1 day. A wide selection of materials, extremely high feature resolutions, and quality surface finishes are possible with SLA.

A type of 3D printing technology called the stereolithography (SLA or SL, also known as vat photopolymerization, optical fabrication, photo-solidification, or resin printing) is used to build models, prototypes, structures, and production parts layer by layer using photochemical processes in which light causes chemical monomers and oligomers to cross-link to form polymers. The body of a three-dimensional solid is created through the integration of these polymers. Despite the fact that research in the area started in the 1970s, Chuck Hull came up with the moniker in 1984 when he applied for a patent on the methods, which eventually received approval in 1966. Among many other things, stereolithography can be used to create prototypes for new products, medical models, and computer hardware.

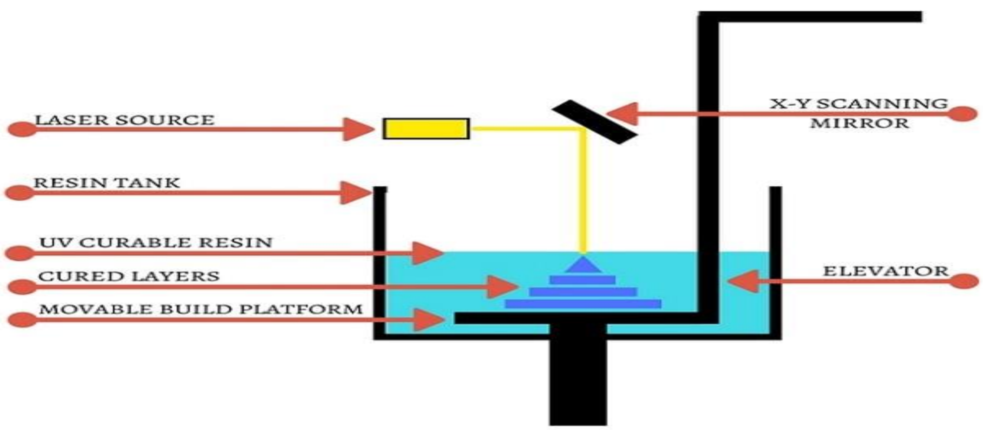


Fig 1.5: Stereolithography

The above fig 1.5 shows stereolithography. While stereolithography is fast and can produce almost any design, it can be expensive. Stereolithography is often used for prototyping parts. For a relatively low price, stereolithography can produce accurate prototypes, even of regular shapes Businesses can use those prototypes to assess the design of their product or as publicity for the final product.

1.3.4 LAMINATED OBJECT MANUFACTURING

Laminated object manufacturing (LOM) is a rapid prototyping system developed by Helysis Inc. (Cubic Technologies is now Helisys' successor organization). It involves successively gluing layers of adhesive-coated paper, plastic, or metal laminates together and cutting to shape with a knife or laser cutter. Objects printed using this technique can be further modified after printing by machining or drilling.

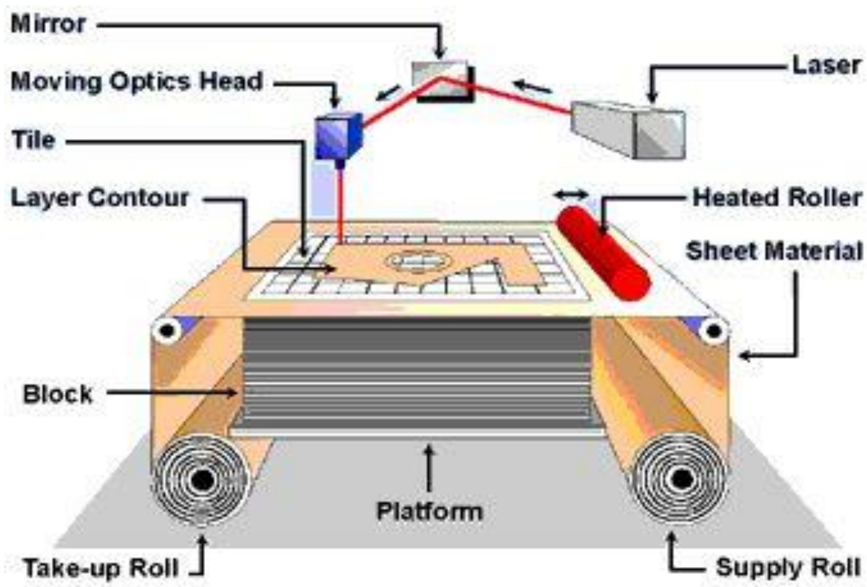


Fig 1.6: Laminated Object Manufacturing

The above fig 1.6 shows laminated object manufacturing. The Objects printed with this technique may be additionally modified by machining or drilling after printing. Typical layer resolution for this process is defined by the material feedstock and usually ranges in thickness from one to a few sheets of copy paper.

1.4 3D PRINTING MATERIALS

Material	Description	Printing Temperature	Bed Temperature
PLA	PLA is one of the two most well-liked substances for desktop 3D printing. (Polylactic Acid). (with the other being ABS). PLA is often recommended as the "default" material for desktop 3D printers, and for good reason: It works well for a broad spectrum of printing applications, is unnoticed and low warp, and lacks a hot bed. PLA plastic is one of the more ecologic 3D printer materials on the market because it originates from renewable resources (cornstarch) and uses less energy than conventional (petroleum-based) plastics.	180-200^{0}C	20-55^{0}C
ABS	Another popular 3D printer material is ABS (Acrylonitrile Butadiene Styrene). It is robust and sturdy, resistant to heat and impact, requires a heated bed to print, and requires ventilation.	220-235^{0}C	80-110^{0}C
	Nylon is a versatile, incredibly durable, and robust material for 3D printing. Nylon lends itself nicely to things like live hinges and other		

Nylon	functional features since it is extremely flexible when thin and has excellent interlayer adhesion. With a translucent surface and bright natural to white printing, nylon filament can take on colour when it is applied post-printing using the majority of traditional, acid-based garment dyes. Since nylon filament is particularly sensitive to moisture, it is highly recommended for best results to take drying precautions both during storage and right before printing.	235-270 °C	60-80 °C
PET(Polyethylene Terephthalate)	There are quite numerous benefits to using high-strength PET (Polyethylene Terephthalate) filament. It has a far higher strength than PLA, hardly warps, and emits no odours or fumes when printed. It is FDA qualified for use in food containers and cutlery. PET fiber is not biodegradable, yet it is entirely biodegradable.	230-255 °C	55-70 °C
TPE	This filament, which is flexible enough to be used in 3D printing, behaves and feels like flexible rubber. Stoppers, belts, springs, phone cases, and other objects that can or must flex to fit	210-225 °C	20-55 °C

	their surroundings can all be made with TPE filament.		
TPU (Thermoplastic Polyurethane)	TPU has a Shore Hardness of 95A and is an open to change, sticky, and abrasion-resistant polymer. It can also be found on caster wheels for automobiles, power tools, for recreational use products, healthcare devices, drive belts, footwear, and inflatable rafts in addition to being used in an assortment of stretched film, sheet, and profile applications.	240-260 °C	40-60 °C

1.5 HARDWARE COMPONENTS

- ARDUINO Mega 2560
- Ramps 1.4
- Stepper Motors
- Stepper Motor Drivers(A4988)
- Extruder
- Filament (PLA)
- Eccentric Nuts
- Hot End
- Aluminum Extrusions
- Wheels
- Stepper Motor Pulleys
- Support Pulleys
- Timing belt
- Switch Mode Power Supply (SMPS)

- Sliding Nuts
- Cooling Fans

1.6 SOFTWARES USED

For the development of this printer, we used the open source “MARLIN firmware” which is one of the most widely used firmware for 3D printer.

1.6.1 ARDUINO IDE:

The Arduino Software (IDE), commonly referred to as the Arduino Integrated Development Environment (IDE), has menus, a toolbar with buttons for basic functions, a message area, a text port, and a code editor. It interfaces with the hardware of the Arduino and publishes applications to it.

Now the entire 3D printing process is divided into three steps as shown below

1.6.2 MODELING SOFTWARE:

Used for creating 3D CAD models. Ex: Tinker cad.

1.6.3 SLICING SOFTWARE:

It is the most important for the operation of 3D printer. In general Slicing Software has 6steps.

- Setting up Printer limitations.
- Importing the CAD model in .STL format.
- Arranging the model on the printer bed.
- Setup Commands where every detail about the object is set.
- Slice and preview layer: important step where the Slicing Software Slices(cuts) and CAD model on the basis of its Z-axis and preview how the layers were sliced and respective G-codes are generated.
- Export: Once the Slicing is finished export that sliced G-codes into the Interface.

1.6.4 INTERFACE FOR 3D PRINTER:

You may monitor and manage your printer using Pronterface, a straightforward graphical user interface, from a computer that is connected through USB. With it, you can do a lot of things like directly control stepper motors, regulate the temperature of the bed and nozzle, and transmit G-code commands via a console window or terminal.

1.7 APPLICATIONS OF 3D PRINTER

1.7.1PROTOTYPING:

A prototype is made to check the form, feel, fit and function of the final product. This prototype is revised quite often to ensure that all customer requirements are fulfilled. The manufacturing process for these prototypes can be quite expensive and time-consuming which delays product launches and takes quite a financial bite.

Prototyping is the process of building a physical version of a proposed product. This can be done using various methods, such as machining, 3D printing, or even manual assembly.

Fig 1.7: Printed Jar Prototype

The above figure 1.6 shows printed jar prototype. This is where 3D printing enters, a single machine can manufacture multiple prototypes of different shapes and sizes, and all of this takes place within a few hours. A prototype is the first example of a product to be manufactured, serving as a starting point for carrying out the necessary modifications, as a model to replicate or as a matrix to produce objects.

1.7.2 DENTISTRY:

By the help of these3D printers, we are able be a prototype, or it can be a jaw bone which can be changed as per our needs. Recently, an 83 years old British woman underwent the first-ever custom transplant of a lower jaw, which is made by 3D printer.

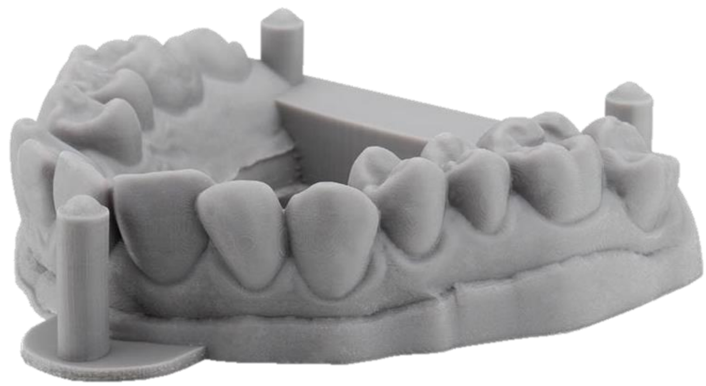


Fig 1.8: Human Jaw prototype

The above fig 1.7 shows human jaw prototype. 3D printing is being used in the medical sector to help save lives by printing organs for the human body such as livers, kidneys and hearts. Further advances and uses are being developed in the healthcare sector providing some of the biggest advances from using the technology of 3D printer.

1.7.3 JEWELLERY:

The pattern which is usually made of wax is a mock-up of the real product, it is made to make a mold that takes its outer shape. once the mold is made around the pattern the pattern is heated and made to melt out of the mold cavity, it is in this cavity that the molten gold is poured into which forms a ring, necklace, pendant etc. The pattern was usual hand made that took long hours and needed a skilled person, also tolerances of the pattern were much larger so as to avoid mistakes and recasting, with the advent of 3D printing these patterns are printed out in cast able materials and much tighter tolerances which end up saving precious gold that would otherwise be wasted.

Fig 1.9: Ring Prototype

1.7.4 EDUCATIONAL

Teaching complex subjects can be really challenging as it sometimes requires a lot of communication skill on the part of a professor to be able to draw amental image to the entire class.

Fig 1.10:3D printed Hand

The above fig 1.9 shows 3D printed hand. A 3D printed model makes visualization a lot easier and helps breakdown harder concepts without stressing yourimagination.3D printing technology can streamline the process of fabricating a prosthetic limb, speeding up the time the prosthesis gets to a patient. As a result, patients dealing with limb loss can more quickly regain their mobility, and ultimately reach a higher quality of life.

1.7.5 APPAREL

Fashion designers are experimenting with 3D-printed bikinis, shoes, and dresses as 3D printing has extended into the realm of clothes. When it comes to commercial production, Nike uses 3D printing to prototype and manufacture the same football shoe for American football players, whereas New Balance 3D manufactures custom fit shoes for all athletes.

So, we printing the required objects for different applications using this 3D printer. Now a days 3d printer is so popular because they take so much of advantages in different applications for easy to made objects with required shapes and dimensions as we mention.

Fig 1.11:3D Printed Shoe and Spectacle

CHAPTER 2

3D PRINTER

2.1 INTRODUCTION

S. SCOTT CRUMP created the Fused Deposit Modeling (FDM) system in the late 1980s, and Stratasys designed it in 1990. After the technology's patent ran out, a sizable open-source development community developed viable alternatives of this sort of 3D-Printer.

The FDM technique is incredibly environmentally stable, easy to use, and clean. It is possible to publish complex shapes and intricate corridors. FDM is at the actual beginning of the request because people use it so heavily. Compared to other 3D printing technologies, FDM is a more economical 3D printing method. One of the techniques used in 3D printing is fused deposit modeling (FDM). This technique, which falls under the umbrella of cumulative production engineering, has gained popularity among experimenters and is being diligently researched and developed. Compared to conventional production, cumulative manufacturing methods perform in fewer waste and many other benefits, producing colourful complex shapes and structures while properly controlling accessories. As a result, it is becoming less and less popular. The FDM fashion technically uses the same component as injection.

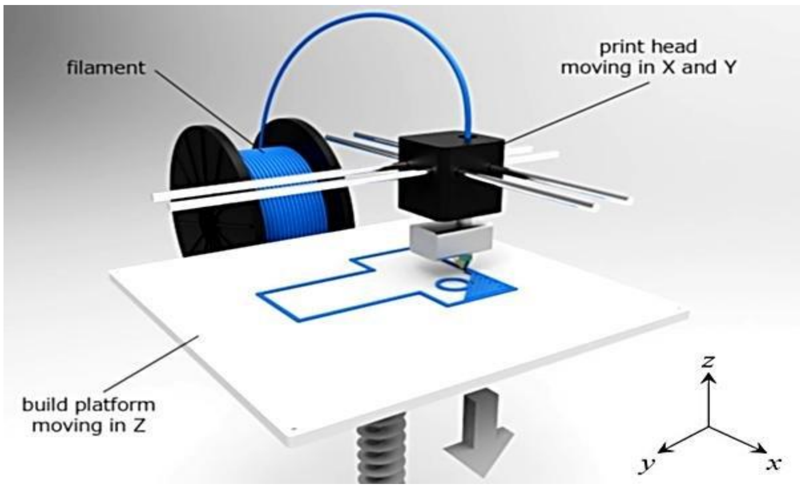


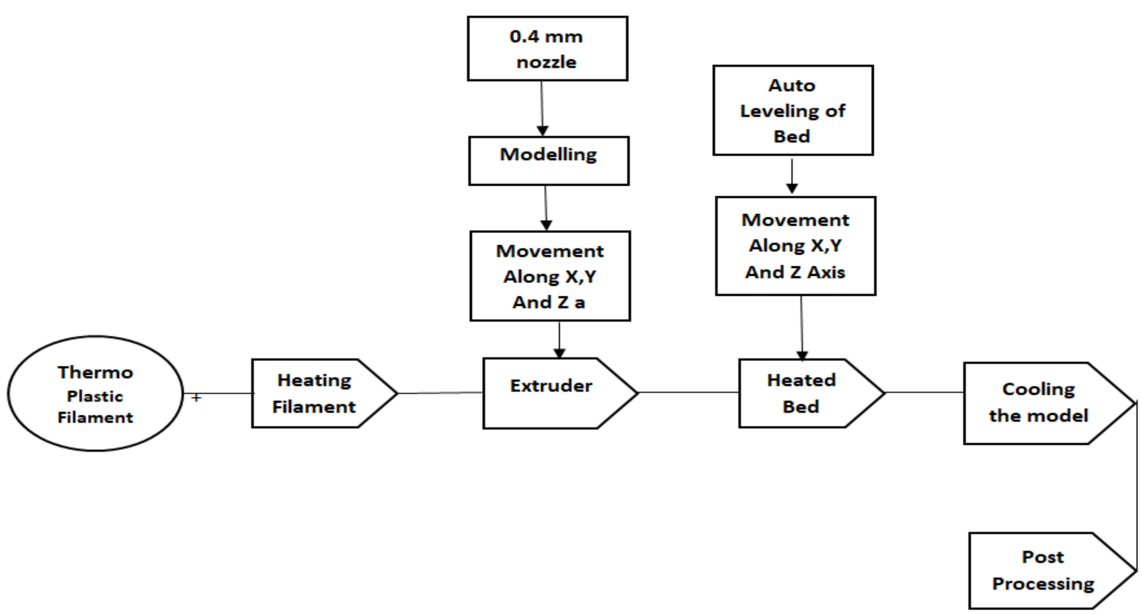
Fig 2.1: Fused Deposition Model

Modeling of fused deposits is shown in fig. 2.1 below. Melting the unprocessed component and then influencing it into new shapes is the basic idea behind the FDM manufacturing method. The substance is a roll of hair that gets pulled by a driving wheel and heated to a semi-liquid state in a temperature-controlled snoot head.

To create subcaste-by-subcaste structural rudiments, the snout carefully extrudes and guides accessories in an ultrathin manner. This is done by following the outlines of the subcaste that the programme—typically CAD—specified and that has been integrated into the FDM work system. Because layers of the thin hair are used to construct the structures in FDM. The most popular polymers used in this way are polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS). The thermoelectricity of the hair is crucial to this process because it affects its ability to produce cling between layers during printing and to solidify at room temperature after printing.

In human's optic FDM 3D printer takes a plastic hair and squeezes it through a hot dig and also depositing it in layers on the prize bed. These layers we fused together, erecting throughout the print and ultimately, they will form the finished part 3D printer that runs FDM (Fused Deposit Modeling) technology figure corridor subcaste- by- subcaste from the bottom up by heating and banishing thermoplastic hair with multiple colours.

2.2 FLOW CHART



2.2.1 EXTRUDER

The capability to employ a binary or multi extruder is the first modification to the extruder that many current 3D printers offer. Color and multi-material printing procedures can be preformulated by printers with a single extruder, but many extruders speed up and simplify these processes. By using 3D printing and multi-material properties, people have produced wood, ABS like PLA, nylon, flexible PLA, marble, carbon fiber, and other specialist fibers. The material for 3D printing has not only undertaken significant material exploration.

Furthermore, it will be exciting to see distinctive combinations of components used to create items, as multi-material performing offers a design that is optimal. Further flexible supplies can be used to address strain concerns, while further rigid material can be used to address stress issues. Currently, this is possible if every element is created in its own place, but in the next five to ten years, design tools will enable things to be created for a variety of accessories. While there are a lot of fibre options for FDM printers, there aren't many resin options for SLA printing, thus it will be interesting to watch what resins are developed in the coming years.

2.2.2 COOLING EXTRUDER

Increasing the rate at which the hair emerges from the extruder is one technique to reduce the total print time, but the plastic subcaste that will be put must first completely solidify. Adding a dedicated cooling head that would swiftly follow the hot print head to the hot plastic to solidify might be one solution to this issue.

2.2.3 MOVEMENT

The extruder can be changed in plenty of ways according to the 3D printer. The most popular ways to move the extruder in the X, Y, and Z ways—or in the Cartesian match system—are to move it in the X and Y directions while the platform moves in the Z direction, or to move it in all three directions while the bed is stationary. It can be possible to reduce the travel time by having the extruder and bed move in the same X, Y, and Z planes.

2.2.4 SPECIAL NOZZLES

The extruder might be suitable to change the print head periphery at different times during the print analogous to how cutlet frosting has special ornamental tips.

2.2.5 MODELING

When 3D printers are outfitted with a video camera or a stereoscopic viewing device, the printing process can be remotely observed by mortal operators or algorithmically controlled in real time. In order to avoid wasting time and resources, the print job could be cancelled and renewed. A complex part may need to be revised and finished depending on the other postprocessing options available, or in a printer that supports both cumulative and subtractive production. As we've already mentioned, for cutting down on time required for travel, the bed and extruder could both move in the X, Y, and Z directions. In terms of delta 3-D printers, they could potentially able to speed up print head travel time by rotating their indirect base.

2.2.6 HOT BED

Many printers currently have the ability to heat the bed to enhance print quality and prevent warping while the print job is taking place

.2.2.7 AUTO-LEVELING

One of the most unpleasant aspects of 3D printing, in my experience using a variety of 3D printers, is levelling the bed. Even a small height variation can prevent print jobs from finishing.

2.2.8 POST PROCESSING

The most popular post-processing techniques now involve deburring, sanding, priming, airbrushing, and using acetone. One of the most common misconceptions about 3D printing is that it can produce products as nicely as those that are purchased in stores. A truly high-resolution print with no post-processing might be a good trade-off for a print of lower quality with some post-processing added to make it smoother.

The two major factors to be considered in these processes is speed vs structure integrity. However, if it's a functional part also the first option is a safer choice, If the thing is to achieve a faster time while not fussing so much about the strength of the object also the low resolution with the post processing seems to be better choice; still.

2.3 WORKING PRINCIPLE

The "3D printer" applies successive layers of material to create objects throughout the 3D printing process. A 3D printer essentially extrudes molten plastic through a precise, computer-controlled tiny snout that it moves around. After waiting for the first subcaste to dry, the next subcaste is printed on top. 3D-printed objects are produced via a cumulative process in which the printer deposits successive layers of material until the requested item is published.

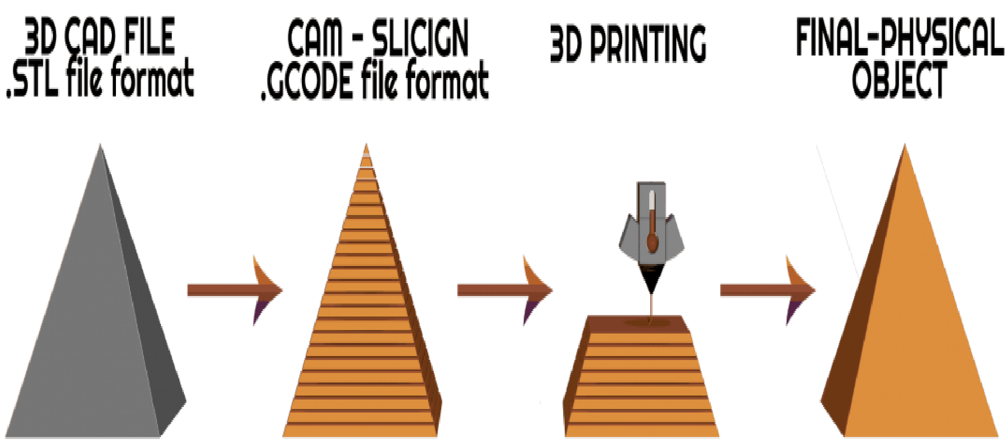


Fig 2.2: working principle of 3d printer

1. Toast the snoot until it reaches the asked temperature. The hair will be fed to the extrusion head and also, it'll be melts in the snoot.

2. The extrusion head can move in the X, Y and Z directions. The extrusion head extrudes melted material in veritably thin beaches. The material is deposited subcaste- by- subcaste on the platform, and also will be cool and solid.

3. When one subcaste is finished, the figure platform will move down (on some machines, the extrusion head moves up) and a new subcaste will be deposited. This process repeats until the part is completed.

All 3D printing ways are grounded on the same principle. A 3D printer takes a digital model (as input) and turns it into a physical three- dimensional object by adding subcaste by subcaste. It's way different than traditional manufacturing processes similar as injection moulding and CNC machining that uses colourful slice tools to construct the asked structure from a solid block. 3D Printing, still, requires no slice tools objects are manufactured directly onto the erected platform. The process starts with a 3D model (a design of the object). The software (specific to the printer) slices the 3D model into thin, two- dimensional layers. It also converts them into a set of instructions in machine language for the printer to execute.

Depending on the type of printer and size of the object, a print takes several hours to complete. The published object frequently requires post-processing (like grinding, lacquer, makeup, or other types of conventional finishing traces) to achieve the optimal face finish, which takes fresh time and homemade trouble. Different types of 3D printers employ different technologies that reuse different accoutrements in different ways. maybe the most introductory limitation of 3D Printing, in terms of accoutrements and operations, is that there's no bone - size- fits- all result.

CHAPTER 3

HARDWARE COMPONENTS

CHAPTER 3
HARDWARE COMPONENTS

3.1 INTRODUCTION

In this section of hardware components, we have discussed various hardware components used to build the 3D printer with uses and specifications.

3.1.1 FRAME

Frame is made of Aluminium Extrusions. We generally use Aluminium Extrusions because they are cost effective and are Resistant to Corrosion. Here we are using a 20×40 V Slot Aluminium Extrusion Profile. An essential component of a 3D printer is the frame. Even if the design appears straightforward, it may be rather intricate. This is as a result of the wide range of design options.

Fig 3.1: Aluminium Extrusions

The figure 3.1 shows the aluminium extrusion which is used to build the frame of the 3D printer. It supports each and every mechanical and electrical component involved in printing operations. It establishes the 3D printer's build volume. It gives the printer both its sturdy aspect and its attractive appearance. It supports each and every mechanical and electrical component involved in printing operations. It establishes the 3D printer's build volume.

Features:

1. Cost-effectiveness
2. Resistance to corrosion
3. High strength-to-weight ratio
4. Variety of size and shapes
5. Thermal adaptability
6. Electrical and thermal conductivity

3.1.2 ARDUINO MEGA2560

The Arduino MEGA 2560 is a microcontroller board grounded on the ATmega2560, has 54 digital input/ affair legs (of which 15 can be used as PWM labours), 16 analogy inputs DARTS (tackle periodical anchorages), a 16 MHz demitasse oscillator, a USB connection, a power jack, an ICSP title, and a reset button. Fig3.2 Shows Arduino MEGA 2560.

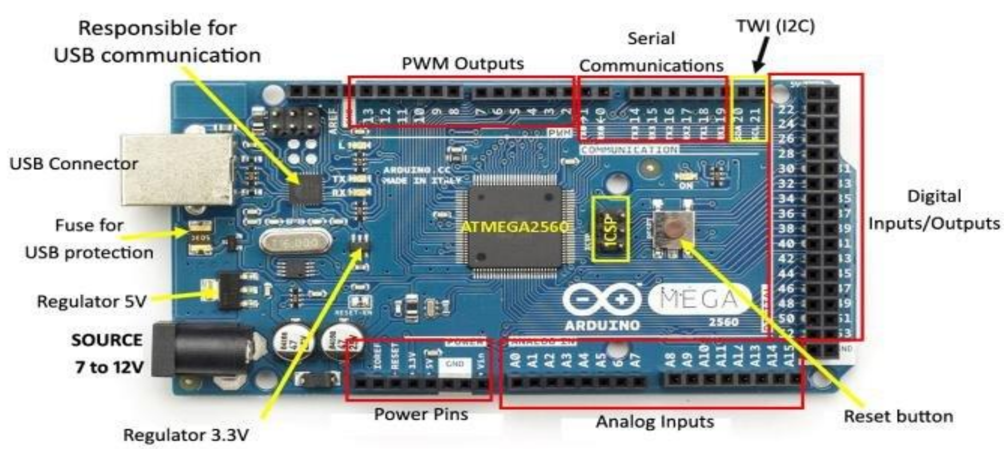


Fig 3.2: Arduino MEGA 2650.

The figure3.2 shows the image of Arduino MEGA 2650 which is used as the interface between the hardware and software used in 3D printer. The power source for the Arduino Mega is automatically chosen between an external power supply and a USB connection. A computer, another Arduino, or other microcontrollers can all be communicated with using the Arduino Mega 2560's many communication features.

Features:

1. Using Mega 16u2 in place of 8u2 for serial converter.
2. 1.0 Pinout.
3. 3. More robust RESET circuit.
4. operating voltage at 5 volts.
5. A recommended input voltage range of 7V - 12V.
6. Input voltage range of 6-20V.
7. DC current per I/O pin: 7.
8. The bootloader uses 8KB of the flash memory's 256 KB capacity.
9. 8 KB SRAM.
10. 4 KB EEPROM.

3.1.3 RAMPS 1.4

Shields, printed circuit extension boards that connect to the typically included Arduino pin headers, are used by Arduino and its similar boards. A low-cost, well-supported hardware controller for your 3D printer is RAMPS 1. 4.

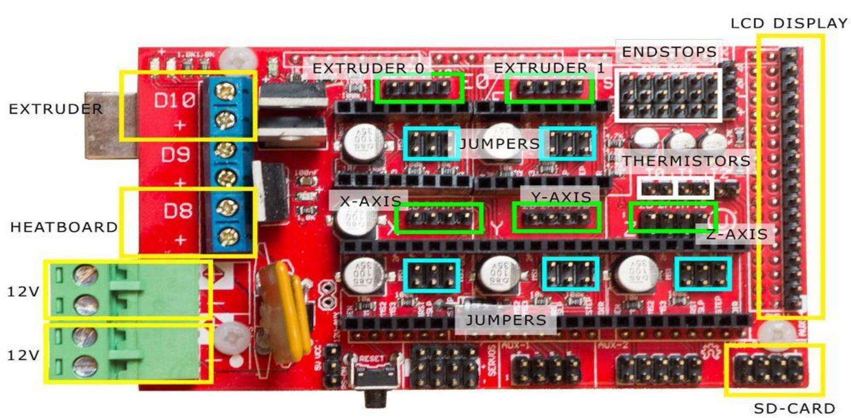


Fig 3.3: Ramps1.4

The figure 3.3 shows the image of Ramps 1.4 motherboard which is mounted on the Arduino Mega 2650 and acts as the interface. The motor controls, GPS, Ethernet, LCD, or bread boarding can be guided by shields. (prototyping). Ramps have emerged as the most well-known and often used 3D printer hardware since 2012, making them the ideal shield for Arduino Mega 2560. It shares hardware concepts (thermistor, radiator MOSFETs, stepper driver, etc.) with many different devices. Also keep in mind that the RAMPS board, Arduino Mega 2560, and Pololu drivers are comparatively less expensive than other shields and controllers.

Features:

1. Designed with a reliable Arduino Mega 2560 base.
2. Modular: Less Difficult to Troubleshoot 1/32 micro stamping and up (using DRVSS2S based driver boards).
3. Three thermistor circuits and three Mosfets for the heater/fan outputs.
4. Additional safety and component protection with fuses at 5A.
5. A second 11A fuse can regulate the heat bed.
6. The pin header sockets on Pololu boards make it simple to swap or remove them for usage in future designs.
7. There are still 12 C and SPI pans available for expansion.
8. For adaptability, all MOSFETs are connected to PWM pins.
9. A USB type B outlet.
10. LEDs show the heater output is active.

3.1.4 STEPPER MOTORS

A stepper motor is also known as step motor or stepping motor. This motor divides a full rotation into equal steps. It is a brushless DC electric motor.

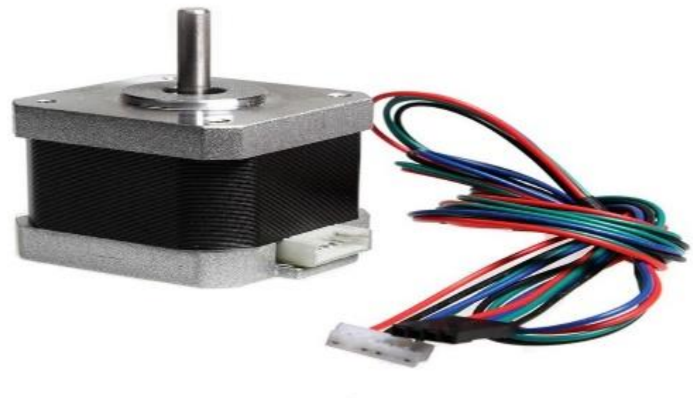


Fig 3.4: Stepper Motor

The below figure3.4 shows a brushless dc stepper motor which is responsible for direct stir along different axes. As long as the motor is meetly gauged for the operation in terms of necklace and speed, the position of the motor can be instructed to move and hold at one of these way without any position detector for feedback (an open- circle regulator).

Brushless direct current electric motors, frequently known as electronically commutated motors, are available. (ECMs, EC motors). Primary effectiveness is a critical trait of BLDC motors. Because the rotor is the lone attraction deliverer and doesn't bear any power. That is, there are no connections, no commutator, and no skirmishes. rather, the motor makes use of control electronics. BLDC motors use regulators, rotary encoders, or a Hall detector to descry where the rotor is at any given time.

3.1.5 A4988 DRIVERS

The A4988 is a micro stepping motorist with a erected- in translator for driving bipolar stepper motors. This means that we can control the stepper motor with just two legs on our regulator, one for gyration direction and the other for way. The A4988 Stepper Motor motorist is a comprehensive micro-stepping motor motorist with a erected- in motor that's simple to use. It can deliver up to roughly and operates from 8 V to 35 V. A single phase with no heat Gomorrah or forced air inflow (it is rated for 2 A per coil with sufficient fresh cooling).

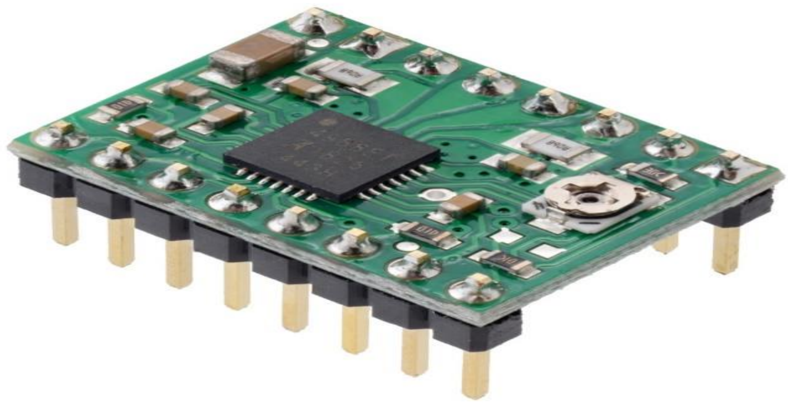


Fig 3.5: A4988 Drivers

The Figure3.5 shows a 4988-stepper motor, which is used to power the axis and extruder stepper motors in a 3D printer. The A4988 Stepper Motor motorist contains a fixed off- time current controller that can operate in slow or mixed decay mode. The motor is critical to the simple perpetration of the A4988. When a complicated microprocessor is unapproachable or overloaded, the operation of the A4988 interface is ideal. The A4988's mincing control automatically picks the current decay mode during the stepping operation. (Slow or mixed). The blend decay current control approach reduces audible motor noise while adding step delicacy and lowering power consumption.

3.1.6 EXTRUDER

The hair is extruded and deposited on the print bed by the extruder, also known as the print head. The extruder is divided into two types. The cold end is appertained to as the cold end, whereas the hot end is appertained to as the hot end. The cold end's part is to lock the hair while gradationally pushing it down to the hot end. The hot end, which has a snoot attached to it, maintains a temperature that's advanced than the melting point of the hair. The hair is melted by the hot end and also put on the print bed. The extruder is made up of several pieces.

Fig: 3.6 Extruder

The above figure 3.6 shows the extruder which extrudes the PLA material into the hot end using stepper motors.

Principle of Extruder

The model has been turned into a series of layers and a G-code file with instructions once the file has been converted to .STL Format by software known as a "SLICER." This G-code file will be produced via 3D software for clients. (Which loads the G-code and uses it to instruct the 3D printer during printing). The 3D printer used G-code instructions to lay down each successive layer that eventually created the model from a series of nozzle cross sections. These layers, which represent the virtual cross sections of the CAD model, are joined or automatically melted to create the final shape. This procedure could take minutes or hours, depending on what the printer is generating.

The extruder drive gear, also known as the **filament drive gear**, is responsible for directing the filament into the hot end.

The heat sink guarantees that the substance stays solid up until it reaches the nozzle by working with the heat sink fan.

The part responsible for heating the filament is **the heater cartridge**.

Thermocouple: The extruder uses a temperature sensor to maintain a constant temperature. The hot end goes in this place.

The cooling fan: After the molten filament has been deposited, it needs to cool down in order to be ready for the next layer to be applied. This is what the cooling fan is supposed to do.

3.1.7 HOT END

The active part of a 3D printer that melts its filament is called the "Hot End." It enables the liquid plastic to flow out of the tiny nozzle and form a small, expensive piece made of material that will stick to the surface it is deposited on. The development of glass or aluminium hot ends is another example of research. The hot end is a boiling zone or container with two holes.

Fig 3.7: Hot-End

Figure 3.8 shows the hot end and its different parts, used to heat, melt and extrude the PLA. The parts of an FDM 3D printer that heat, melt, and eject material layer by layer via a nozzle. The entire construction of the hot end contributes to maintaining a steady and accurate temperature while also offering optimal thermal dissipation.

3.1.8 END STOPS

On every moving axis of a 3D printer, end brakes or limit switches are used. End stops provide two vital tasks in a 3D printer: they serve as a reference system for the axis system and they provide safety. Another critical function of an end stop is to safeguard the hardware from harm. The end stop will cut any movement that attempts to surpass the physical boundaries of the machine. Cartesian axes are used to reference movements that require a datum. Each axis needs to be backed up until it reaches the datum position at the beginning of each build. The controls also stop the gadget from straying beyond of its designated area and harming itself.

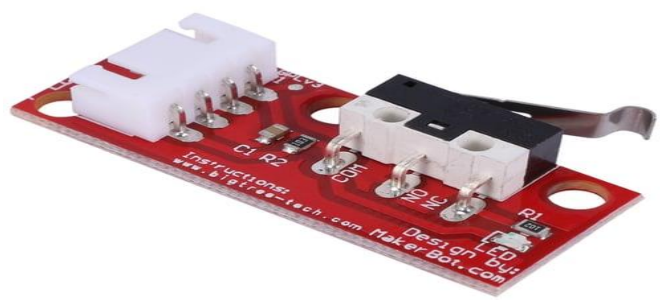


Fig 3.8: End Stops

The Figure 3.9 shows the image of an end stop which is used to tell the printer when the axes end point is reached. Hardware end stops are electrically attached to the printer control board's end stop ports and provide a signal when the end stop condition is fulfilled. The basic method of operation is the same regardless of the type. A normally 5 Volt (HIGH) signal is reduced to 0 Volt (LOW): Switch that is normally closed (NC).

3.1.9 SWITCH MODE POWER SUPPLY

A power force is an electrical device that provides electricity to a cargo. A power force's primary function is to convert electric current from a source to the proper voltage, current, and frequency to power the cargo. The motor with a single hot end can consume up to 5A, while the heated bed typically consumes 5A- 15A. Look for an aggregate of 18- 30A, which is around 220- 360W at 12V, for a conventional configuration with the heated bed. Some setups may be suitable to use lower power ones.

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Fig 3.9: power supply

The Figure 3.10 shows the image of power supply which is used to give supply to the 3d printer. To convert mains AC current to the DC voltages needed by the steppers and the electronics circuit, switch mode power supply has very complicated circuits. The key benefit is that a switch mode power supply converts energy with great efficiency.

3.1.10 FILAMENT

PLA, or polylactic acid, is one of the most extensively used materials in desktop 3D printing.

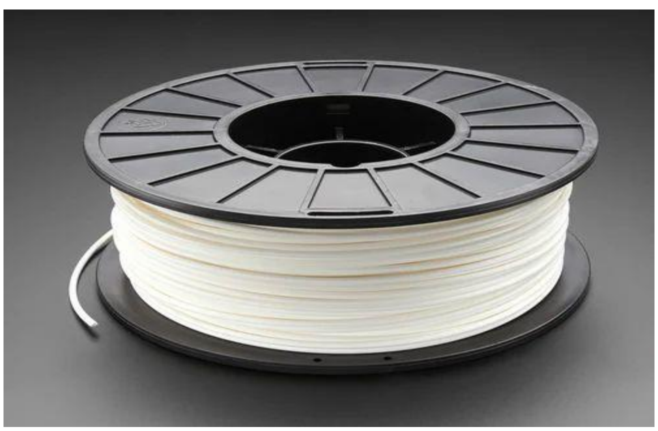

Fig 3.10: Filament (Poly Lactic Acid Filament)

Figure 3.10 indicates that polylactic acid (PLA) filament is recyclable. A wide range of extrusion-based 3D printers employ it by default as it can be created at low temperatures without a requirement for a heated bed. Figure 3.10 displays an illustration of the PLA Filament. The filament is mechanically powerful, has a high heat capacity, and is biodegradable under appropriate conditions.

3.1.11 ECCENTRIC NUTS

You may alter the tension of your V-wheels using the eccentric nuts. The usual rule is to provide enough stress to the wheel against the rail to initiate contact, but not so much that they crush. The video below will lead you through the process of finding and correcting your eccentric nuts. The eccentric nuts are used to change the wheel tension.

Fig 3.11: Eccentric Nut

The figure 3.12 shows the image of an eccentric nut which is used in this 3D printer to hold the wheels tight towards the frame that is responsible for the good movement of parts. The eccentric hole is not in the centre; instead, it is moved to one side to modify the eccentricity and allow the wheels to fit properly.

3.1.12 PULLEY AND TIMING BELT

A 3D printer timing belt helps to accurately position and move the printer's extruder head. It consists of a continuous loop of flexible material, typically made from rubber or polyurethane, that is fitted with regularly spaced teeth on one edge. The Pulley and Timing Belt combination is an essential component of the 3-D printer. GT2 Timing Be Pulley is extensively used in 3D printers for precision motion to create even the most elaborate patterns. This pulley has 20 teeth and an inner bore of 5mm. Two set screws can be used to securely attach a to any mm diameter shaft. Because they are made entirely of aluminium, they are both light and strong.

Fig 3.12:GT2 Pulley and Timing Belt

The figure 3.13 shows the GT2 Pulley and Timing Belt which are connected with stepper motors for the movement in 3D Printer. Timing Belt Pulley GT2 The Aluminium GT2 Timing Pulley 20 Tooth 5mm Bore for 6mm Bet is specially designed for NEMA 17 stepper motors used in 3d Printers. GT2 belts and pulleys give high precision at an affordable price.

3.1.13 THREADED RODS

These are used in controlling the Z-Axis of the 3d printer. With the help of Threaded Rods connected to the stepper motor and the nut connected to the Z-axis extrusion we can control Z-Axis movement in 3d printer. Fig 3.14 shows the Threaded rod mounted with nut. Threaded rods have numerous applications since they function as a pin to fasten or link two materials together.

Fig: 3.13: Threaded rod with nut

The figure 3.14 shows the image of a threaded rod which is responsible for the movement in Z-axis of the 3D Printer. Threaded rods have numerous applications since they function as a pin to fasten or link two materials together. They are also used to support constructions and can be inserted into various materials such as concrete, wood, or metal to either temporarily establish a stable platform during construction or permanently install.

Features:

1. 4 Begin Lead Screw
2. Primarily used for stepping motor guide rail driving.
3. T-shape design composed of high-quality stain-resistant steel.
4. It is simple to install and use.
5. Excellent producing and usability.

3.1.14 SLIDING NUTS

Here we are using T nuts of size M5. This flat M5 T nut is a kind of simple economy T slot nut, pre-assembly slide in nut. This simple sliding nut can only be inserted into the t slot from the end of aluminium profile.

Fig 3.14: Sliding Nuts

The figure 3.12 shows the image of sliding nuts which are used in our 3D printer to fix the screws to aluminium extrusions to build the frame. It is usually used with hexagon socket bots for fastening connections on aluminium profiles (Aluminium Extrusions).

CHAPTER 4

FIRMWARE &SOFTWARE

CHAPTER4

FIRMWARE & SOFTWARE

4.1 INTRODUCTION

Firmware is the permanent software that is stored in read-only memory (ROM) in the form of nonvolatile memory in a computer programme and allows the device to be controlled in hardware. It can give a standard operating environment to more complex software that allows hardware to run on the operating system (os), to complete all monitoring and other manipulation functions. Firmware is used for a variety of reasons, including consumer electronics, computer peripherals, and so on. Electronic equipment in 3D printers are controlled by CPUs such as Intel processors and Arduino microcontrollers. These processors are used in computers to run basic software. The firmware element of the overall software is responsible for the 3D printer's operation.

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4.2 FIRMWAREUSED

MARLIN

4.2.1 MARLIN

Marlin is an open-source firmware that allows any member of the RepRap family to duplicate in rapid-fire prototyping and is generally appertained to as a 3D printer. Grbl and Sprinter acquired it, and it came open source for all 3D printers. Several brands provide a marlin variation, including Printouts, Prusa, and ultimate, which are well-known 3D printers. The Arduino Mega2560 with RAMPS1.4 is the open-source reference platform for marlin, which runs on 8-bit microcontrollers. Any single-processor device, such slic3r, ramps, and a number of other Arduino2570-based 3D printers, can use marlin firmware. It uses look-ahead line planning and can publish flyers from USB or SD cards. Marlin is distributed under the terms of the GNU GPL version 3 or later. It is based on sprinter firmware, which has GPL v2 or more recent license. A number printing companies, including well-known 3D printer brands Printrbot, Prusa, and ultimate, provide a marlin variant. The open-source reference platform for marlin, which utilizes 8-bit microcontrollers, is the Arduino Mega2560 with RAMPS1.4. The marlin firmware can be used with any single-processor device, including slic3r, ramps, and other other Arduino2570-based 3D printers. It makes advantage of look-ahead line planning and has a USB or SD card scanner for printing flyers. Marlin is made accessible by users in accordance with the GNU GPL version 3 or later. The sprinter firmware on which it is built has a GPL v2 or later copyright.

To publish a model using Marlin, it must first be restated to G- law with a programme known as a" slicer." Because each printer is unique, but we will not be suitable to get G-law lines, we'll have to slice them ourselves. As Marlin gets commands, it places them in a moving line to be executed in the sequence they were entered. The stepper will intrude the line processes and begin turning direct movements into impeccably timed electrical beats to the stepper motors. Indeed, at slow pets, Marlin must produce thousands of steppers beats every second. Because the CPU speed limits how quickly the machine can be moved, we are constantly searching for innovative ways to optimise the stepper intruder. The main circle manages command processing, display updates, and regulator events, while the second intrude, which operates at a much slower rate, maintains heaters and detectors. For security purposes, the Marlin firmware will in fact restart if the CPU becomes too busy to read the detector.

4.3 STEPSTOINSTALLFIRMWARE

Step 1: Download the Arduino development tool from the Arduino homepage and install it in accordance with your operating system's instructions as the first step in firmware. The environments of Linux, Windows, and Unix can all be used to compile Marlin.

Step 2: Using the provided website, grab the marlin firmware source code, then choose the correct version depending on the codebases.

Step 3: For a description of the settings file format and a rundown of the majority of options in these files to indicate which equipment is in use, see Configuring Marlin.

Step 4: Verify and publish the firmware using the Arduino IDE.

Step 5: Use a USB cable to connect the joystick to the computer.

Install the firmware software on your controller's CPU in step 6 to complete.

Fig 4.1ProgramofArduino

4.4 SOFTWARE

A part of a computer system known as computer software might be either data or instruction files. Software is a generic term for all data and programmes processed by computer systems. Information can only be assigned from one location to another utilizing the software in the 3D printer. Without software, we are unable to slice and print any simulated items. The 3D printer's movement and parameter specifications are instantaneously calibrated and loaded on the controller thanks to the C++ program, which is an essential element of the embedded C and C++ advancement platform. Any 3D model can be created with any 3D software on the programme's platform.

4.5 SOFTWARES FOR DESIGNING AND PRINTING

In this, we have discussed about the software required for the 3D printer. In our 3D printer we use four types of software’s. They are modeling software called TINKER CAD for 3D modeling, SLIC3rfor slicing to obtain G-codes, a graphical user interface like Pronterface and Arduino IDE for interfacing Arduino mega 2650.

4.5.1 TINKERCADFORMODELING

Tinker cad is an online set of Autodesk software tools that allows newcomers to construct 3D models. Grounded on formative solid figure (CSG), this CAD programme allows druggies to produce complicated models by incorporating simpler factors. Tinker cad constructs models using a reduced formative solid figure system. A design is composed of primitive shapes that can be" solid" or" hole." By combining solids and holes, new shapes can be constructed, which can also be assigned the solid or hole property. Away from the usual primitive shape library, a stoner can develop custom-made shape creators using the erected- in JavaScript editor. The software has an easy- to- use block- structure idea that allows you to produce objects from a set of introductory forms. Tinker cad is packed of tutorials and tips to help any aspiring developer get the designs they want. It also makes it simple to partake and export lines. druggies can choose shapes that suit them stylish and manipulate them as they wish thanks to a library of literally millions of lines. It also features direct connectivity with third- party printing services, allowing you to publish and have it delivered to your door with the click of a button. Even though it can be a bit too simple to the point of limitation, it serves as a greatwaytolearnabout3Dmodeling.

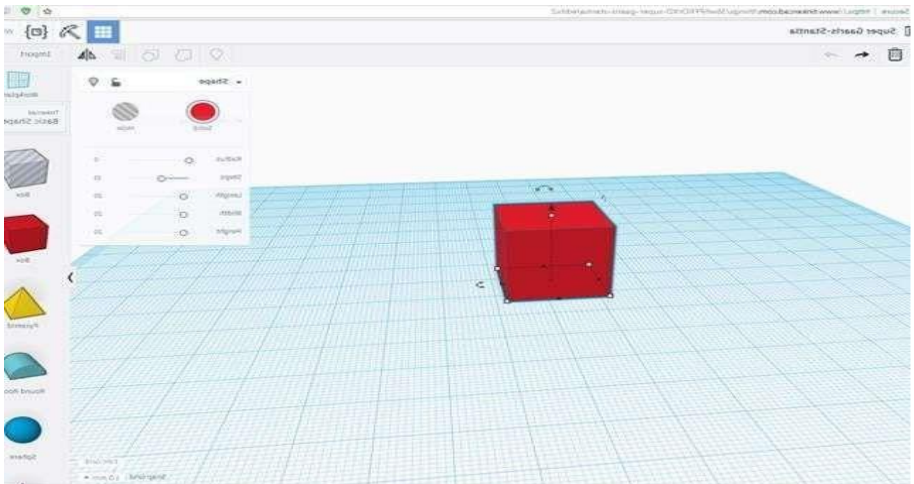

FIG 4.2TINKERCAD

4.5.2 SLIC3rTOOBTAING-CODES

Slic3r is a 3D slicing machine for 3D printers that's free software. G- law is generated from 3D CAD lines. (STL or OBJ). Once completed, an applicable G- law train for the product of the 3D modelled part or object is delivered to the 3D printer for physical object fabrication. Slic3r was supported by nearly half of the 3D printers tested by Make Magazine in 2013.

A slicer is tool path generating software that's used in the maturity of 3D printing procedures to convert a 3D object model to precise printer instructions. In particular, in fused hair fabrication and other similar processes, the conversion from an STL model to printer commands in g- law format. The slicer splits the object into flat layers, which are also described as direct movements of the 3D printer extruder, fixing ray, or original. All of these movements, along with other printer directives like controlling the extruder temperature or bed temperature, are ultimately stored in the g- law train.

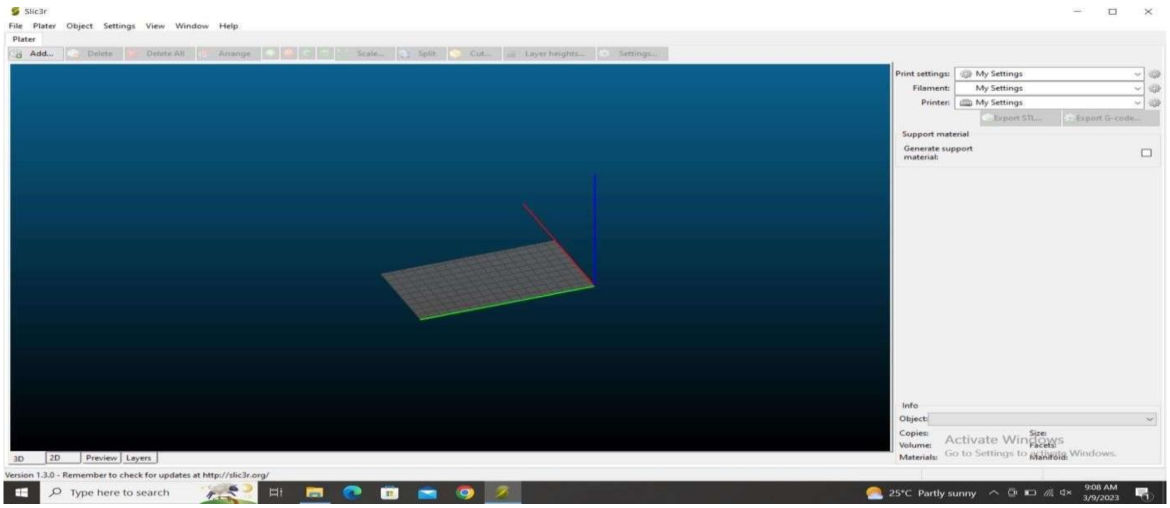

Fig4.3slic3r

4.5.3 G-CODE INTERPRETER & SENDER

It's a popular language for controlling CNC machines. The Arduino, which is a train style that can be prepared in medicines from design lines, much like CAD lines, is used in 3D printers. Each line of the railway is examined by the G- law practitioner, who then instructs the motor to drive the symmetrical gadget by sending factual signals. The firmware of a tackle practitioner will be integrated with a printer electronic platform. The G-canons train is sent to the printer, establishing connection between the workstation and the 3D printer. In order to connect an USB connection via machines to the three-dimensional printer with the aid of a microcontroller that recognizes the G- law language and may communicate with projects on the desktop similar to pronterface, we must induce the G- law through any slicing software along with load the railroad on a flash drive if it can support it.

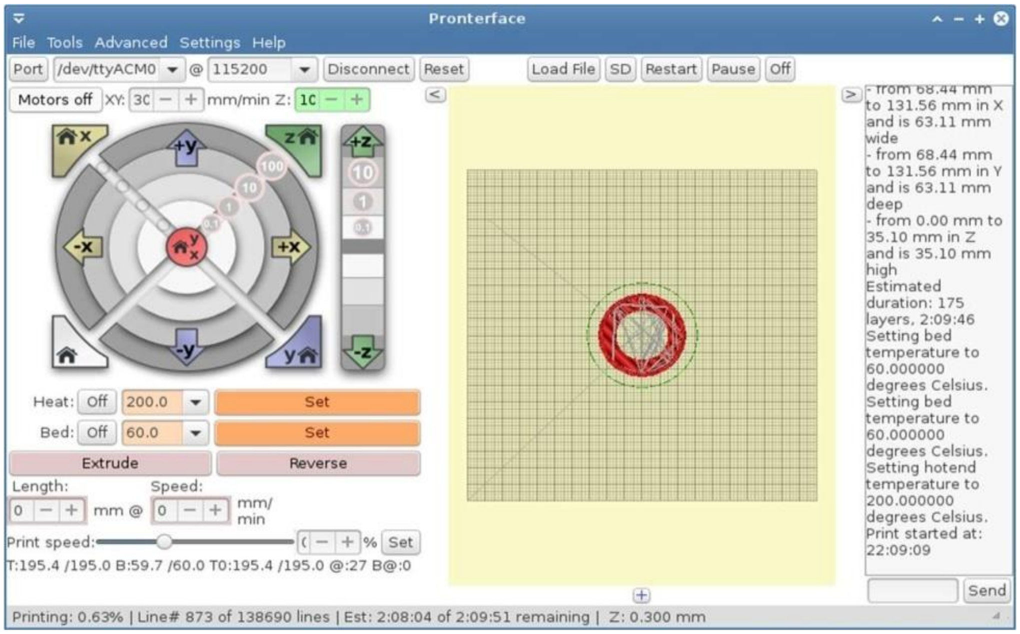

Fig4.4PronterFace

CHAPTER 5

CIRCUIT AND CALIBRATIONS

CHAPTER 5

CIRCUIT AND CALIBRATIONS

5.1 INTRODUCTION

3D Printer Controller Board RAMPS1.4 Arduino Mega Shield is an each- by- one design to fit the necessary factors for a 3D printer into one draw in guard for an Arduino MEGA. The draw in guard design includes draw in stepper motorists and extruder control electronic sockets for easy service, part relief, upgrade capability and expansion also, a number of Arduino expansion boards can be added to the system as long as the main RAMPS board is kept to the top of the mound. Ramps boards are the heart of 3D printers on the request and a nice clean compact way to integrate all the systems into a compact quadrangle mountable format. RAMPS can only work when connected to its motherboard Mega 2560 and Burro/ DRIVE25 retaining to its stability in operation and great comity with the most 3D printers. The combination of Ramps1.4 MEGA2560 A4988 is getting a mainstream of 3D printer control board. The design generalities of the 3D Printer deals with the circuit illustration of Ramps1.4 mama board in which the connection of Ramps1.4 with end stops, extruder stepper motors.

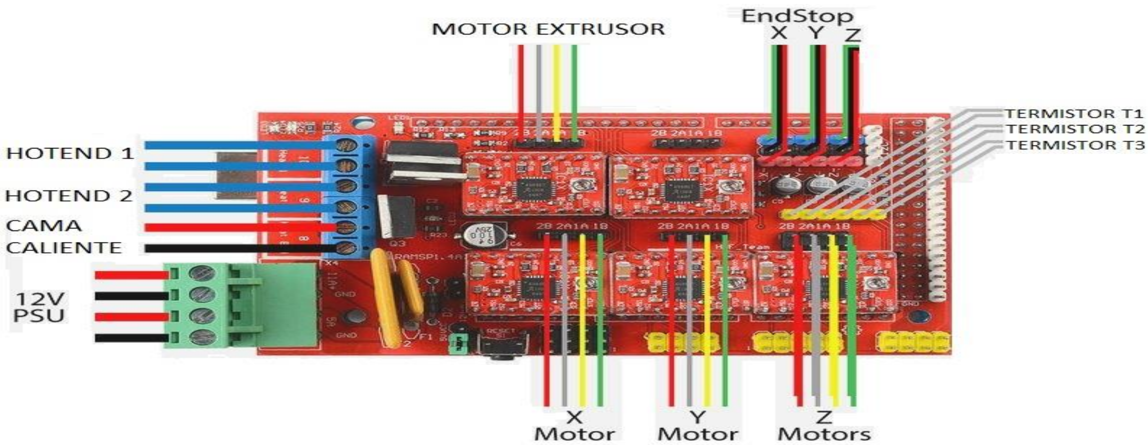

Fig 5.1: Circuit diagram of Ramps 1.4

In this section we provide information regarding the linear motion along x,y and z axes, stepper motor rated current and also different calibrations which have to be done to increase the efficiency of the machine to get good quality print. Figure 5.1 shows the Ramps 1.4 board and its connections for the x, y, z, E_0 and E_1 stepper motors. The Z connector is actually doubled, so we can plug 2 separate stepper motors into this one stepper driver. EO and El are for extruder stepper motor connections and we have one extruder stepper motor and it is connected to El pin. From left to right of Ramps 1.4, each column corresponds to x-min, x-max, y-min, y-man, z-min, z-max. The three end stops for the three axes x, y and z are connected to these pins on Ramps 1.4.

5.2 LINEAR MOTION ALONG DIFFERENT AXIS

The direct stir system of a 3D printer is one of the most significant of the colorful mechanisms that comprise a 3D printer. A 3D printer's direct stir medium is used to move the hot end and/ or erected platform along the x, y, and z axes. The direct stir systems of 3D printers are made up of two major factors the motor, which converts electrical energy into rotational stir, and some form of medium to convert the rotating stir of the motor into direct stir. For direct stir, utmost 3D printers employ a blend of lead screws and timing belts.

5.2.1 LEAD SCREWS

Lead screw systems are a straightforward method of converting the rotational action of stepper motors to linear motion of the 3D printer build platform and/or extruder. A lead screw linear motion system is made consisting of a threaded rod that is rotated by a stepper motor and a mating nut that moves up and down with the threaded rod.

Fig 5.2 T8 LEAD SCREW

The above figure Fig 5.2 shows lead screw for linear motion ofthe system to control motion along the z-axis. During the build process, a lead screw is typically utilised to lift the build platform or extruder up one layer at a time.

5.2.2 TIMING BELTS

The great majority of 3D printers use belt drives on the x and y axes. A belt drive is made up of a timing belt with teeth, a toothed pulley connected to the motor, and a carriage connected to the belt. When the motor turns, the pulley turns. The teeth on the pulley interact with the teeth on the timing belt, causing the timing belt to be pulled in the desired direction as the motor rotates the pulley. A carriage is usually attached to the belt and moves back and forth with it.

Belt drive systems offer relatively little backlash assuming that the system has been properly set up and optimized, which we will describe shortly. This makes them suitable for usage on the x- and y-axes, which regularly change direction. Because of the reduced backlash, the linear motion will maintain its positional precision over time. The second-to-last point is also critical. Belt drives are substantially faster than lead screw systems, therefore prints are completed in less time.

Fig 5.3 TIMING BELT WITH TOOTH PULLEY

The above figure Fig 5.3 shows the timing belt with tooth pulley for linear motion of the system to control motion along the x-axis and y-axis. Typically, a timing belt will be used to move the heated bed and hot end respectively.

5.3 CALIBRATIONS

Calibrating a 3D printer plays an important role in ensuring consistent accuracy. 3D printers are part of that product group. They are exceptionally accurate pieces of equipment, but only if they are calibrated after the initial setup and whenever they are moved.

5.3.1 BED LEVELING

To get the best results we must ensure the build platform or bed is levelled. When the 3D printer bed is not well levelled, it will affect the quality of the prints as the layers may not be printed accurately or evenly. Before bed levelling we must make sure to clean the bed using Isopropyl alcohol and a piece of cloth. Now for bed levelling we take a piece of paper and place it in the middle of the bed and then lower the nozzle head until it barely touches the paper or feels like it has snugged between the bed and the nozzle. Now continue snugging the paper back and forth in all four corners of the bed until we find the spot where the piece of paper offers the least resistance. This spot is usually where the bed is levelled. Finally, once you have found the level spot, tighten all the screws on your bed so that it doesn't move during printing. The biggest problem when manually levelling a 3D printer bed is finding the correct distance between the nozzle and the print surface. Too far and your prints won't stick. Too close and you'll damage the print surface. So the nozzle should be in paper thickness difference with the base platform where the printer prints the 3D object.

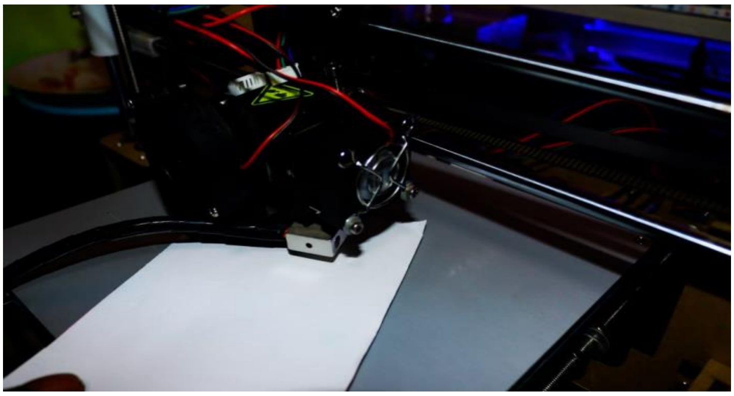

Fig 5.4 BED LEVELING USING A PIECE OF PAPER

The above Fig 5.4 shows us how to perform bed levelling using a piece of paper.

5.3.2 TEMPERATURE CALIBRATIONS

Calibrating the 3D printer ensures that each print is identical every time. Improper 3D printer nozzle temperatures can cause a range of issues, including oozing and stringing filament on 3D printed products. Similarly, while testing out a new filament, the extruder may skip steps at random. The temperature at which the filament should be heated for a decent print is determined on the type of filament used. The testing temperatures for PLA range from 190°C to 220°C.The best temperature for a high-quality print should be determined from the temperature range. The best way to find the ideal temperature is to build a temperature tower with different temperatures, as illustrated in figure 5.5, and then identify the best temperature for the filament.

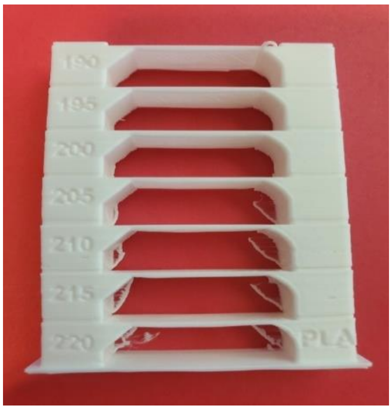

Fig 5.5 TEMPERATURE TOWER

The below Fig5.5 shows us the Temperature palace which is a perpendicular structure that consists of multiple vertical crossbeams. Each slab is 3D published with a different temperature. This way, you can snappily pinpoint the temperature that gives you the stylish result with a specific hair.

5.3.3 RETRACTIONS DISTANCE AND RETRACTION SPEED CALIBRATIONS

When your print head moves from one location to another during printing, the heat of the nozzle combined with any pressure in the hot end forces some surplus filament out. This is a type of over extrusion that frequently leaves faint strings along the path of the print head between spots. After printing, these strings can be removed with tools and heat (e.g., a hairdryer), but they're still a pain to deal with. To tackle this, our slicers use retraction, which removes the filament from the hot end, relieving pressure and reducing goo.

The two most important calibrations are retraction distance and retraction speed.

RETRACTION DISTANCE: The amount of filament pushed back by the extruder is referred to as the retraction distance.

RETRACTION SPEED: The pace at which the extruder pulls the filament back during the retraction process is referred to as retraction speed.

By varying retraction distance and retraction speed, the section of print where the ooze and drip from the nozzle gets minimized, that retraction values are taken into consideration. For an FDM based 3D printer retraction distance ranges from 2 to 7 mm, retraction speed ranges over 20mm/s to 50mm/s but these values depend on the extruder configuration, hot end, and other factors. To find the optimum values for these calibrations, we prefer to publish estimation halls for different retraction pets and retraction distances independently. utmost of the time the retraction speed works impeccably at its dereliction range but we may need to acclimate it while switching from one hair material to another material. To set perfect Retraction speed and Retraction distance we need to set accurate temperature for hot end because high temperatures can beget the problem as the hair will melt snappily and may start dropping.

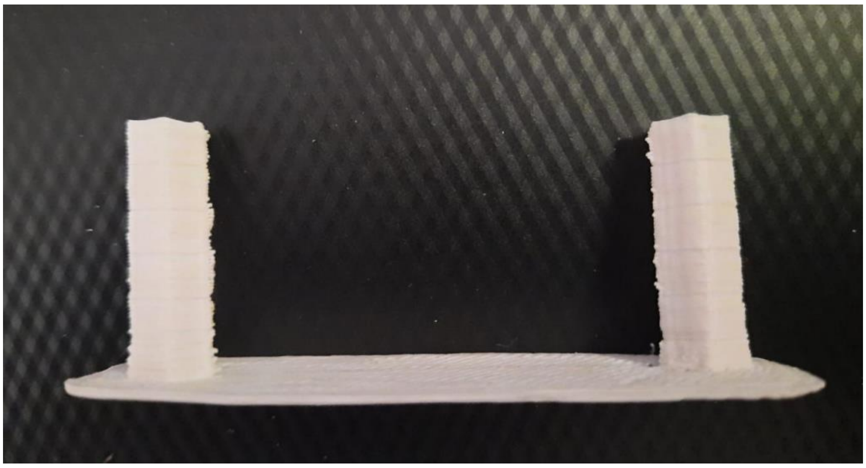

Fig 5.6 Retraction distance testing tower

Figure 5.6 shows the Retraction Distance Testing Tower; the print retraction distance is varied from 4mm up to 7.5 with a difference of 0.5mm per section of the print. From the Figure 5.5we can clearly see that at retraction distance of 7mm print is clear.

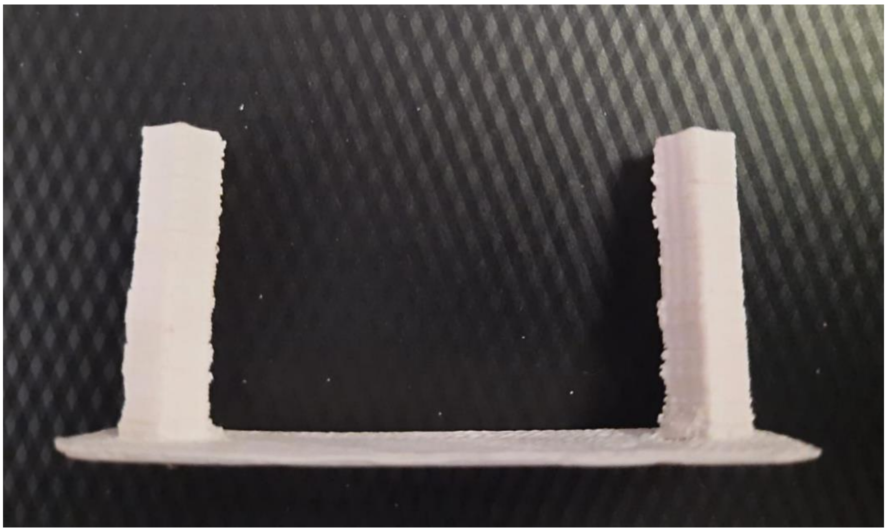

Fig 5.7 Retraction speed testing tower

Fig 5.7 shows the Retraction Speed Testing Tower where the print retraction speed is varied from 20mm/sec to 50mm/sec with a difference of 5mm/sec per section of the print and from the figure 5.6 we can clearly see that at retraction speed of 35mm/sec the print is clear.

5.3.4 X, Y, Z Axis Calibrations

For 1.8^{o} stepper motor, in micro stepping mode (1/16 of full step) makes 3200 steps to complete one full revolution (i.e.,360^{o}). For X and Y axes we had used timing belt with 2mm pitch and pulley with 20 teeth for linear movement along the axes. So, for one full rotation of the stepper motor the axis would move 40mm

Steps per mm along X and Y axes = $\frac{Motor\ steps\ per\ revolution}{No.of\ pulley\ teeth * Belt\ pitch}$

This results in 80 steps for a stepper motor to make a linear movement of 1mm along the X & Y axes.

Along Z axis we had used a 4 start lead screw of 2mm pitch, for linear movement along the axes, for one full 360° rotation of stepper motor the axis would move 8mm,

Steps per mm along X and Y axes = $\frac{Motor\ steps\ per\ revolution}{No.of\ pulley\ teeth * Belt\ pitch}$

This results in 400 steps for a stepper motor to make a linear movement of 1mm along the Z axis.

CHAPTER 6

RESULT

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RESULT

6.1 INTRODUCION

Nowadays 3D printing is playing a crucial role in many fields especially in medical field, to build different prototype models in different industries, educational fields, art and jewellery, etc. For 3D printing an object it is important to design the object with required dimensions and then to print the designed object we need to slice the object with perfect calibrations. Now the printer is provided with mechanical input i.e., PLA filament and then this filament is heated to 210^{o}C, which converts the filament into semi-solid state which is now used to print the object layer by layer through means of INKJET technology. Once the printing is completed it is left to cool down before removing it from the build platform and if any support materials are provided then they have to be removed manually. Now after cooling down, we remove the printed object and then we perform post processing which is smoothing rough edges, and adding any finishing touches such as sanding or painting.

6.2 3D PRINTED OBJECTS

6.2.1 SQUARE WITH AND WITHOUT CALIBRATIONS

DESIGN

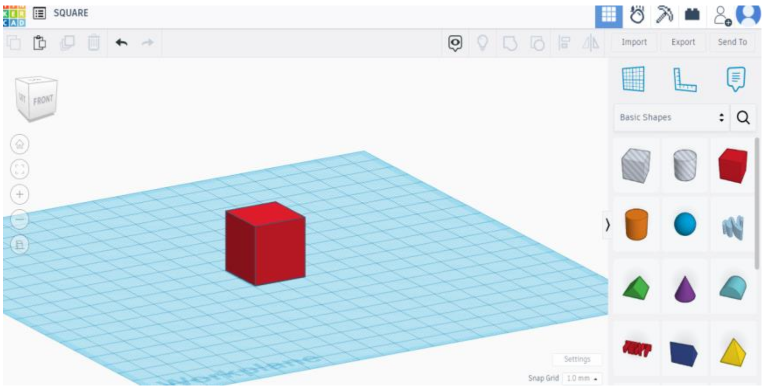
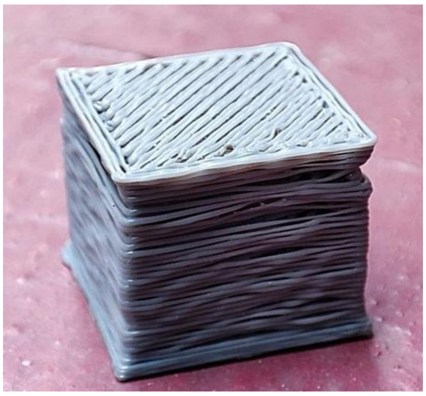


Fig 6.1 Cube designed using Tinkercad

In Fig xyz we can see the SQUARE which was designed using the software named **TINKERCAD** with our required dimensions.

OUTPUT



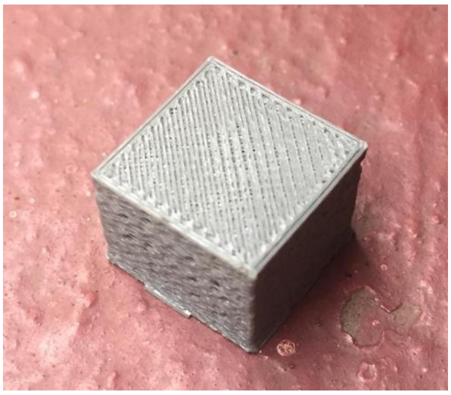


Fig 6.2 Cube without calibrations Fig 6.3 Cube with calibrations

In Fig 6.2 represents the square without calibrations because of which the layers didn't get attached to each other properly and also because of improper calibrations there have extra oozing because of which the print is not accurate.

In Fig 6.3 represents the square with calibrations which made the printed object to have even surfaces in all directions and also the width of the layer has been reduced to 0.24mm.

6.2.2 ALPHABETS

DESIGN

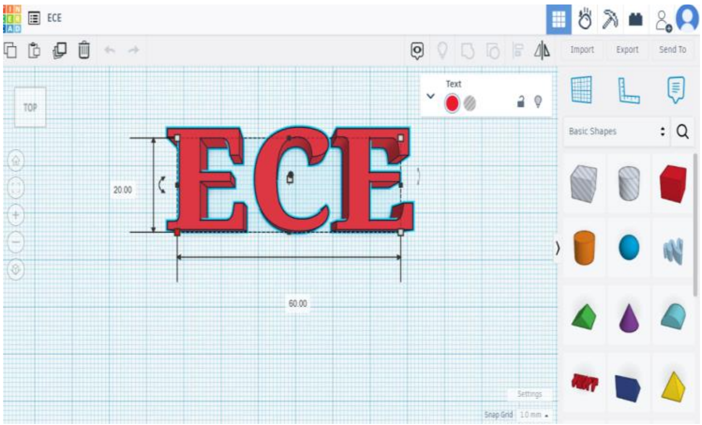


Fig 6.4 Alphabets designed using TINKERCAD

In Fig 6.4 we can see the alphabets resembling **ECE** which were designed using the software named **TINKERCAD** with our required dimensions.

OUTPUT

Fig 6.5 Alphabets printed using FDM technology

The above Fig 6.5 is the 3D printed output of the design shown in Fig 6.4.

6.2.3 WHEEL RIM

DESIGN

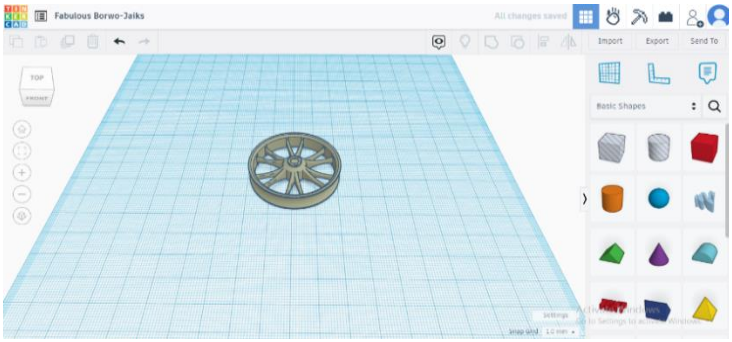


Fig 6.6 Design of WHEEL RIM

In Fig 6.6 we can see the design of the Wheel Rim which was designed using TINKERCAD with our required dimensions.

OUTPUT

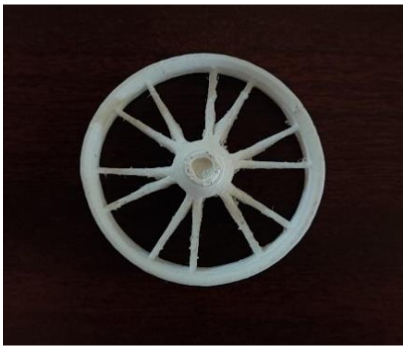


Fig 6.7 3D printed WHEEL RIM

In Fig 6.7 we can see the Wheel Rim printed using FDM technology.

CONCLUSION

This project emphasizes on fused Deposition modeling (FDM) 3D printing technology which is rapidly evolving. This project focuses on making a economically feasible FDM 3D printer using Arduino. This 3D printer enables a person to print a 3D object layer by layer using Poly Lactic Acid (PLA) material. The PLA material is chosen because of its printing ability at low temperature and it doesn’t require a heat bed.

The 3D printer is built using an Arduino IDE software for programming the Arduino MEGA 2650 for its high processing power and user-friendly nature. It also uses slicer software for converting STL format files into G-codes. The print area (150mmx130mmx90mm) and moment of base platform allows manufacturing complex parts. Now a 3D printer which is capable of manufacturing both education as well as commercial prototypes was built and tested by printing 3D objects using PLA.

FUTURE SCOPE:

3D printing can also be done using similar filament with two different colours. Dimensions of the printer can be increased to get prints with larger size. It is better to install a display module to make it reduce the complexity of understanding.

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