CHAPTER 1

INTRODUCTION

1.1 3D PRINTER

3D printing uses the technique of additive manufacturing where an object which is required is made by adding successive layer of materials. This technique is also known as Rapid Prototyping. This is a time saving activity where we can complete a object in a single process. The object formed by this technique can be used to test the functionality and assembly of the object in its real material, which cost more in time and raw material. It also helps in validating the products designs and identify the error which otherwise would not have been noticed in virtual simulation and analysis. 3D printing technology finds its application in various industries such as Shelter, Food, Bio-organ, Dental Implants, Education etc.

1.2 History

The history of 3D printing begins in 1981 with Dr. Hideo Kodama's patent application for a rapid prototyping device. As far as we're aware, Dr. Kodama is the first person ever to apply for a patent in which laser beam resin curing system is described.Unfortunately, the Japanese doctor's application never went through. Due to issues with funding, he was unable to complete the process before the one-year deadline.

Nevertheless, the idea of "rapid prototyping devices" continued to develop, and the next people we know about who had an impact on the idea were Jean-Claude André, Olivier de Witte, and Alain le Méhauté.Back in the 80s, le Méhauté was working at Alcatel researching fractal geometry parts. He argued with his colleagues because they thought his thinking was "off the path". Still, he was determined to prove himself, and so started thinking about how to produce such complex parts.

Le Méhauté shared his problem with de Witte, who was working for a subsidiary of Alcatel. Having worked with lasers, de Witte knew about liquid monomers that could be cured to solids with a laser. This opened the way to building a rapid prototyping device.The two brought the new idea to André, who was working at the French National Center for Scientific Research (CNRS). Although he was interested in the idea, the CNRS ultimately didn't approve of it. Apart from a lack of equations, they claimed it simply didn't have enough areas of application…The trio filed for a patent in 1984, but without proper funding, they were forced to abandon the project.

1984 was the lucky year for 3D printing. Working for a tabletop and furniture manufacturer, Charles "Chuck" Hull was frustrated at the long times it took to make small, custom parts. He therefore suggested turning the company's UV lamps to a different use: curing photosensitive resin layer-by-layer, eventually creating a part. Fortunately, Hull was given his own small lab to work on the process. Only three weeks after the team in France applied for their patent, Hull applied for his, calling the technology stereolithography.

The patent was issued in 1986, and in the same year, Charles started his own company in Valencia, California: 3D Systems. They released their first commercial product, the SLA-1, in 1988.

Today, 3D Systems is one of the biggest 3D printing companies, and of course, one of the market's leaders for 3D printing innovation.

In 1988, the same year that the SLA-1 was introduced, another 3D printing technology was invented. This time, it was selective laser sintering (SLS), the patent for which was filed by Carl Deckard, an undergraduate at the University of Texas.

Deckard's machine, the first SLS 3D printer, was called Betsy. It was able to produce only simple chunks of plastic. However, as the main purpose of the printer was to test the idea for the SLS, object details and print quality weren't the highest priorities.

In the meantime, while the patent for SLS was awaiting approval, another patent for an additive manufacturing technology was submitted to the US government.

This time it was for fused deposition modeling (FDM). Interestingly, despite now being the simplest and most common of the three technologies, FDM was actually invented after SLA and SLS.

The patent for FDM was submitted by Scott Crump, who is today well known for being the co-founder of Stratasys. Founded in 1989, the Minnesota-based company is one of the market leaders for high precision 3D printers.

In 1992, the patent for FDM was finally issued to Stratasys, which marked the start of the intense development of the technology. One of the first industries to take on the technology in the early 90s was medicine.

1.3 Principle

A viscous material 3D printer is one in which a raw material is fed into the printer and the printer then follows sequential steps of operation to give a 3D object as output. The motion and printing mechanism of our machine is governed by four programmable stepper motors (Nema-17). The efficient framework design of our 3D printer machine enables smooth motion of the printing head in 3 directions (X, Y, Z). The motors receive their instructions for required magnitude and direction of motion speed from a MKS Base 1.4 board. In order to achieve 3D printing using chocolate and other viscous materials, certain changes have to be made in the design and working concept of the existing 3D printers currently available in the market. The challenges faced during the development of viscous material printer are a result of lack of availability of documentation and literature on the related topics. The materials in use (chocolate) are difficult to deal with due to their physical properties. Different set of control parameters are required to print 3D objects, when using different materials. Due to limitations in the physical properties, only few viscous materials including chocolate, concrete, cement paste, porcelain, wax, silicone or clay can be utilised for three dimensional printing. The set of physical properties that determine the effectiveness of a viscous material for 3D printing include easy to attain melting and freezing point temperatures, ease of melting, ease of solidification upon cooling or drying, viscosity lying between a suitable range allowing material to flow through nozzle when under pressure and viscous enough to be able to hold in a syringe in absence of pressure, chemically inertness.

There is an increasing market need for customized food products, most of which are currently designed and made by specially trained artisans. The cost for such a limited number of pieces is relatively high.

1.4 APPLICATIONS

1 .APPAREL

3D printing has spread into the world of clothing with fashion designers experimenting with 3D-printed bikinis, shoes, and dresses. When we talk about the commercial production, Nike is using 3D printing to prototype and manufacture the very same football shoe for the American football players and the company New Balance is 3D manufacturing custom fit shoes for all the athletes.

3D printing has come to the point where companies are printing consumer grade eyewear with on demand custom fit and styling (although they cannot print the lenses). On demand customization of glasses is possible with rapid prototyping.

FIG 1 : 3D PRINTED SHOES AND SPECTACLES

2. CONSTRUCTION

With the help of 3D printers, we are able to build civil models like prototype of building or plan structures. So that the customers can easily visualized the models.

FIG 2 : 3D PRINTED BUILDING PROTOTYPE

3. BIOMEDICAL

Medical applications for 3D printing are expanding rapidly and are expected to revolutionize health care. Medical uses for 3D printing, both actual and potential, can be organized into several broad categories, including: tissue and organ fabrication; creation of customized prosthetics, implants, and anatomical models; and pharmaceutical research regarding drug dosage forms, delivery, and discovery. The application of 3D printing in medicine can provide many benefits, including: the customization and personalization of medical products, drugs, and equipment; cost-effectiveness; increased productivity; the democratization of design and manufacturing; and enhanced collaboration. However, it should be cautioned that despite recent significant and exciting medical advances involving 3D printing, notable scientific and regulatory challenges remain and the most transformative applications for this technology will need time to evolve

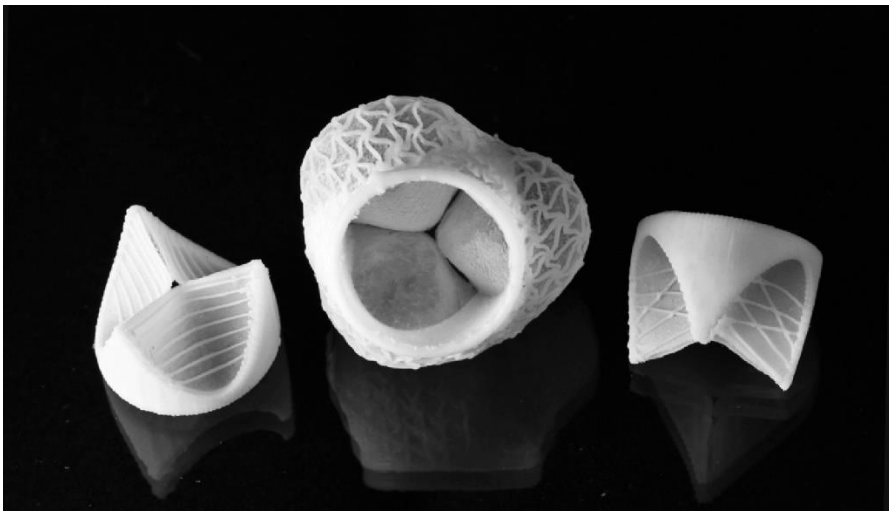


FIG 3 : 3D PRINTED SILICON HEART VALVES

4.DOMESTIC USE

The domestic market of the 3D printing was mainly practiced by hobbyists and enthusiasts and was very little used for many of the practical household applications which are inapplicable. A working clock was made and gears were printed for home woodworking machines among other purposes. 3D printing was also used for ornamental objects. Websites associated with home 3Dprintins include coat hooks, doorknobs etc.

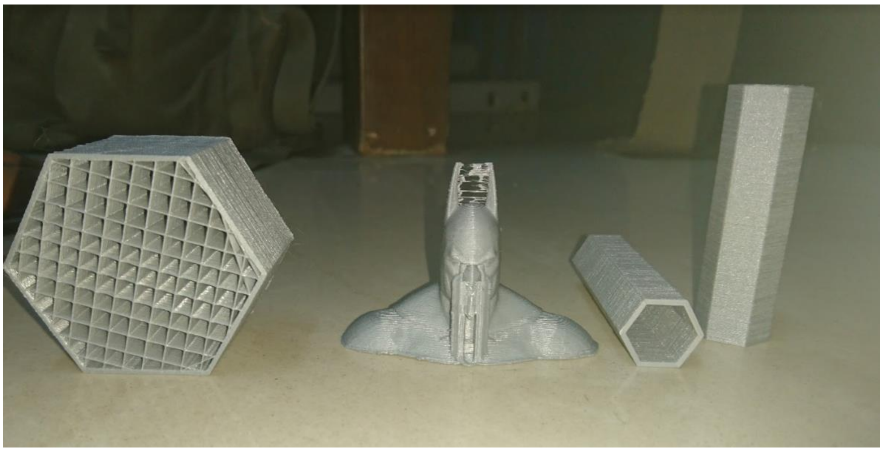


FIG 4 : 3D PRINTED DOMESTIC ITEMS

5.FOOD

Three dimensional (3D) food printing is being widely investigated in food sector recent years due to its multiple advantages such as customized food designs, personalized nutrition, simplifying supply chain, and broadening of the available food material. Currently, 3D printing is being applied in food areas such as military and space food, elderly food, sweets food. An accurate and precise printing is critical to a successful and smooth printing. In this paper, we collect and analyze the information on how to achieve a precise and accurate food printing, and review the application of 3D printing in several food areas, as well as give some proposals and provide a critical insight into the trends and challenges to 3D food printing

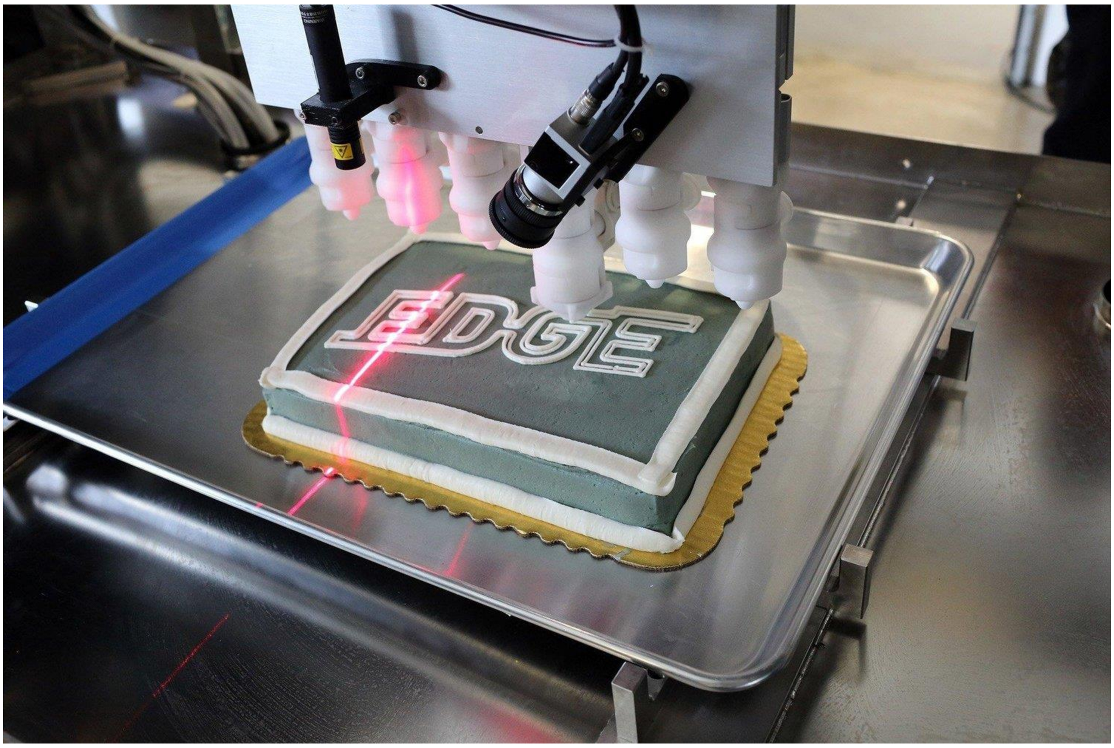


FIG 5 : 3D PRINTING CAKE ICING

CHAPTER 2

LITERATURE REVIEW

2.1 DIFFERENT ADDITIVE MANFACTURING TECHNIQUES

1.FUSED DEPOSITION MODELING (FDM)

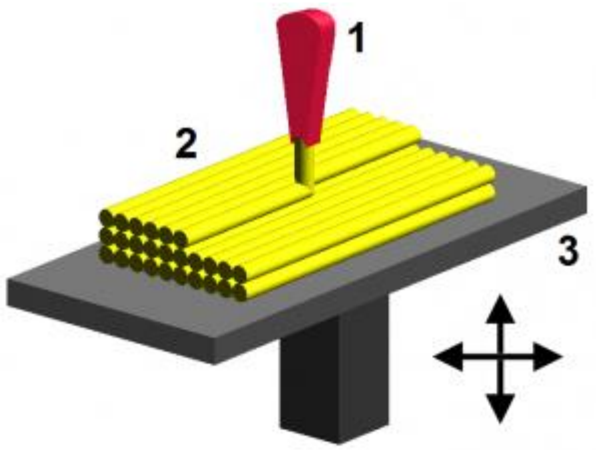


FIG 6 : FUSE DEPOSITION MODELLING

Sometimes called Fused Filament Fabrication (FFF) is a 3D printing technology that uses a process called **Material Extrusion.** Material Extrusion devices are the most widely available - and inexpensive - of the types of 3D printing technology in the world today.

They work by a process where a spool of filament of solid thermoplastic material (PLA, ABS, PET) is loaded into the 3D printer. It is then pushed by a motor through a heated nozzle, where it melts. The printer's extrusion head then moves along specific coordinates, depositing the 3D printing material on a build platform where the printer filament cools and solidifies, forming a solid object.

Once the layer is complete, the printer lays down another layer, repeating the process until the object is fully formed. Depending on the object's complexity and geometry, support structures are sometimes added, for example, if the object has steep overhanging parts.

Common applications for FDM include electrical housings, form and fit testings, jigs and fixtures, and investment casting patterns.Strengths of FDM are that it offers the best surface finish plus full color along with the fact there are multiple materials available for its use.

It is limited by being brittle, therefore unsuitable for mechanical parts. It also has a higher cost than SLA/DLP.

2. STEREOLITHOGRAPHY (SLA)

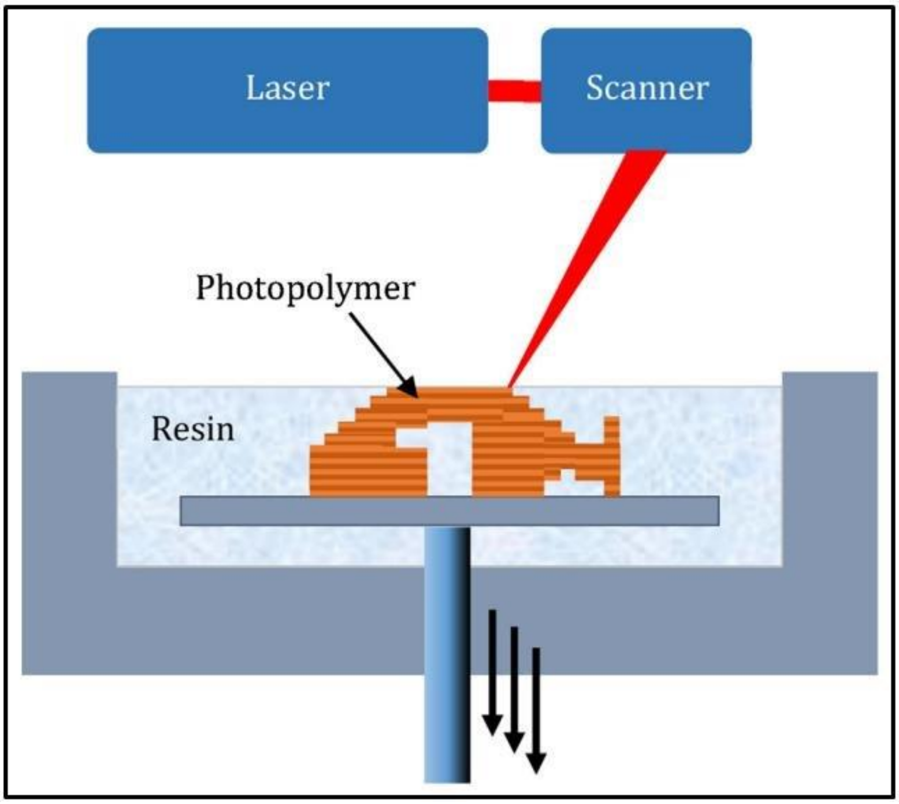


FIG 7: STEREOLITHOGRAPHY

It is the world's first 3D printing technology. It was invented by Chuck Hull in 1986

Specifically, an SLA printer uses mirrors, called galvanometers or galvos, where one is positioned on the X-axis, the other on the Y-axis. These galvos aim the point of a laser beam across the vat of resin, selectively curing and solidifying a cross-section of the object in the build area, building it up layer by layer.

3.DIGITAL LIGHT PROCESSING (DLP)

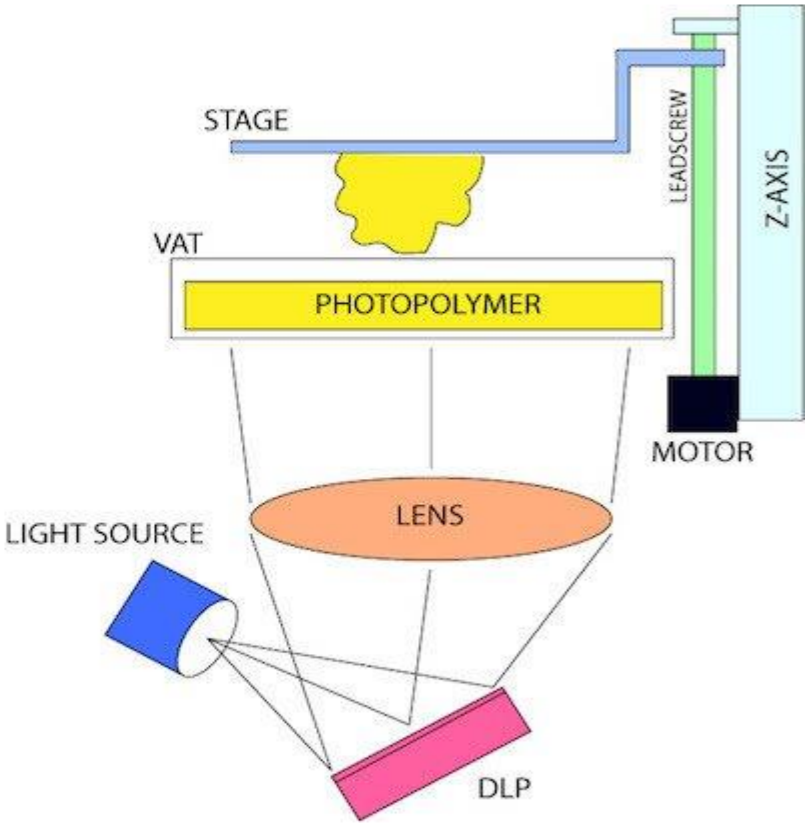


FIG 8: DIGITAL LIGHT PROCESSING

It is a 3D printing technology and is almost the same type of machine as SLA. The main difference being DLP uses a digital light projector that flashes a single image of each layer all at one time - or does multiple flashes for larger parts.

Light is projected onto the resin by light-emitting diode (LED) screens or an ultraviolet (UV) light source, such as a lamp. It is directed onto the build surface by a Digital Micromirror Device (DMD), which is an array of micro-mirrors that control where the light is projected and generate the light pattern on the build surface.

Since the projector is a digital screen, the image of each layer is made up of square pixels, so each layer is formed from small rectangular blocks called voxels.

DLP has faster print times than SLA because each layer is exposed all at once, instead of tracing the cross-section of an area with the point of a laser.

Common applications for SLA and DLP are injection mold-type polymer prototypes, jewelry, dental applications, and hearing aids.Their strengths are they have fine feature details and smooth surface finish.

They are limited by being brittle, therefore unsuited for use as mechanical parts.

4. SELECTIVE LASER SINTERING (SLS)

It uses a 3D printing process called Power Bed Fusion. A bin of thermoplastic powder (Nylon 6, Nylon 11, Nylon 12) is heated to just below its melting point. Then, a recoating or wiper blade deposits a thin layer of the powder - usually 0.1 mm thick - onto the build platform.

A laser beam begins scanning the surface, where it selectively ‘sinters’ the powder, meaning it solidifies a cross-section of the object. As with SLA, the laser is focused on a location by a pair of galvos.

Once the entire cross-section is scanned, the platform moves down by one thickness of layer height and the whole process is repeated until the object is fully manufactured. Powder that is not sintered remains in place supporting the object that has been sintered, eliminating the need for support structures.

Common applications for SLS are the manufacturing of functional parts, complex ducting requiring hollow designs, and low-run production.

Its strengths are in the creation of functional parts, parts with good mechanical properties, and with complex geometries.

SLS is limited by requiring longer lead times and its higher cost when compared with FDM/FFF.

5.ELECTRON BEAM MELTING (EBM)

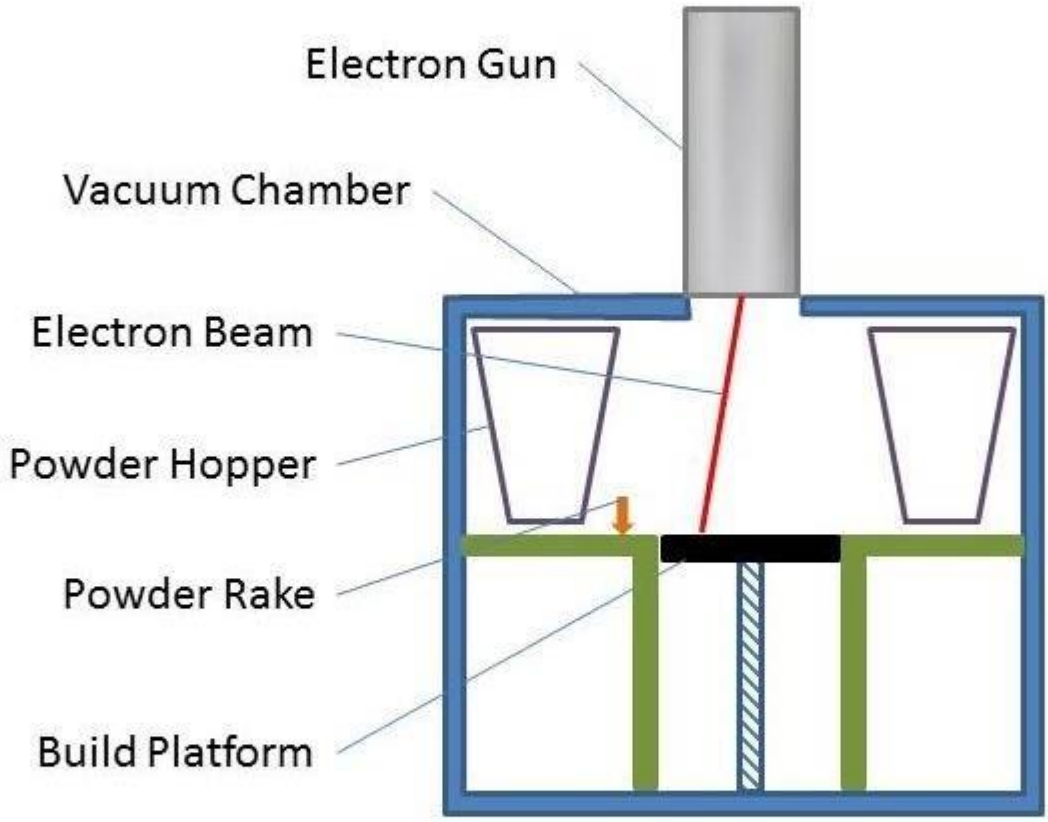


FIG 9: ELECTRON BEAM MELTING

It is also uses the Metal Powder Bed Fusion process. Unlike DMLS and SLM, instead of a laser, it uses a high energy beam of electrons for inducing fusion between metal particles in a powder.

A focused beam of electrons scans over a thin layer of powder, causing localized melting and solidifying over a particular cross-sectional area. The areas are then built up to create a solid object.

Because of its higher energy density, EBM has a much better build speed than DMLS or SLM. Minimum feature size, powder particle size, layer thickness, and surface finish are generally larger with EBM.

Also, because of the nature of the process, EBM parts must be made in a vacuum and can only be used with electrically conductive materials.

Common applications for these last three 3D printing technologies are functional metal parts for the aerospace, automotive, medical and dental industries.

Strengths are the fabrication of the strongest functional metal parts and the ability to produce complex geometries.

Limitations are high cost and small build sizes.

2.2VARIOUS CONFIGURATIONS IN 3D PRINTING

1.CARTESIAN CONFIGURATION

Cartesian 3D printers are pretty much named after the coordinate system the X Y and Z axis which is used to determine where and how to move in three dimensions and the Cartesian 3D printers which have a heated bed which moves only in the Z axis. The extruder sits on the X-axis and Y-axis, where it can move in four directions on a gantry. This is the principle which can be seen in action on the models from Ultimaker and MakerBot . With the Printrbot Simple instead of moving the print head purely in XY space, one of the axes are changed by moving the print bed itself. This is a very easy and simple design, and therefore it will be easier to maintain, but at the sacrifice of printing speed.

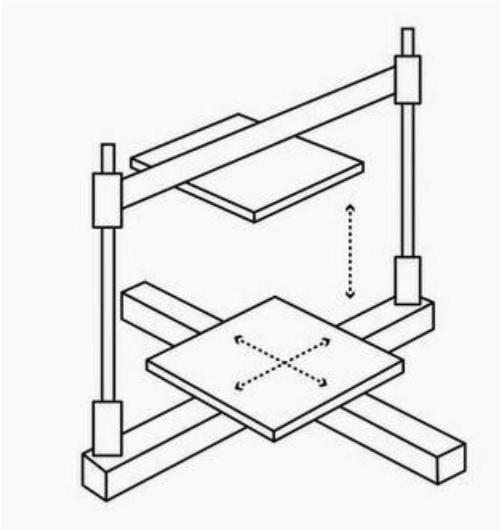


FIG 10:CARTESIAN CONFIGURATION

2.DELTA CONFIGURATION

Delta 3d printers feature a circular print bed. The extruder will be suspended above that by three arms in a triangular configuration thus the name “Delta” . These nifty robots were designed for speed and they also have the advantage of a print bed that does not move which could be advantageous for certain prints. The benefits which are obtained from the Delta configuration is that when the moving parts are lightweight it will be easier to travel. That results in faster printing with greater accuracy. Most “traditional” printers have a moving build platform. This means that the object you are printing is always moving which can lead to prints coming loose due to the constant jerks and to inaccurate prints especially when the prints get higher. Delta configuration are much more better in building higher objects like a vase because the platform is fixed. They tend to be higher anyway which creates a bigger build volume[13]. Because of the way they are build it is also fairly easy to make them bigger (not in width but certainly in height). When the overall construction is much less complicated and uses very less parts which will be reducing the maintenance and costs. Because of the arm construction it must be a lot taller than your build volume.

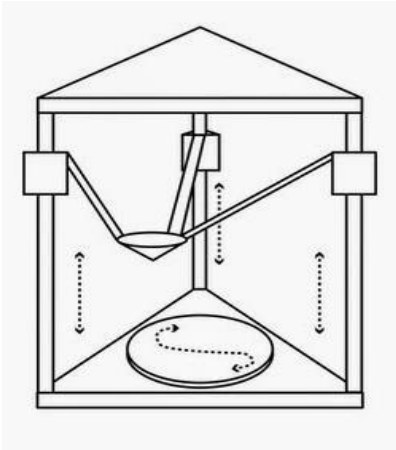
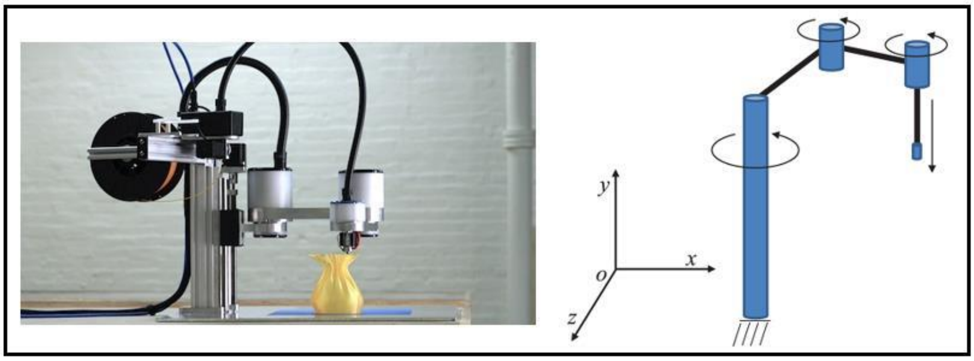


FIG 11: DELTA CONFIGURATION

3.SCARA CONFIGURATION

Selective Compliance Assembly Robotic Arm abbreviated as SCARA type robotic system has three degrees of freedom and it is actuated by three servo motors to do one vertical and two horizontal motions. Feeding system for 3d printing is placed to back of robot and it is extended at the end of the robotic arm.

FIG 12:SCARA CONFIGURATION



4.POLAR CONFIGURATION

This category uses a polar coordinate system. It is pretty much similar to that of Cartesian configuration except that the coordinate sets describe points on a circular grid rather than a square. All of which means that you can have a printer with a spinning bed, plus a print head that can move up and down. The biggest advantage of a polar configuration 3D printer is that the printer can easily function with only two stepper motors.

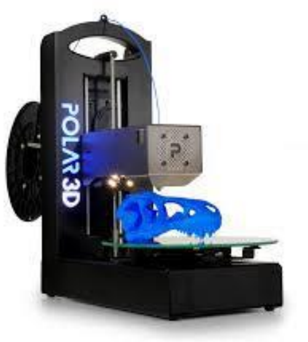


FIG 13 : POLAR CONFIGURATION

CHAPTER 3.

METHODOLOGY

3.1 3D PRINTING PROCEDURE

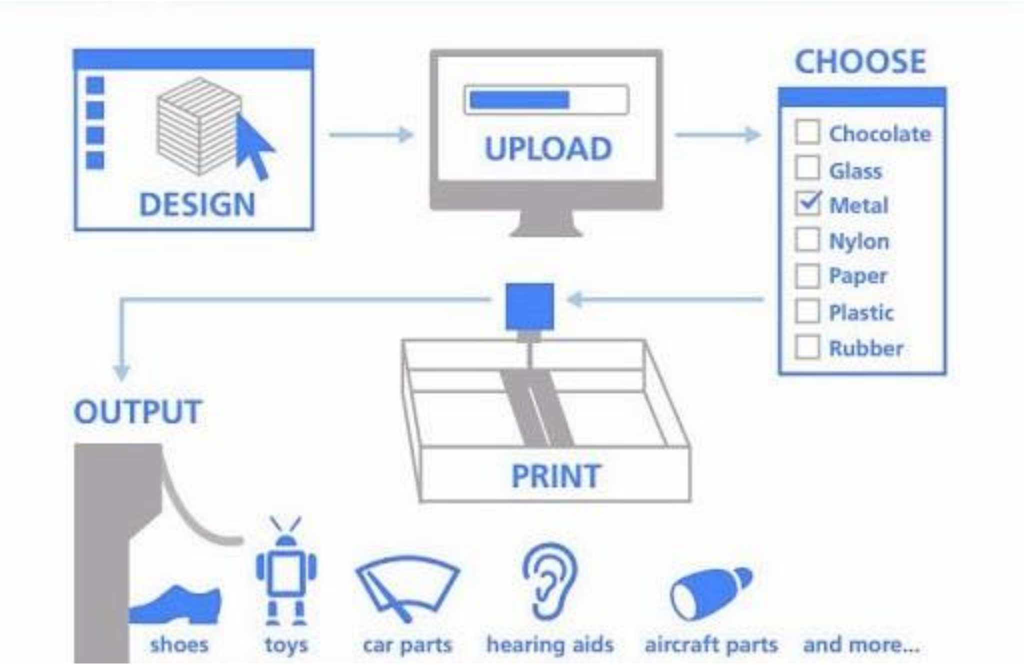


FIG 14: PROCESS FLOWCHART

STEP 1 : 3D MODELLING SOFTWARE

There are many different 3D modeling software tools available. Industrial grade software can easily cost thousands a year per license, but there's also open source software you can get for free. The free version of Google SketchUp, for example, is very popular for its ease of use; and the free Blender program is popular for its advanced features.

STEP 2 : 3D SLICING SOFTWARE

Slicing is dividing a 3D model into hundreds or thousands of horizontal layers and is done with slicing software.Some 3D printers have a built-in slicer and let you feed the raw .stl, .obj or even CAD file.When your file is sliced, it's ready to be fed to your 3D printer. This can be done via USB, SD or internet. Your sliced 3D model is now ready to be 3D printed **layer by layer**.Cura is the most commonly used slicing software.

STEP 3 : ACTUAL PRINTING

The g codes generated from the slicing software are feed to the printer. And accordingly the signal is send to the stepper motors through arduino and the object is printed.

3.2 Working

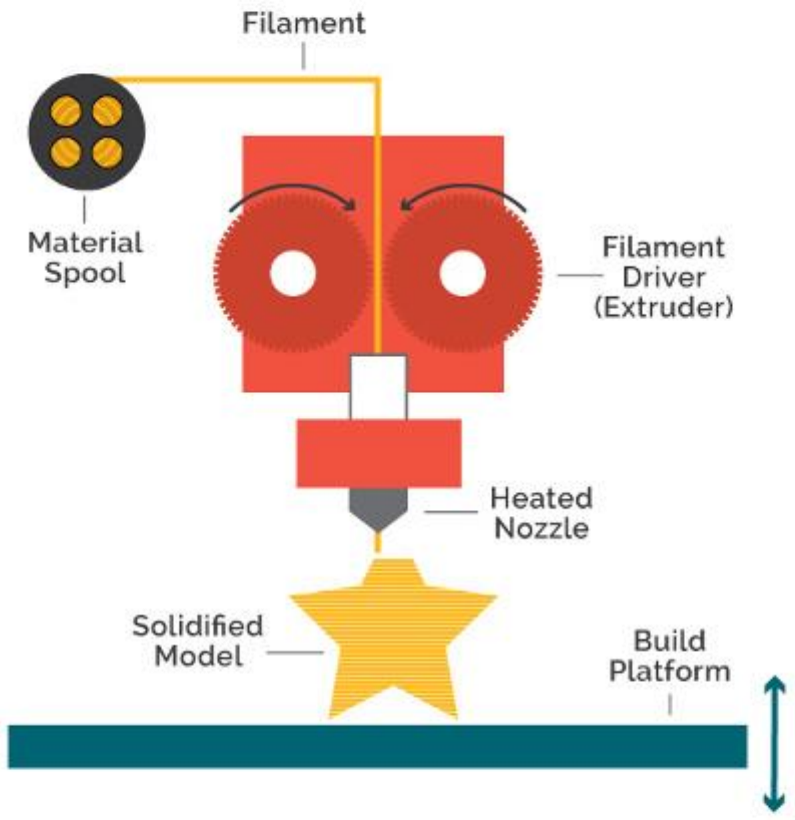


FIG 15 : WORKING OF 3DP

A 3d printer prints through fused deposition modeling (FDM). It creates 3D objects by stacking thin layers of heated plastic, which fuse and set into a solid shape as they cool and harden. The printer pulls plastic filament from a spool into the extruder where the plastic is heated to melting. The melted plastic is then extruded into a pre-set pattern onto a flat plate where it will form the final shape of the model. No of materials are used to print a object following is the list of materials

MATERIAL	DESCRIPTION	PRINTING TEMP	BED TEMP
PLA	PLA (Polylactic Acid) is one of the two most commonly used desktop 3D printing materials (with the other being ABS). It is the ‘default’ recommended material for many desktop 3D printers, and with good reason - PLA is useful in a broad range of printing applications, has the virtue of both odorless and low warp and it will not require a heated bed. PLA plastic is also one of the eco-friendlier 3D printer materials available; it is made from annually renewable resources (corn-starch) and requires less energy to process compared traditional (petroleum-based) plastics.	180 - 220	20 - 55
ABS	ABS (Acrylonitrile Butadiene Styrene) is another commonly used 3D printer material. Best used for making durable parts that need to withstand higher temperatures. In differentiating to PLA, ABS plastic is less brittle. It can also be post-processed with acetone to provide a glossy finish.	220-235 °C	80-110 °C
NYLON	Nylon is an incredibly strong, durable, and versatile 3D printing material. It is very Flexible when it is thin but it is high inter layer adhesion and the nylon lends itself well to things like the living hinges and the different functional parts. Nylon	235-270	60-80

	filament prints as a bright natural to white with a translucent surface and can absorb color added post process with most common, acid-based clothing dyes. Nylon filament is very sensitive towards the presence of moisture so taking drying measures during storage and immediately prior to printing is highly recommended for best results		
TPU (Thermoplastic Polyurethane)	TPU is an elastic grease resistant and abrasion resistant material with a Shore Hardness of 95A. TPU has various applications that are used inside automotive instrument panels, caster wheels, power tools, sporting goods, medical devices, drive belts, footwear, inflatable rafts, and a variety of extruded film, sheet and profile applications. It is also commonly used in mobile phone cases.	240-260	40-60
LAYBRICK	LAYBRICK is a 3D printing material that gives parts the look and feel of grey stone while retaining the resiliency of plastic, making it ideal for landscape and architectural designs. Which is made up of the LAYBRICK can be painted and sanded. In the lower range of 165°C to 190°C, the print will come out mostly smooth, whereas with higher temperatures it will begin to have a more pitted, sandstone-like	180-200	20-55

	texture.		
CHOCOLATE	It is easier to print plastic than to print chocolate. Chocolate has very different melting and cooling properties than plastic, thus melted chocolate can't harden as fast. This could lead to 3D printed chocolate losing its shape due to the temperature and gravity. The type of chocolate is also important.	40-50	31-36

CHAPTER 4

DESIGN DETAILS

4.1 SELECTION OF MOTOR

Assumptions:

Constant speed of the motor = 400rpm=6.667rps

v = r ω

ω = [2πN]/60

= 41.908rad/s

Therefore;

400 = r*41.908

r = 9.547mm

Torque = Force*Radius

Force = 41.87N (considering NEMA 17 stepper motor having torque = 0.4Nm)

Conclusion for motor design

4.2 kg can be pulled over a distance of 500mm in 1second using NEMA 17.

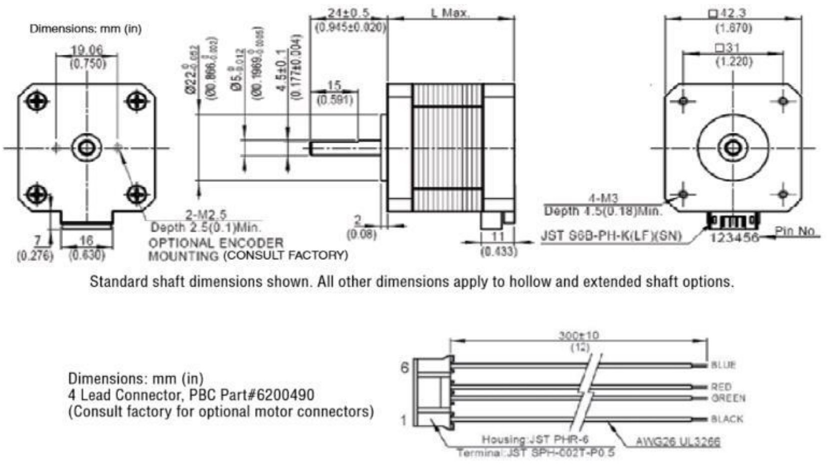


FIG 16 : NEMA 17 STEPPER MOTOR

4.2 Design of steel rods for X - axis movement

Bearing weight = 0.065kg

Extruder + Heating element + Nozzle = 0.2kg

Carriage weight = 0.05kg

Length of the rod = 320mm

Total Load = 0.315kg

Considering FOS = 2, The acting Load = .63kg

Material: High Speed Steel (HSS)

Young's modulus, E = 210MPa

Using Center Load condition: -

I = [πd4]/64 = 201.06mm4

Ymax=148($WL3EI$) = 10.18 microns

Conclusion for X axis rod design

In order to increase the accuracy of the print maximum deflection in rods must be less than 120microns, by trial and error method the diameter of steel rods is found to be 7.65mm and standardized to 8mm.

4.3 Design for Zaxis movement

Design of Lead Screw for Z - axis movement

Total load acting on the bed = Volume of bed * Density of filament(ABS)

= 0.5×0.5×0.5×1050 = 131.25kg = 1290 N

Considering:

Single start thread n = 1

Lead =n×p = 1×2 = 2mm

Pitch = 2mm

Coefficient of friction μ = 0.17

Torque = 3Nm

Considering Torque equation: -

$T = F \times (Dm2)[L + \mu\pi Dm\pi Dm - \mu L]$

Dm = 9.77mm

Dstd = 12mm

Conclusion for lead screw

The diameter of lead screws is found to be 9.77mm and standardized to12mm.

4.4 Bearing Details

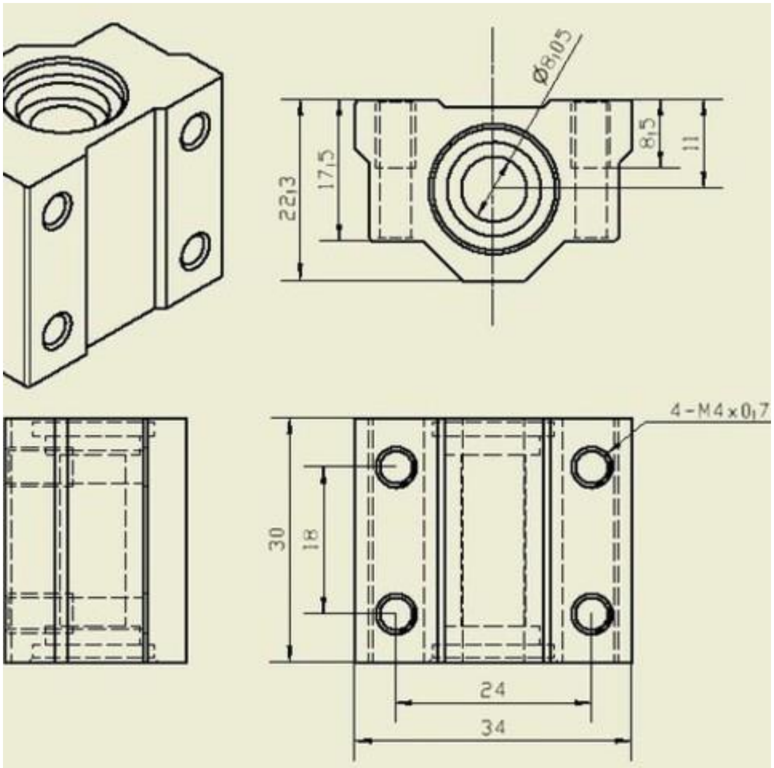


FIG 17: LINEAR BEARING

Linear ball bearing SC8UU

Bearing number : SC8UU

Bore Diameter (mm) : 8

Bearing dimensions and specification in Samick catalogue:

d - 8 mm

h - 11 mm

A - 6 mm

D - 17 mm

E - 5 mm

G - 18 mm

H - 22 mm

J - 24 mm

K - 18 mm

L - 30 mm

S1xℓ - M4

S2 - 3,4 mm

W - 34 mm

Weight - 0,056 Kg

Basic dynamic load rating (C) – 260N

Basic static load rating (C0) - 400N

4.5 TIMING BELT

A Timing belt, timing chain or cambelt is a part of an internal combustion engine that synchronizes the rotation of the crankshaft and the camshaft(s) so that the engine's valves open and closes at the correct circumstances during each cylinder's intake and exhaust strokes .

FIG 18: GT2 TIMING BELT

Design of timing belt

D=d= Diameter of pulley = 2cm

C = Center distance between two pulleys = 700mm

L = Length of the timing belt

$L=(\pi/2)(D+d)+\sqrt{4c2+D2+d2}$

L=1.46319m

The ultimate strength of polyurethane = 20.77MPa

Considering FOS = 4

Force = 40N (From Motor)

$\sigma/\text{FOS} = F/A$

Area = 7.703 mm2

Width=5.925mm

Standard width=6mm

Conclusion for timing belt selection

The width of the belt is found to be 5.925mm and standardized to 6mm.

CHAPTER 5

ELECTRONICS

5.1 List Of Components

- Arduino Mega 2560 x 01 Nos.
- Ramps 1.4 controller board x 01 Nos.
- Optical endstop switch x 03 Nos.
- NEMA 17 stepper motor x 05 Nos.
- A4988 stepper motor driver x 04 Nos.
- Power supply 12V/20A x 01 Nos.
- Lcd display for 3D printer

5.2 Electrical Components Short Intro :

- **Ramps 1.4 controller board:**

it is used for generally for interfacing serval things like endstop switch, stepper motor driver, heatbed, hotend etc with Arduino.

Features of Ramps

➢ Built on stable Arduino Mega 2560 Base

➢ Modular - Easier to TroubleshootUp to 1/32 microstamping (using DRVSS2S based driver boards)

➢ It has provisions for the cartesian robot and extruder

➢ 3 Mosfets for heater/fan outputs and 3 thermistor circuits

➢ Fused at 5A additional safety and component protection

➢ Additional 11A fuse can control heat bed

➢ Fits 5 Pololu stepper driver board

➢ USB type B receptacle

➢ LEDs indicate when the heater output is on

- **Optical endstop switch:**

it is one type of sensor switch, it has NO or NC (normally open or normally closed) switch are trigger when 3d printers XYZ axis reaches to its end position.

end stop switch is generally two types 1. optical type 2. simple mechanical type. you can use whatever you want.

- **NEMA 17 stepper motor:**

FIG 19: NEMA 17 STEPPER MOTOR

I used stepper motor which has 200 steps, in one revolution 1.8 degrees of each step. A NEMA 17 stepper motor is a typical motor with 1.7x1.7 inch faceplate. The NEMA 14 is bigger and for the most part exceptionally heavier than the alternate motors, for example, NEMA 14, yet this additionally implies it has more space to put a higher torque. Its size isn't an indication of the power. This 4 wire bipolar stepper has a 1.8 degree for each progression for smooth movement and the decent holding torque. The engine was is determined to have a maximum current of 350mA so it could be driven effectively with Adafruit engine shield for Arduino and the divider connector or lead corrosive battery.obally accessible.

- **A4988 stepper motor driver:**

FIG 20: STEPPER MOTOR DRIVER & HEATSINK

A stepper driver is a chip that goes about as a sort of mediator between a stepper motor and the controller. It rearranges the signs that should be sent to the stepper motor, so as to inspire it to move. Once in a while, the stepper drivers are on independent circuit sheets that are connected to the controller by means of links. Here and there the stepper drivers are on little circuit sheets that are connected straightforwardly to the controller itself. For this situation, the controller will have space for no less than four of the little circuit sheets (one for every stepper engines). At last, some of the time the stepper drivers are fastened directly to the controller itself.

- **Power supply 12V/20A:**

FIG 21: POWER SUPPLY

each stepper motors draw around 1.2 A current per phase, a total of 5 stepper motors are used, and other electrical parts draw some amount of current so current ratting minimum 20 A is suitable.

- **LCD CONTROLLER**

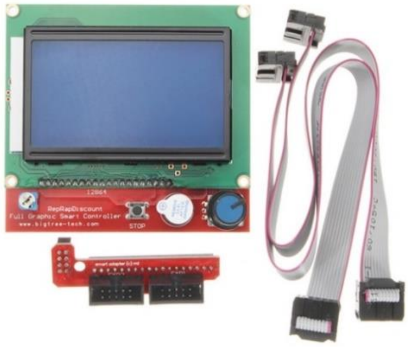


FIG 22: LCD DISPLAY

This full graphic smart controller contains an SD Card peruser a turning encoder and the 128x64 dot matrix LCD display. IT can without much of a stretch be associated with the slopes of the 3d printer utilizing the keen connector included. After the connection with ramps, it doesn't require pc any longer as the smart controller supplies control for your SD card. Facilitate all activities like Further all actions like the calibration, axes movements can be done easily with this Smart controller

5.3 Electrical Connection

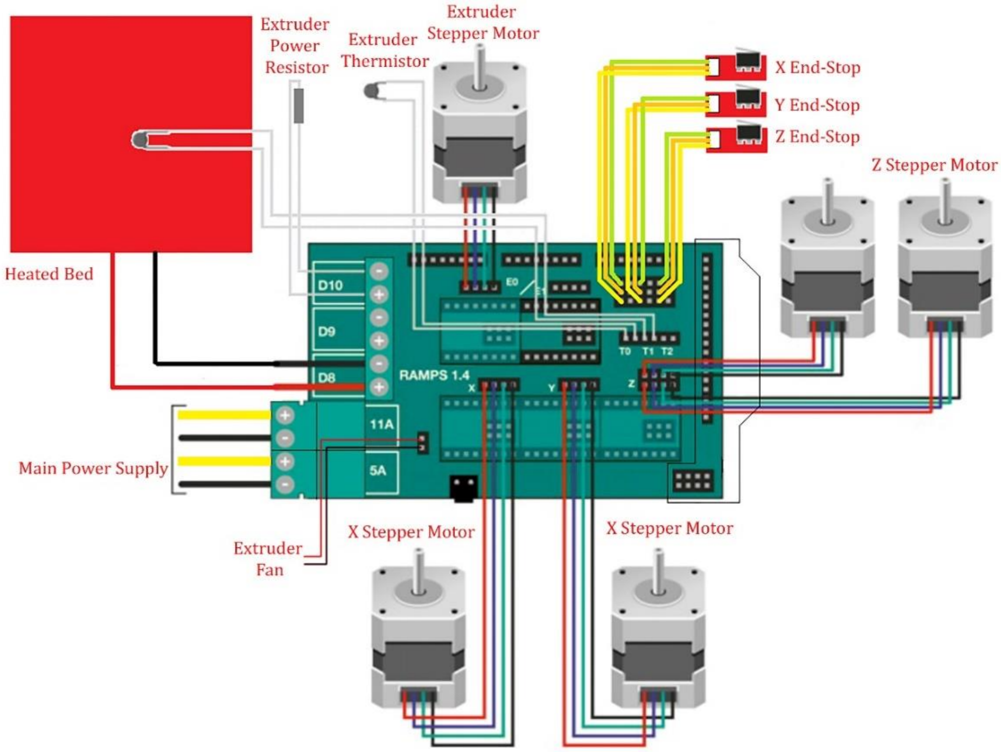


FIG 23: ELECTRICAL CONNECTIONS

CHAPTER 6

FIRMWARE

6.1 Introduction

Firmware is the permanent software used in read-only memory(ROM) in the form of nonvolatile memory in a computer program that provides to control the device in hardware. It can provide a standard operating environment to the devices to more complex software that allows hardware to run on the operating system (os), to perform various devices to complete all monitoring and other manipulation functions. The firmware is used for different purposes like consumer appliances, computer peripherals etc. 3D printer electronic devices are controlled by CPU such as Intel processor and Based on Arduino microcontroller used in the 3D printer. These processors are used in the computer to run the primitive software. The firmware of entire software makes the 3D printer work, the firmware portion of it is the closest you get to actual programming. Therefore, the term what you are doing with firmware is called cross-compiling.

6.2 List Of Firmwares

- Sprinter
- Teacup
- SJFW
- Marlin
- Sailfish

Marlin is an open source firmware in which any of RepRap family to replicate in Rapid prototyping and it is popularly known as a 3D printer. It was obtained by Grbl and Sprinter and it became open source for all 3D printer. Marlin is used for a respected 3D printers like ultimate, Prusa, and Printrbot for just a few of the vendors who ship a variant of marlin. Marlin runs in 8-bit microcontrollers the chips are at the center of open source reference platform for marlin Arduino Mega2560 with RAMPS 1.4. Marlin is firmware can be used in any of single-processor electronics, like supporting for ultimaker, ramps, and several other Arduino2570-based on 3D printers. It

supports printing over USB or from SD cards with folders and uses look-ahead trajectory planning. Marlin is licensed under the GNU GPL v3 or later. It is based on sprinter firmware, licensed under GPL v2 or later. Marlin Firmware runs through a 3D printer's main board, to manage all the real-time activities on the machine. It coordinates the heaters, buttons, sensors, steppers, LCD display, lights and everything will be involved in the 3D printing operation. Marlin implies on additive manufacturing process called as FUSED DEPOSITION MODELING. In this process a motor pushes the thermoplastic filament into a hot nozzle which melts and extrudes the material while the nozzle is moved under computer control. After several minutes it start laying layer by layer to form a physical object. The control-language for Marlin is used to derivative of G-code. G-code gives commands about machine to do simple things like to "set heater 1 to 210°," or "move to XY at speed F." To print a model through Marlin, it must be converted to G-code using a program called a "slicer." Since every printer is different, but we won't find G-code files from download we should need to slice by yourself. As Marlin receives movement of all commands it allows themselves into a movement queue to be executed in the order received. The stepper will interrupt the processes for queue and they start converting linear movements into precisely-timed electronic pulses to the stepper motors. Even at modest speeds Marlin needs to generate thousands of stepper pulses every second. Since CPU speed limits how fast the machine can be moved, we're always looking for new ways to optimize the stepper interrupt! Heaters and sensors are managed in a second interrupt that executes at much slower speed, while the main loop handles command processing, updating the display, and controller events. For safety purpose in Marlin firmware it will actually reboot the CPU gets too overloaded to read the sensors.

6.3 Steps to install firmware

Step 1: The first step in firmware is to be download the Arduino IDE from the Arduino website and install it following the usual procedure for your OS. Marlin can be compiled in Linux, Windows, and Unix.

Step 2: Download marlin firmware source code from website choose the proper version based on code bases from the given website.

Step 3: See Configuring Marlin for an explanation of the configuration file format and a synopsis of most of options in these files to specify which hardware is in use.

Step 4: Verify/Compile the firmware using Arduino.

Step 5: connect the controller to PC via USB cable Step 6: upload the firmware program to controller CPU.

CHAPTER 7

EXTRUDER

7.1 Peristaltic Principle

As with any kitchen, you have to keep your space clean and maintain hygienic standards. And so, a clean printer is a must.

The tubing is fixed between the tube-bed and the rotor at each roller location the tubing is squeezed • position A, B and C

- the tubing is continuously squeezed by the rollers which push the liquid in the direction of the revolving rotor
- The rollers on the revolving rotor move across the tubing
- The tubing behind the rollers recovers its shape, creates a vacuum and draws liquid in behind it.

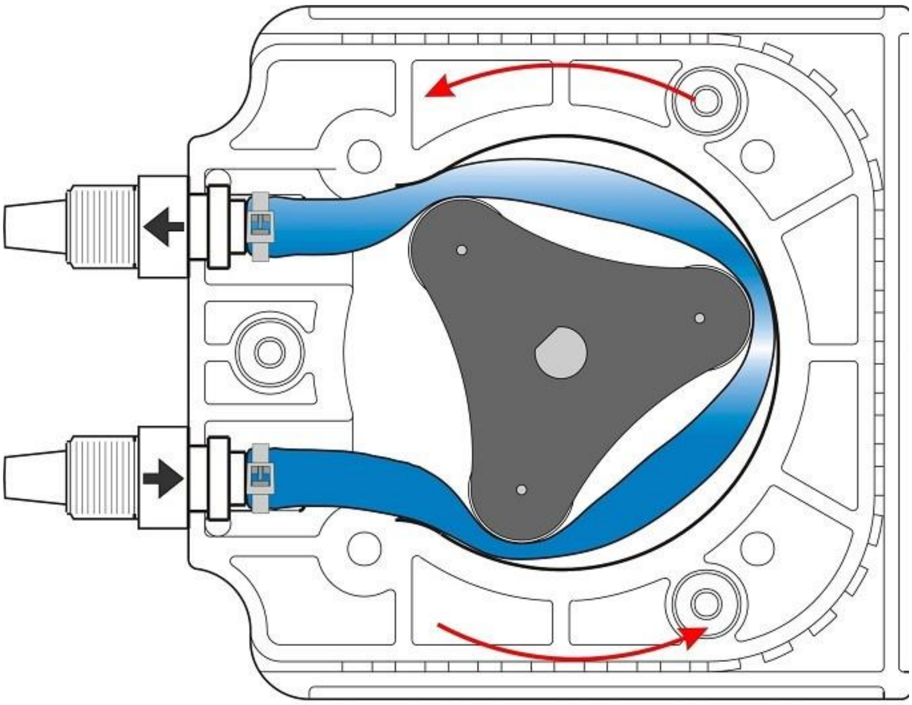
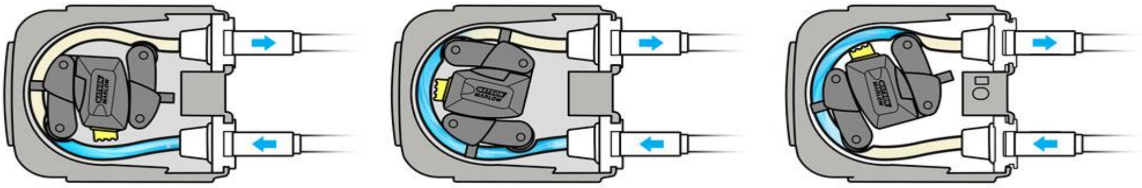


FIG 24: PERISTALTIC PUMP

7.2 Peristaltic Principle

A 'pillow' of liquid is formed between the rollers

- the pillow is the pump chamber and determines the volume per roller step and, hence, the flow rate
- the pillow volume not only depends on the inner diameter (i.d.) of the tubing, but also on the tubing properties, the drive and pump-head specifications as well as the liquid and the physical application conditions
- The pillow volume determines the roller-step volume which depends on
- Pump system
- number of rollers
- pump-head design - e.g. spring-loaded tube-bed
- occlusion setting
- rotation speed
- Liquid
- type of liquid
- temperature
- viscosity
- Application conditions
- suction lift / vacuum
- differential pressure
- Tubing
- inner diameter
- wall thickness
- formulation
- age of tubing



7.3 Flow Rate

The flow rate is calculated as follows:

- Volume per roller step (pillow volume) x Number of rollers = Volume per revolution
- Volume per revolution x Rotation speed per minute = Flow rate per minute

7.4 Advantages

no contact of the liquid with mechanical parts

- tube is only part to wear
- service and maintenance costs are minimal
- easy to clean and sanitize
- multi-channel systems available
- Ismatec pumps available up to 24 channels
- insensitive to dry-running
- self-priming
- excellent suction height
- use tubing with small i.d., thick wall and stiff material
- no siphoning effect when pump is stopped
- immune to many chemicals
- depends on the tubing material
- suspensions and sludge can be pumped
- with a solid content of up to 60%
- virtually immune to abrasive media
- liquids of high viscosity can be delivered
- gentle delivery due to very low shearing forces

- ideal for delicate suspensions e.g. blood cells or bio-technological media are not damaged
- some tubing material can be autoclaved
- very high repeatability - suitable for auto-analyzers
- pumps system must be calibrated

7.5 Limitations

- slight pulsation is inevitable
- tubing requires recalibrating and changing
- due to wear
- at certain intervals depending on the application
- very important for accurate and repeatable pumping
- more frequently in comparison to gear and piston pumps
- tubing may leak after extensive us
- depending on the pump-head system the flow
  rate is sensitive to varying differential pressure
- conditions (all spring-loaded tube-beds!)
- accuracy and repeatability of the flow rate also
  depend on the tubing age and material used
- max. differential pressure is lower in comparison
  to gear and piston pumps
- depends very much on tubing material and inner diameter

in relation to wall thickness

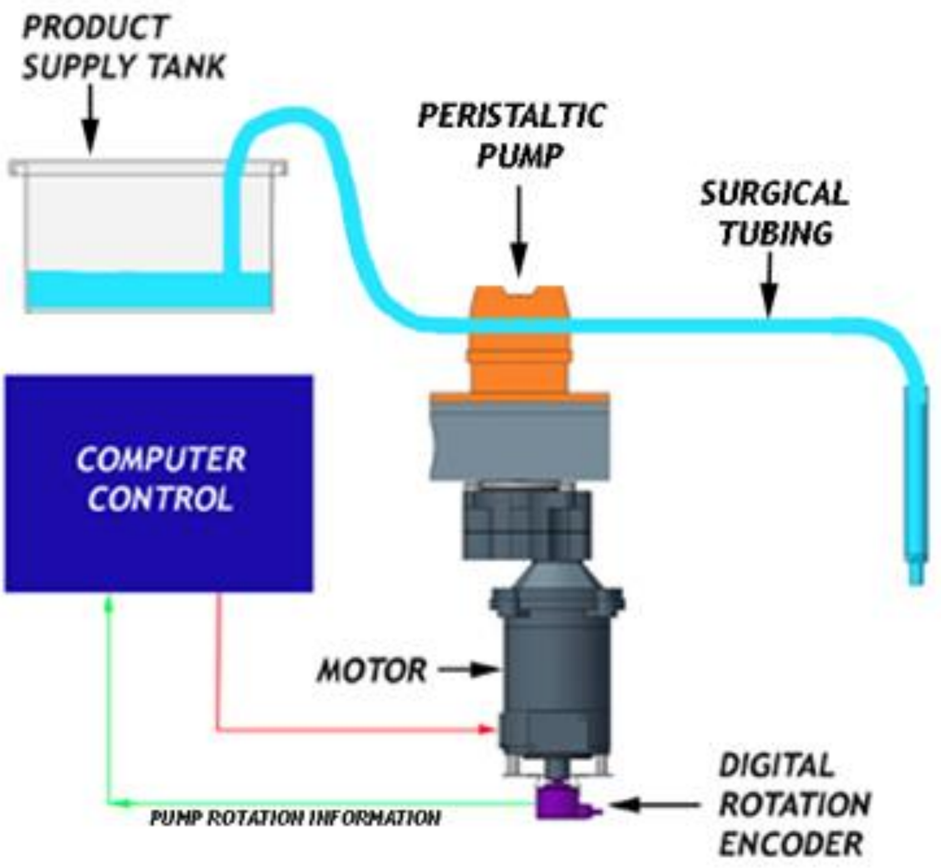


FIG 25: PUMP ASSEMBLY

7.6 Tubing Size

The tubing is the pump chamber of the peristaltic pump and, hence, one of the most important parts!

The following tubing specifications have particular effects on the pumping process:

- inner diameter (ID)
- wall thickness (WT)
- material (formulation)

Different combinations of these parameters change the pumping behaviour and consequently lead to different results.

7.7 Tubing Life

- Life expectancy of the tubing depends on the following features:
- tubing material
- drive speed
- number of rollers
- operating temperature
- pressure conditions
- liquid used
- chemical composition, particles, etc
- tube-bed and roller design
- Ismatec catalogue provides overview of approximate tubing life

8 PROS AND CONS OF FOOD PRINTING

PROS

1. Reliability: You want to have every 3D print as precise as the last one. With 3D printing food, the needed tolerances can be achieved. But the result usually is limited in the texture – unless you can 3D print fragile structures with sugar.

2. Speed: 3D printing a whole meal in a restaurant takes a lot of time… and if there 's one thing chefs don't have, it's time! All in all, 3D printing food still is way too slow for mass production.

3. Cost: Specialized food 3D printers are expensive. If you want to save money, you can mount any 3D printing food nozzle mounted on your regular printer. But only the specialized food 3D printers will give you satisfactory results.

4. Safety: When it comes to food, you don't want to play with your health. So, every aspect of a food 3D printer has to be clean and food-safe.

CONS

1. Nozzle movement speed and extrusion rate affect the quality of 3D food printing

2. The extruder assembly should be as rigid as possible, especially for chocolate 3D printing

3. A effective active cooling system is needed for chocolate 3D printing

9. FUTURE SCOPE

Refinement of the printing mechanism, material composition, temperature control means will lead to better result output from the machine and hence enhance the reputation of practicability achieved by 3D printer.Further development of this technique will lead to the printer being more economical and will reach the masses.Introduction of industrial-size 3D printer will give rise to a new industry which caters to the personalised need of consumers where consumers can give their designs over the internet and the company will print their concept with specified material, followed by professional refinement of the print produced and eventually delivering it to the consumer’s footstep.Other viscous materials printing may be achieved by varying these parameters: Temperature control of extruder and conditioned region (depending on the melting and solidification points of material), extruder nozzle diameter (depending on viscosity of material to be printed).

10. CONCLUSIONS

Preparing a Chocolate printer is a challenging task and may require extensive knowledge of basics of engineering to solve the numerous problems that come along in the way. These issues can be easily resolved if we follow the scientific methodology of problem solving. Chocolate 3D printer has multiple advantages over traditional and conventional processes involved in manufacturing of chocolate items. It allows us to create personalized and customized items. It has several applications in confectionary industry. Other viscous materials can also be used in the same framework with minimal changes.

As we know the 3D printing machine has high cost in the market, so we tried to optimize its cost in every possible manner and made a 3D printer which cost around Rs. 16000/- which is much lower than market price.

Our 3D printer has accuracy of up to 100 microns. This optimization will be helpful in society and in the field of manufacturing. In future it may be possible that the 3d printer can be easily installed in household at cheaper cost. Since this technology growing day by day, it creates great impact in today's world and their might be huge scope in this field

11.REFERENCES

[1] A. Ramya and Sai leela Vanapalli, 3d Printing Technologies In Various Applications.
International Journal of Mechanical Engineering and Technology, 7(3), 2016, pp. 396–409.
http://www.iaeme.com/currentissue.asp?JType=IJMET&VType=7&IType3

[2] Millen, C. I. (2012). The development of colour 3D food printing system. Master thesis. Massey University. New Zealand.

[3] Dr. Rajashekar Patil, Deepak D, Dharshan Gowda S, Krishna Kashyap C S, Mohammed
Murtaza, Prashanth S N, Harsha N and Bharath V G, Economical 3d – Printer by Adopting
FDM Technique, International Journal of Mechanical Engineering and Technology, 8(4),
2017, pp. 442-447.

[4] Hideo Kodama, "Automatic method for fabricating a three-dimensional plastic model with photohardening
polymer," Review of Scientific Instruments, Vol. 52, No. I l, pp 1770-1773, November
1981

[5] Hideo Kodama, "A Scheme for Three-Dimensional Display by Automatic Fabrication of Three-
Dimensional Model," IEICE TRANSACTIONS on Electronics (Japanese Edition), vol. J64-C,
No.4, , April 1981

[6] Barton, C., Raynor, S. 1968. Peristaltic flow in tube [7] Amon, C. H.; Beuth, J. L.; Weiss, L. E.; Merz, R.; Prinz, F. B. (1998). "Shape Deposition
Manufacturing With Microcasting: Processing, Thermal and Mechanical Issues"
Journal of Manufacturing Science and Engineering 120 (3).

[8] Neethirajan, S., & Jayas, D. S. (2011). Nanotechnology for the food and bioprocessing industries. *Food and Bioprocess Technology*, *4*(1), 39–47.

[9] Wegrzyn, T. F., Golding, M., & Archer, R. H. (2012). Food layered manufacture: a new process for constructing solid foods. *Trends in Food Science & Technology*, *27*(2), 66–72.

INTERNET SOURCES

[10] http://marlinfw.org/

[11] https://all3dp.com/

[12] https://www.arduino.cc/