

DESIGN AND FABRICATION OF STEERING WHEEL USING RAPID PROTOTYPING TECHNOLOGY

Submitted in partial fulfilment of the requirements for the award of Bachelor
of Engineering degree in Mechanical Engineering

By

S. MUKESH ARAVIND (Reg. No. 38150706)

S. SUKESH KUMAR (Reg. No. 38150116)



**DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of S. MUKESH ARAVIND (38150706) and S. SUKESH KUMAR (38150706) who carried out the project entitled "**DESIGN AND FABRICATION OF STEERING WHEEL USING RAPID PROTOTYPING TECHNOLOGY**" under our supervision from September 2021 to April 2022.

Internal Guide

Dr. M. ANISH., M.E., Ph.D.,

Head of the Department

Dr. G. ARUNKUMAR, ME., PhD.,

Submitted for Viva voce Examination held on _____

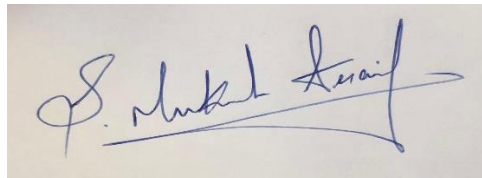
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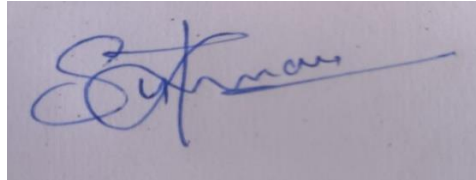
DECLARATION

We S. MUKESH ARAVIND (38150706) and S. SUKESH KUMAR (38150706) hereby that the Project Report entitled “**DESIGN AND FABRICATION OF STEERING WHEEL USING RAPID PROTOTYPING TECHNOLOGY**” done by us under the guidance of **Dr. M. ANISH, M.E., Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

1.

A handwritten signature in blue ink, appearing to read 'S. Mukesh Aravind', with a long horizontal flourish extending to the right.

2.

A handwritten signature in blue ink, appearing to read 'S. Sukesh Kumar', with a long horizontal flourish extending to the right.

DATE:
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SIGNATURE OF THE CANDIDATE

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ABSTRACT

The project is about the design and construction of four steering wheels using Rapid Prototyping technology. In the early days the steering wheels in cars were made of steel that was covered with wood. As the time passed, wood has been replaced by plastics like Bakelite, not only because of the cost but also because the wood can disintegrate or break in middle of use which might cause serious injuries. In the 1950's it was popular to hit steering wheels with real or artificial leather, which gave drivers better grip. Most modern wheels we use now have an almost excessive number of functions. But whether we are nostalgic or not, the horn has always been a factor. Since the 2000s, many functional elements have been included in our steering wheel. We have Radio controls such as tuning and volume, cruise control, phone and on-board computer function - all of these can be operated with small buttons on what are now called "multifunction steering wheels." Air bags have also been added. Therefore, by using this modern method of Rapid Prototyping the driver who is driving the car will be a feel ride.

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CHAPTER 1

INTRODUCTION

1.1 3D PRINTING

3D printing is an additional production process in which CAD (computer aided design) is used to print 3D objects. Various methods are accessible in 3D printing technologies such as (1) FDM (integrated compositing method), (2) SLS (selective laser sintering) (3) EBM (electron beam machining, (4) LOM (laminated object processing), (5) I -DLP (digital light processing), etc. Here, we focus on the development and production of an economically viable Steering Wheel. Which we adopt FDM technology, where it separates substances such as PLA (polylactic acid), ABS (acrylonitrile butadiene styrene), HIPS (high impact polystyrene), etc. Material -filament is heated in its melting point which deposits in layers. The fusion of many layers of this kind will provide us the ultimate 3D model.

A 3D printer is a production method with additions in which the sand parts of 3D objects are made with the adding up of multi layers of objects. This is known as rapid prototyping. This is a technique where instant 3D objects are fabricated according to the necessary size machine attached to a software of computer that contains blue prints for any object. The method of addition changes from the extraction process, in which the component is separated from the block by drawing or piercing. The important purpose for using a 3D printer is 90% of the material used which extends the life of product, simplicity and durability. 3D printing is well used in different fields such as aerospace, automotive, medical, construction and household products.

1.1.1 Cartesian Configuration

Cartesian 3D printers are best crafted with X-axis, Y-axis and Z-axis coordination system shown in Fig 1.1 used to decide the three-dimensional motion and Cartesian 3D printers have a hot bed that moves only on the Z-axis. The extruder resides on the X-axis and the Y-axis, so it can proceed in all four directions. The principle that is shown in the performance of models from Ulti maker and Make Bot. With the Print bot instead of head of the printer is moving

instead of XY only, one axes is replaced by operating the printer bed itself. It's a simple and easy model, so it is easy to sustain, but at the expense of speed of printing.

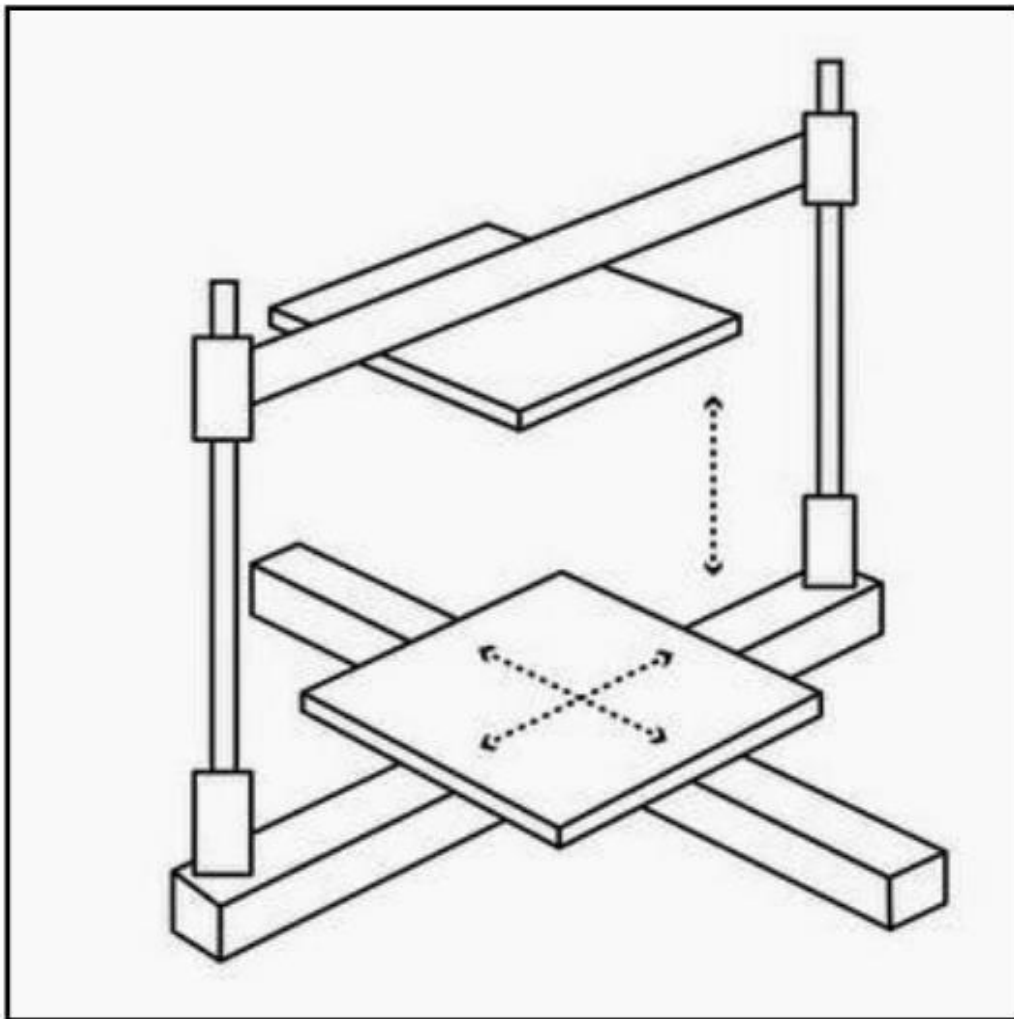


Fig 1.1: Cartesian Configuration

1.1.2 Delta Configuration

Delta 3d printers have a ring-shaped print bed as shown in Fig 1.2 The extruder swings further with three arms in the triangle configuration thus becoming the name "Delta". These robots are planned for speed and have the benefits of a durable print bed that can be useful for certain prints. The advantages of the Delta configuration will be easier to move because the parts which are moving are not heavy which will result in great accuracy and printing in faster face. Many "traditional" printers have platform that moves. This means that the object you are printing is constantly moving which can lead to top prints loosening due to incessant movement and improper printing especially when printing is high.

Delta configuration is very high and it is better to build high objects because the stage is fixed. They tend to be high however which creates a huge build capacity. Because of this they are built it is easier to make them bigger (not wider but certainly higher). When the whole construction is very simple and uses very small parts it will reduce the maintenance and cost. Due to the construction of the arm, it should be much longer than your building capacity.

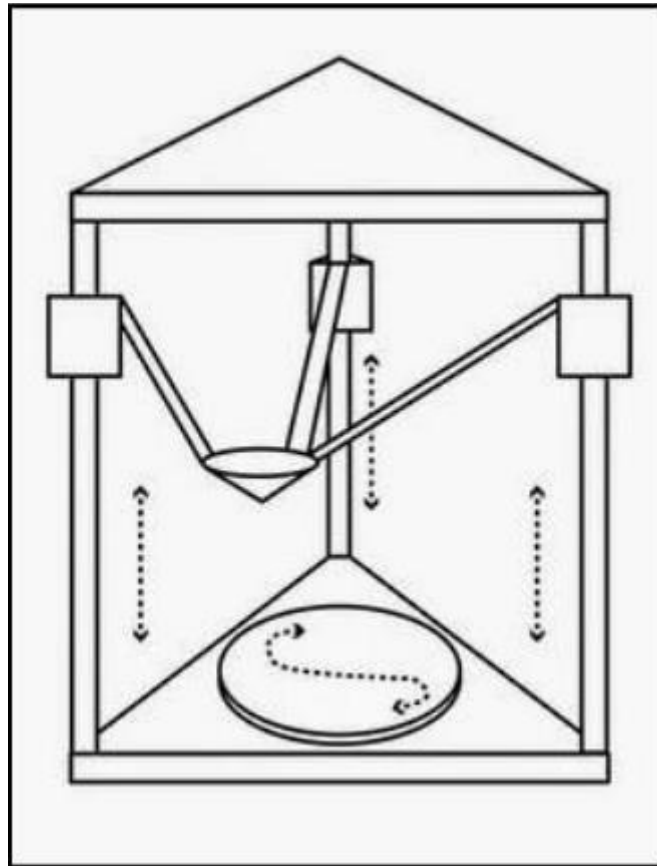


Fig 1.2: Delta Configuration

1.1.3 Scara Configuration

The Selective Compliance Assembly Robotic Arm is abbreviated as the SCRA- type robot system has freedom of three degrees and is operated by three servo motors to perform one straight and double horizontal motion. The 3d print feed system is located at the back of the robot and is extensive at the other-end of the robot arm.

1.2 PRINTER

The design is mould to STL, it must first be tested for "errors", this step is called "fix up". Many of the applications that CAD can create errors in the output of STL error such as skel intersection, incorrect holes; normal surface needs to be fixed. File has been transformed to STL, the file must be sort out with software known as "slicer" that model is converted into a series of layers and produce instructions of G code file for specific 3D printer instructions. Actually, client software and cutting system are available, including Cura, Slic3r, repetier host, pronter face and skein forge and closed source systems such as 3D simplified and KISSlicer 3D 3D printer follows G code instructions to lay down consecutive layers of liquid, powder, paper or sheet material to create a prototype from the cross sections.

Sand, plastics, metal etc. is used using a printing mouth. These layers, corresponding to the visible in the CAD model from cross section, are automatically integrated or merged to produce the final design. Based on work the printer does, the process may take more minutes or hours. Printer adjustment refers to the thickness of the layer and the dots with X-Y adjustments per micrometers (μm) or inch (dpi). The thickness of the available layer may be around 100gm, the connex object series and the 3D Systems ProJet series printed as fine as 16 μm layers. This adjustment (X-Y) compared to that of printing in laser method. Particles (3D dots) are around 50(510 Dpi) μm to 500(250 Dpi) μm in diameter.

Model Design can take a few hours to a few days, depending on the size of the model, the used method, the speed of printing, and the complication of the model. Generally, the time can be minimized depending on the machine used by few hours and the size. 3D printers provide concept and design models using the 3D printer desktop size.

1.2.1 Photopolymerization

Cutting of photo reactive polymers/ resins with laser or UV light (Ex: SLA, MATERIAL JETTING, TPP)

1.2.1.1 Stereo lithography Apparatus (SLA)

The Stereo lithography Apparatus (SLA) method was developed in 1986 and was used commonly in start of 3D printers. Printers that use stereo lithography to focus the UV rays over the surface to be replicated. The object is filled with filament called resin. As shown in Fig 1.3 when the light hits the frame, you get a 3D model of high clarity of the model used.

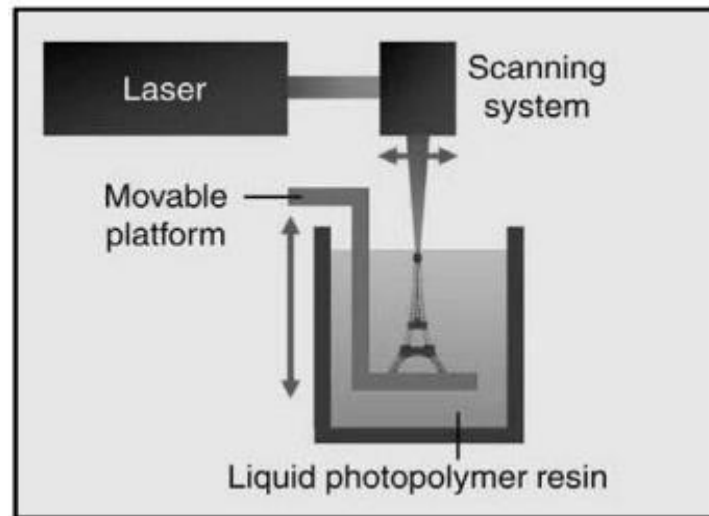


Fig 1.3: Stereo lithography Apparatus (SLA)

1.2.1.2 Material jetting

The Material jetting is a unique, the only additive manufacturing technology that can be a coalition of many various print material with similar 3D print model inside the print job. As said in Fig 1.4 printer uses photopolymer resin and support resin. Multi 18 material is evidently a printing process that is very capable of building functional assemblies that reduces the need for more construction. With the right ASTM level of jetting of objects, the only way in which there are other droplets that can form material can be added by selecting a hot bed to create a 3D object.

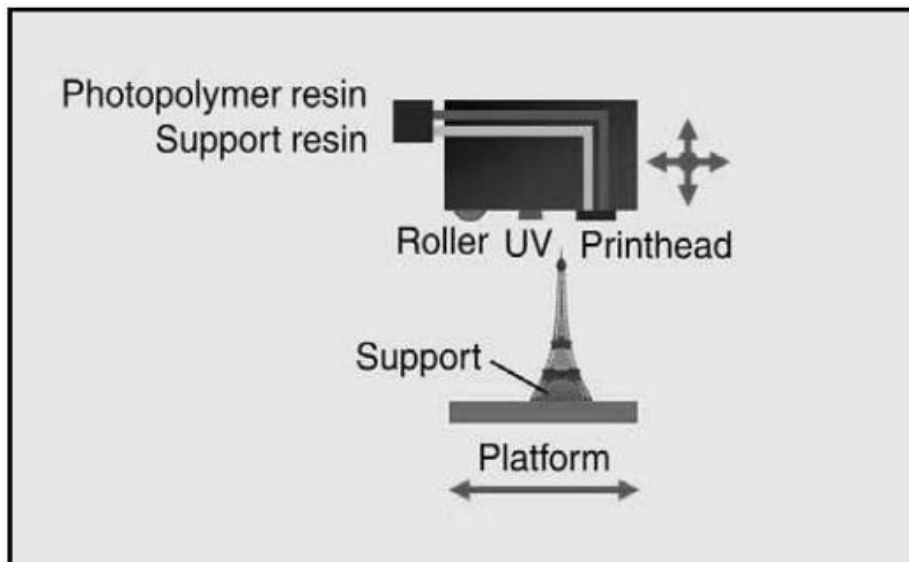


Fig 1.4: Material jetting

1.2.1.3 Two photon Polymerization (TPP)

Two Photon Polymerization (TPP) is a promising three-way technique recently attracted a lot of notice based on photon polymerizations with ultra-short laser pulses. It is by focusing on the volume of the photo sensitive image the pulses begin to absorb as in Fig 1.5 two photon polymerization two photons subsequent and absorption polymerization.

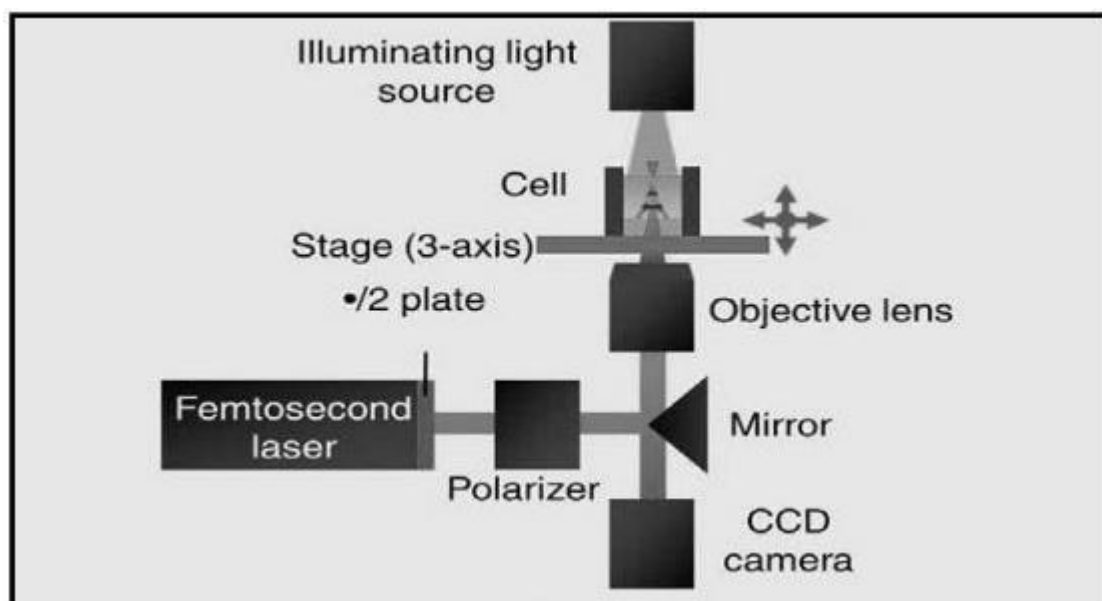


Fig 1.5: Two photon Polymerization (TPP)

1.2.1.4 Selective Laser Sintering (SLS)

Selective Laser Sintering (SLS) is a fast-paced measurement that creates media in the form of a powder, which is compacted using a carbon- dioxide which is a powerful laser used to produce the final product. Selective Laser Sintering as in Fig 1.6 uses a powerful carbon-dioxide laser to assemble micro particles of powdery mildew to form three dimensional particles. If the laser from which it will be selected will assemble the powder by scanning the opposite parts of the X&Y over the top of the powder bed. The design is construct single layer at once from 3D CAD data provided SLS is very effective of building the most durable parts of realistic testing.

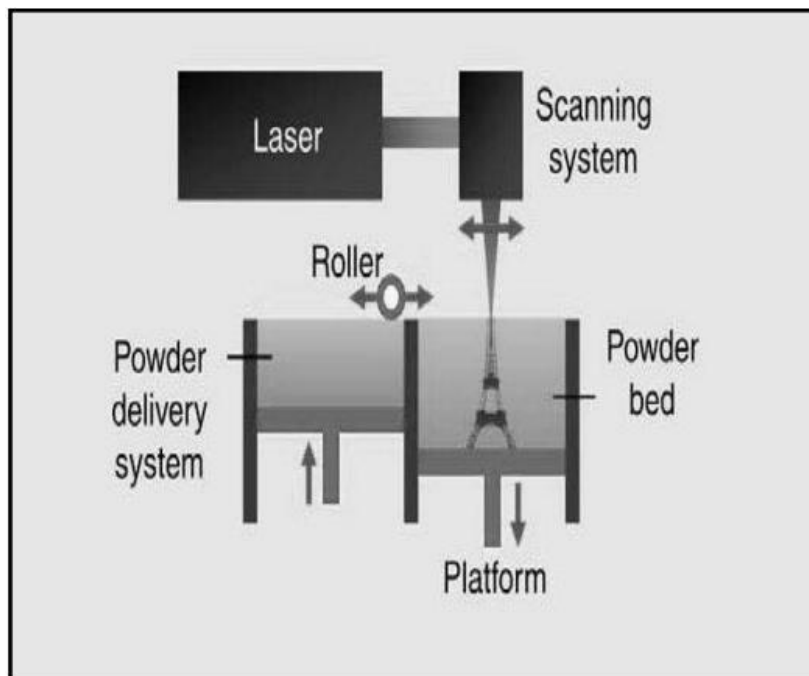


Fig 1.6: Selective Laser Sintering (SLS)

1.2.1.5 Binder Jetting

Binder Jetting is a rapid prototyping here in Fig 1.7 the jet material in the binder is jetted and is sprayed selectively on the powder bed of part where material to mix the required part layer at a time to 3D print.

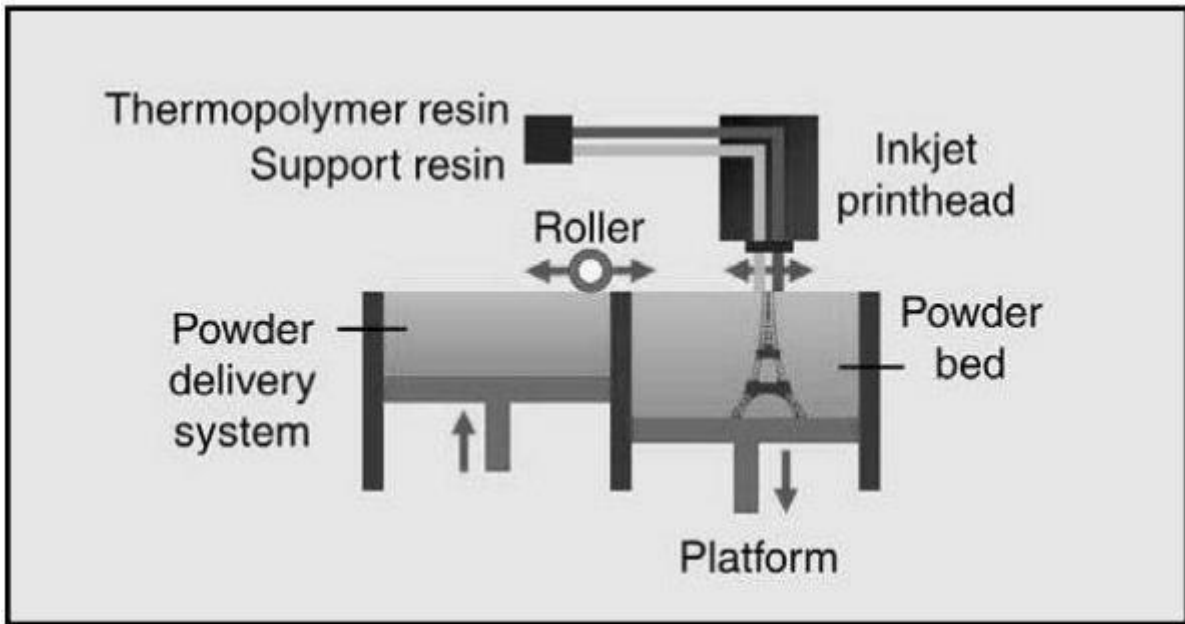


Fig 1.7: Binder Jetting

1.2.2 Material Extrusion

Extruding a filament at appropriate temperature (Ex: FDM, DWA)

1.2.2.1 Fused Deposition Modeling (FDM)

The process in a machine applies a resin (wax or thermoplastics). On or near the same object, to create a hot or sticky joint as shown in Fig 1.8.

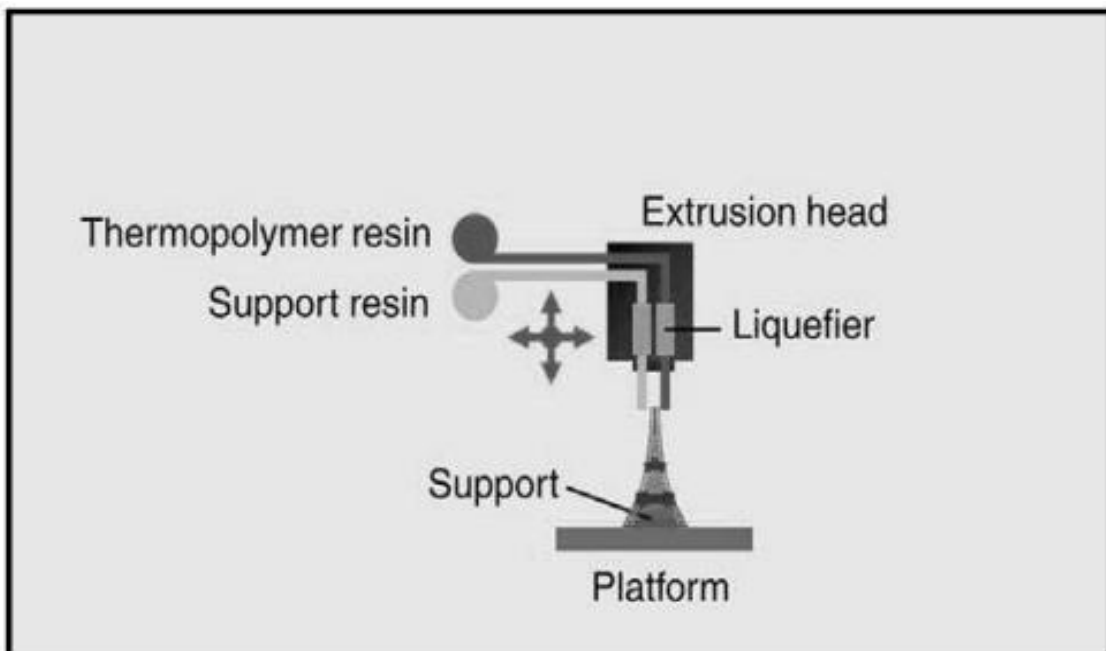


Fig 1.8: FUSED DEPOSITION MODELING(FDM)

1.2.2.2 Direct Writing Assembly (DWA)

Direct writing assembly is to express the practical techniques that is used in the control phase of a computer that will move a device that produces a hole in the ink input pattern to form many objects that may be under architectural and design control as we in Fig 1.9.

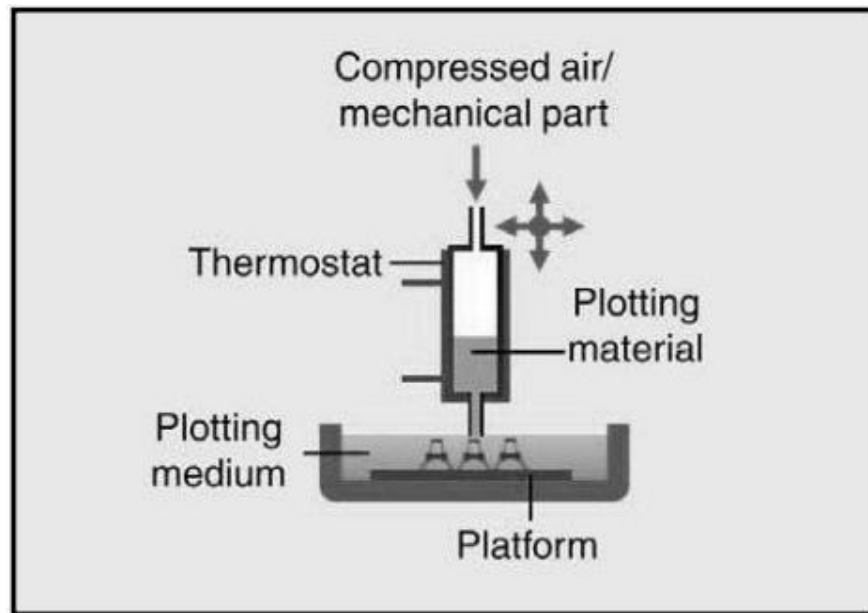


Fig 1.9: Direct Writing Assembly (DWA)

1.2.3 Lamination

Layering sheet materials which are cut and laminated together

1.2.3.1 Laminated Object Manufacturing (LOM)

In Laminated Object Manufacturing technology, coated objects are rolled into the platform area. Items covered with adherent layer and feeding roller starts to heat up to melt the resin. Then high point layer will be attached to the before one. A laser will be used to design the geometry of the material to be constructed and to design crosses throughout the space to facilitate the removal of the final material.

1.2.3.2 Selective Deposition Lamination

This method involves paper-coated layers that are tightly wrapped with a hot roller and cut in the essential manner with the laser cutter by layers. As in Fig 1.10 when the roller with these materials which move each sheet of new component over

the last one and repeat the process of object is finished.

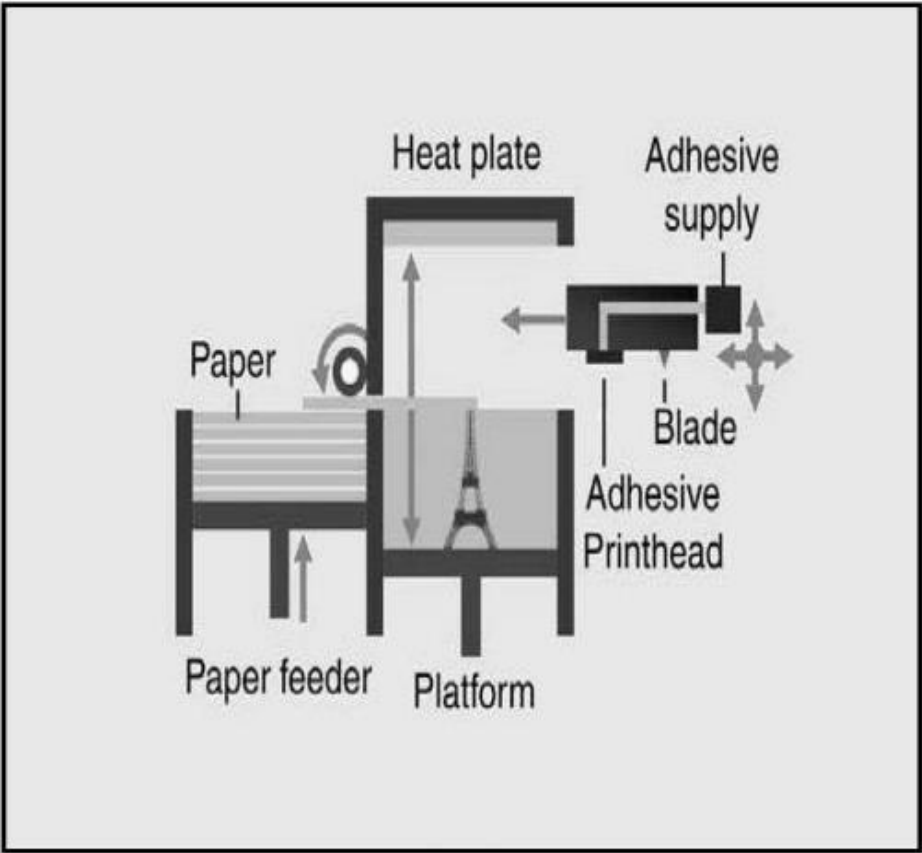


Fig 1.10: Selective Deposition Lamination

1.3 MATERIALS USED IN FDM 3D PRINTING

There are different filaments widely used in 3D printing in various factors and production purposes. Those are mentioned in Table1.1

Table 1.1: Materials used in FDM 3D Printing

MATERIAL	DESCRIPTION	PRINTING TEMP	BED TEMP
PLA	PLA (Poly lactic Acid) is one of the two mostly used 3D printer desktops (one is ABS). It is the items that is default suggest by many 3D printer desktops and that for a better reason - PLA is useful for a wide range for print	180 - 220	20 - 55

	application most importantly its odorless and low wrap.		
ABS	ABS (Acrylonitrile Butadiene Styrene) is widely used 3D printers. It is used to make solid parts which can withstand high temperature. In collation with PLA,ABS plastic has strength a little higher than PLA. Acetone can be handled to provide a shiny finish.	220-235 °C	80-110 °C
Nylon (Polyamide)	Nylon is highly durable, very strong and has many 3D printing. It is very bendable when it is fine but adheres very well between layers and nylon is able to borrow well from such things as living hinges and various functional components.	235-270 °C	60-80 °C
PET (Polyethylene Terephthalate)	PET (Polyethylene terephthalate) has a several great features which is used as an industrial strength filament. It as a strength which is elevated than PLA, it is FDA accepted for the tool we use for food consumption and the for the food containers, it barely warps, and odorless and produce no fumes when printing. PET is not a bio degradable filament so it is completely reclaimable.	230-255 °C	55-70 °C

TPE	TPE filament is a bendable 3D printing method that material sense and acts much like flexible rubber. TPE filament can be used to make bendable or flexible parts to suitable surrounding - phone cases, stoppers, belts, springs, and more.	210-225 °C	20-55 °C
TPU (Thermoplastic Polyurethane)	TPU is a material that is resistant to elastic grease and abrasion with Shore95A hardness. TPU has a variety of applications running internally car metal panels, sports goods, electrical tools, caster wheels.	240-260 °C	40-60 °C
LAYBRICK	LAYBRICK is a 3D printing function that makes a look and sense of a gray stone while keeping the durability of the plastic, making it for architectural and landscapes designs. LAYBRICK structures are be sanded and painted.	180-200 °C	20-55 °C
LAYWOO-D3	LAYWOO-D3 is a 3D wood-like printer that gives 3D printer which look and sense of material as fiberboard. It also focuses on parts and other features such as wood, such as cutting, painting, and sanded.	175-250 °C	30 °C

Gel-Lay	Gel-Lay is distinguished as a very porous sticky like substance. This 3Dprinting material is made of rubber-elastomeric polymer and part of PVA. When you wash the item in water, part of the PVA vanish then the micro porous object remains as a rubber.	225-235 °C	20-55 °C
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CHAPTER 2

LITERATURE SURVEY

Arvind et.al. (2013) [1] Project on developing a car turn radio that uses a four-wheel-drive steering wheel. The main purpose of this work is to reduce the vehicle's rotating radius using a standard four-wheel drive (4WS). The analyzed system here is a mechanical connection between the front axle and rear axle with a rack and pinion steering system on bilateral ends.

DishankBari et.al. (2014) [3] Project on Designing and manufacturing a turning Radius measuring system. Production vehicles are planned to be under control and rarely do over steer. If the vehicle can automatically compensate for the steering directing problem, the driver can enjoy moderate steering under different operating state. A four-wheeled drive steering wheel is a major effort on the part of automotive engineers to provide a steering wheel near the center.

Rajashekar Patil et.al. (2017) [4] In this paper we are focused on the design and production of a portable 3D bed frame (150 x 180 x 200 mm³) that can be economically constructed. We use 4 axes where 3 axes are x axis, y axis, z axis and the fourth axis is the extruder. The process we adopt is FDM method, where it separates substances such as PLA (polylactic acid), ABS (acrylonitrile butadiene styrene), HIPS (high impact polystyrene), etc. the filaments heated in its melting point and inserting it layer by layer. The combination of many layers of such type will give us the ultimate 3D model.

Ismail Durgan et.al. (2014) [6] The mechanical properties and surface finish of functional parts are important consideration in rapid prototyping, and the selection of proper parameters is essential to improve manufacturing solutions. The purpose of this paper is to describe how parts manufactured by fused deposition modelling (FDM), with different part orientations and raster angles, were examined experimentally and evaluated to achieve the desired properties of the parts while shortening the manufacturing times due to maintenance costs.

Hye Won Lim et.al. (2019) [10] This work introduces significant improvements to the electrical properties of 3D printed parts through the distribution of multiwall carbon nanotubes (MWCNTs) using a twin-screw micro-compounding extruder with space for back flow channel. The composite structure obtained and processed on a single 3D printing thread; 1.7 mm wide. Consumer, electrical and melting fluid components of the MWCNT reinforced ABS component, with up to 10% load being introduced for the first time in this project, using a commercial 3D printer.

Izabela Hager et.al. (2016) [11] The paper introduces the modern state of the present world in the field of 3D printing and building materials. 3D printing technology, when compared to creative architectural techniques, can be considered as a natural alternative that offers almost unlimited possibilities for the realization of geometric complexity. Two types of techniques were described in this paper by identifying Contour Crafting as a promising approach the construction industry that could transform them in the near future. Many of the benefits of this technology, such as reducing costs and time, reducing pollution and reducing injuries and deaths in construction sites. Despite the many advantages and disadvantages, some concerns are summed up in conclusions, as technology still has its limitations.

Popescu et.al. (2018) [18] Designing and producing functional components for sectors like engineering and medicine is a major goal of Fused Deposition Modeling (FDM). These functions are based on the knowledge of how the different process parameter settings affect the mechanical behavior of the products. However, obtaining this information is a daunting task when it comes to the complexity of 3D printers-slicing software-process parameters. Therefore, the importance of studying current research of this subject is to identify useful and practical features, important process limitations and parameters and to understand how important the results of this study are and can be pragmatic to additional studies and actual applications.

Ramya et.al (2016) [19] The adoption of the 3D printing industry has gradually increased from prototyping to producing selected low-volume components. The need for customizations such as dental crowns, hearing aids, and flexible orthopedic components have led the health science industry to adopt 3D Printing. The need for the remaining low-volume components of old cars and older models makes 3D printing very useful in the automotive industry. It is possible to 3D printing on a variety of materials including thermoplastics, thermoplastic compounds, pure metals, metal alloys and ceramics. At present, 3D printing as the ultimate production technology is still commonplace. But in the upcoming days, and in line with synthetic biology and nanotechnology, it has the potential to dramatically change many design, production and transportation processes.

Vinod Gokhare et.al. (2017) [23] This is a research paper for 3D printing and the various materials used in 3D printing and their structures being a significant topic in the field of technology. First, explain what 3D printing means and what is important for 3D printing. We will go into the history of 3D printing and learn about the 3D printing process and what materials are used to make 3D printed materials and choose the best materials among them that fit our 3D printing machine. Also, see the benefits of 3D printing compared to additional production.

Zhang et.al. (2017) [24] Active-grade materials FGPMs are small structures with a porosity gradient distributed over volume. They have many potential applications in the aerospace, biomedical, and other industries. Despite important efforts to make FGPMs, existing production techniques are complex, expensive, unable to control precise porosity distribution, or cannot create closed cell structures. This paper introduces an additional method for the production of polymer FGPM with both closed cells and open cell structures using thermal bonding techniques.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1. AIM

- I. Our objective here to make a steering wheel using PETG (Polyethylene terephthalate glycol) by a FDM (Fused deposition modeling) 3D printing method.
- II. By preferring PETG for steering wheel to ABS (Acrylonitrile Butadiene Styrene) or metal we can reduce the emission of fumes while recycling or manufacturing.
- III. Polymer material we are using here has same stiffness and lower weight of metal we were using before.
- IV. We can manufacture in large scale and in an untroubled way.
- V. Using this method, we can make it more economical and most importantly eco-friendly.

3.2. SCOPE

The scope of this project is to manufacture a steering wheel without a steel alloy and use polymer PETG (polyethylene terephthalate glycol) material as a substitute of steel alloy. The future of polyethylene terephthalate glycol looks bright as the global market continues to increase and which is eco-friendly at the same time give us the better hardness in lower weight without any emission of fumes while manufacturing and recycling compare to alloy or ABS produces. So, the PETG filament is used to make a steering wheel with FDM printing method.

CHAPTER 4

EXPERIMENT, METHODS, AND MATERIALS

4.1. FABRICATION OF DESIGN



Fig 4.1. Design of steering wheel

4.2. FABRICATION PROCEDURE

The main objective has been clearly studied and various journals are studied to have an in-depth knowledge. The design has been drawn using solid works software. The solidworks software has been chosen as it is one of the user-friendly software. The prototype has been fabricated using the fused deposition modeling method. The PETG material was used for the fabrication of the steering wheel. The final prototype was thus prepared using the 3d printing method and the initial stage of fabrication as shown in Fig 4.2 then the final stage of fabricated prototype is shown in Fig 4.3. The method of fabrication of steering procedure is shown in Fig 4.4 in methodology flow chart.

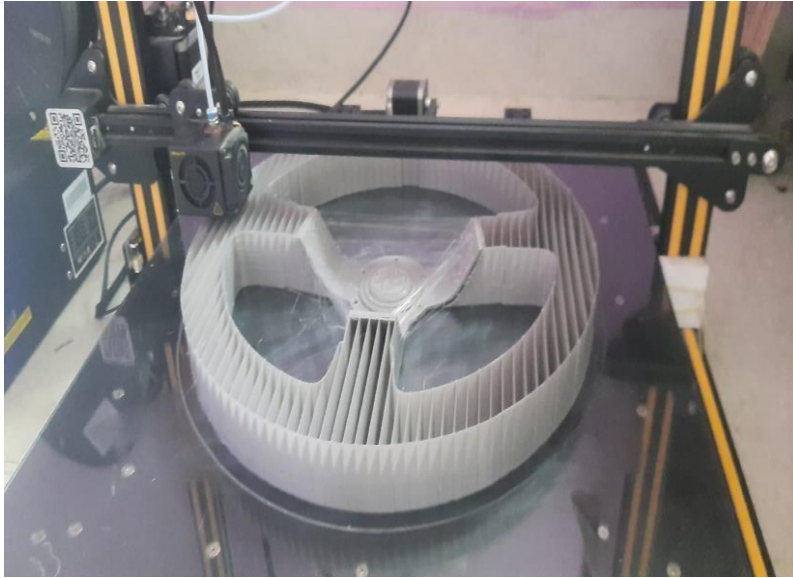


Fig 4.2: Initial stage of fabrication

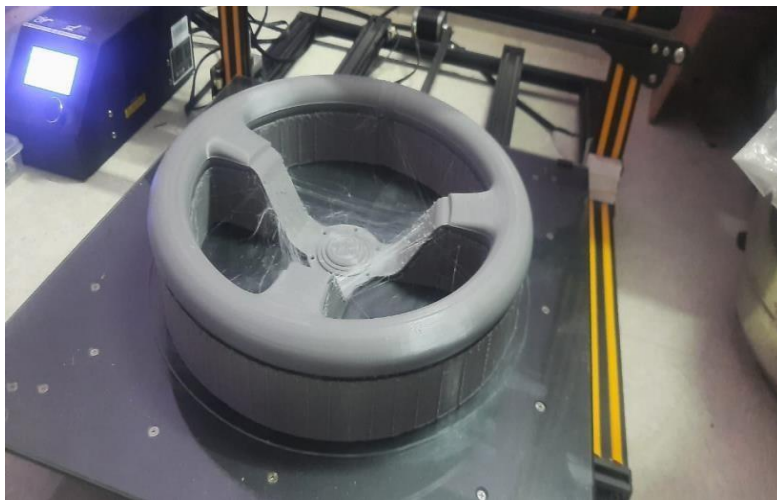


Fig 4.3: Final stage of fabrication

The project scopes are

I. Investigation of the problem.

In this process, the main idea is to identify the problems that occur in the control system that is the steering wheel. Identify hidden problems in the cart control system and write down a possible solution to the problem.

II. Set target specifications

It is based on the type of steering and benchmarks (Measurement is the knowledge of competing products collected to support the stand). Improve metrics for each type of steering wheel to help identify system specifications. Set

the correct and perfect values for each steering system.

III. Conceptualization.

Focus on designing the integration line and creating a custom component of the directional system by making simple drawings known as the thumbnail sketches for each concept. This is a discussion of ideas about the design of the costume made part that will fulfill the required details of the component.

IV. Further refinement and final concept selection.

Draw 2D or 3D with part of the lessons and test the features of the proposed product and performance (solid work). The diagram will be analyzed using Solid Works to obtain the required information such as maximum and minimum stress and safety feature for each component.

V. Control drawing

Here, the main focus is on information about document features, functionality, size, key dimension and surface finish for each component. The information helps to create final project report.

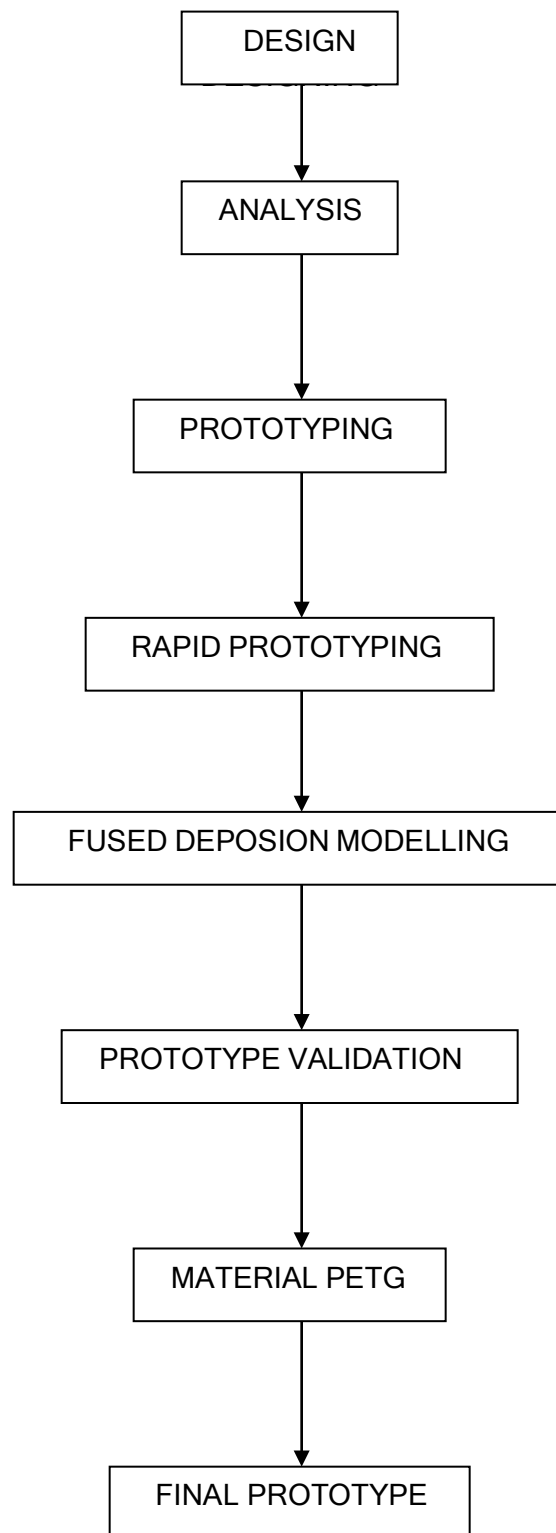


Fig 4.4: Methodology Flowchart

4.3. SOFTWARE

Computer software is a component of a system which contains the data and computer instruction software for all details handled by a computer data and computer program. In 3D printer, software plays a crucial role in uploading details from a location to other location without requiring software being able to make any virtual object that has to be cut and printed inaccessible. The programming platform is an embedded system for C and C++ where the C++ system plays a crucial role in 3D printer the required movement details and parameters are automatically measured and loaded into the controller. Software is a platform for building any 3D model by any 3D software.

4.3.1. Software Used for Designing

Published by Dassault systems, Solid functions are used in the robust engineering computer-aid design (CAD) mode. Works on operating system like Windows 7, 8, etc.

The 3D printed components were built by solid functions to amplify the 3D printer combining with a full model by Solid Works as shown in Fig 4.5 that 3D printer can directly print, as the same way you print a document on your regular printer. This offers various outcomes such as STL, IGES, VRML and JPEG etc. We probably use the STL file accepts 3D print format and there are many formats that give additional details about the print design. It doesn't require any background process to define data such as shape, color, equipment, etc. Solid operations support software analysis reduces any G code printing 3D models, so we chose the robust 2015 functions to design the complete model of this software.

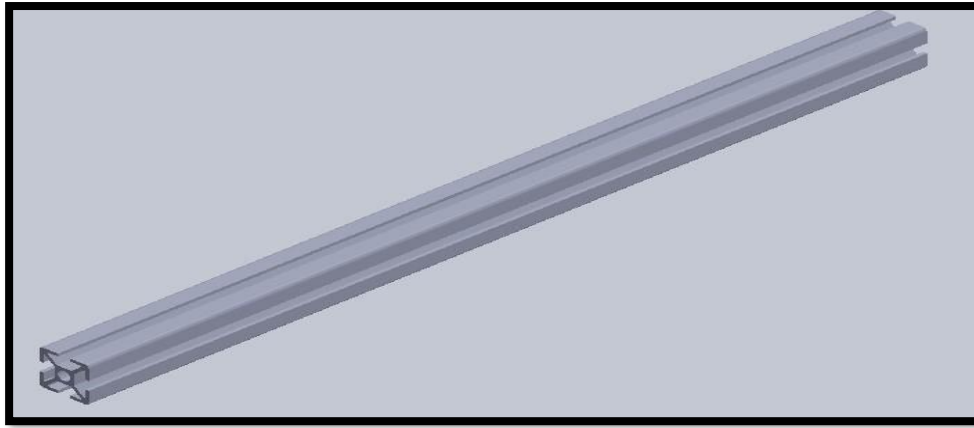


Fig 4.5: Design in Solid Works

4.4. MATERIAL USED FOR FABRICATION

Polyethylene terephthalate glycol which also known as PETG shown in Fig4.6, which is thermoplastic polyester conveys' remarkable chemical resistance, formability and durability. PETG is a transformation of PET (Polyethylene terephthalate) in which 'G' represents glycol, add up to the molecular level to provide various chemical properties. PET has monomers similar to glycol altered PETG, but PETG has greater durability and greater toughness as well as resistance to impact and suited better to high temperatures.

Because of the low temperatures the formation of polyethylene terephthalate glycol, vacuum easily builds up pressure or hot bend, building it favored with a different of consumers and businesses application. These structures also make it one of the most commonly used 3D printing method and further heat devising process. PETG is also a relevant procedure that includes die cutting, bending and routing.

In mid-20th century scientists break through advancement in polymer chemistry, new uses of material that could replace traditional natural products. Varnishes and Paints use, while synthetic glycol-related fibers were in fabrics although, phthalic acid products are smooth and soft so it cannot be used as fibers and glycol-based materials had very low melting points to permit them in fabrics.

John Whinfield and James Dickson the British scientists merged these materials in 1941 to produce polyethylene terephthalate (PETG). Esterification process is used with terephthalic acid to heat glycols; they formed a string molecule of PET that can be

converted into high melting points fibers that do not easily dissolve. In 1946 PET began to be used extensively in fabrics and in 1952 PET was used as a packaging for foods. In 1976, PET was used for the construction of sturdy bottles could hold softened carbonated beverages, mineral water, and beer.

Although it is one of the most use extensively plastics today, PET has some drawbacks, exposure to high temperature. This transforms PET weakens and opaque structure.

The modification of polyethylene terephthalate glycol, or PETG, ethylene glycol is changed with a large monomer in a molecular chain, cyclohexane dimethanol, which halts crystallization process related with PET. The increasing temperature resistance, PETG molecules doesn't bind jointly as easily as PET, reduces the melting point then prevents crystallization.



Fig 4.6: POLYETHYLENE TEREPHTHALATE GLYCOL (PETG)

Polyethylene terephthalate glycol can be implemented for thermoforming, 3D printing and more high-temperature doesn't loss in its character and properties.

4.4.1. Uses Of PETG

PETG has a wide range of industrial applications due to its resistance to hot, solvents and impact. This extensively used for packing (both commercial and medical), electrical insulators and electrical insulators advertising displays.

This extensively used in 3D printing that glycol protects PET-related problems, such as being fragile and cloudy and overheating. Sterilization of PETG items is also possible. With better traction between layers, minimal deterioration during printing, good thermal resistance, chemical resistance against bases and acids, and no odor during printing, PETG is becoming a popular 3D printing product. polyethylene terephthalate glycol is suitable to produce bendable components with better resistant to shock, like wear-resistant components, safety components or containers for food.

PETG may take a long time even decades to decompose thoroughly sent to a landfill, this can be recycled easily and broken-down polymer chains using chemicals to return to their original components. These components are used as materials in the production of new polymers.

Manufacturing new plastics consumes an excessive water and energy, so recycling plastics mostly lessen the use of organic resources. This protects PETG products from broken to smaller particles that contaminate the ocean and supply the earth's water, marine life.

Therefore, although polyethylene terephthalate glycol, plastics, harmful to the surrounding, recycling can greatly reduce the negative impact.

4.4.2 Properties

Like the co-polymer, PETG merges the properties of PET with glycol. This collaboration has the heat problems associated with PET are reduced.

The most important properties of polyethylene terephthalate glycol include hardness, chemical and resistance to impact, ductility and clarity. An easily removable material with better thermal stability, PETG is especially suitable for food related uses. polyethylene terephthalate glycol is good at 3D printing, with temperatures between 220 ° and 260 ° C, and printing speeds of 40- 60mm/ s.

Even so, for all its advantages, PETG uses heat plate to avoid warp obtained by ABS 3D printing and likely to scratch than PLA. It is suggested that the tray shouldn't surpass 80 ° C. The adherent aspect of PETG also means that the basics of printing can be hard to erase.

PETG absorb moisture and so it should be kept in a cool, dry place.

4.4.3. Advantages

Polyethylene terephthalate glycol offers more advantages over other materials, including acrylic and polycarbonate. These benefits include:

I. Strong and Cost-Effective

PETG resistance to strength and resistance to impact means optimal gloss and high strength durable units. Also suitable for 3D printing logos.

II. Food-Safe and Recyclable

PETG is so safe to use in containers for packaging of food and beverage bottles. It is also recycled; thus, waste is reduced and has an opposing impact on the environment.

III. Easily Formable

PETG for both vacuum and thermo flexible and resistance to high pressures without breaking. It is injected into different shapes into sheets.

IV. Easily Colored

PETG is transparent, allowing for special results, but easily blended and colored to form a unique look.

V. Non-Toxic and Odor less Emissions

PETG is non-toxic and does not smell slightly during 3D printing, ideal for home and office use.

4.4.4. Disadvantages

There are a few serious side effects related with use of polyethylene terephthalate glycol, but care is still needed, especially with temperature limits.

VI. Parameters to Follow

When 3D printing PETG, it is used to appropriate temperature parameters. It is recommended to follow the parameters for each manufacturer, common temperature for 210-260 °C extruder and a 60-80 °C base, even though a cold foundation can be used. Print speed is suggested (30 - 35 mm / s) while ideal 3D printer values are attained.

VII. Prone to Oozing

PETG tends to flow better than PLA or ABS, you'll need to check bridging and adjust settings during 3D printing. As a result, there may also be a need for further processing after processing to eliminate any defects.

VIII. Brittle if not Stored Correctly

PETG will absorb moisture if it is not stored in a dry place, that make the parts breakable.

IX. Environmental Issues

Like all plastics, PETG has a negative impact on the environment if it isn't properly disposed. It takes long time to decompose and formation of small plastics lead to the oceans of the world. However, PETG is easily recyclable, this eliminates the problems of environments.

4.4.5. Production Methods

PETG is created by a two-step process, a melt phase poly condensation melting process. This is a simple process combines two separate monomers together, corresponding to let loose of a small molecule like water. PETG can be injected molded, extracted as a sheet filament for 3Dprinting. This amorphous thermoplastic can be colored during the process.

4.4.6. Applications

The characters of polyethylene terephthalate glycol make it acceptable for an extensive range of applications, including:

I. Food Containers

Since it has better chemical resistance and it is incorporated into thermoform, PETG is extensively used in various items such as containers for cooking oil, drinking bottles and FDA-compliant food containers. It utilizes for packaging of cosmetics items and lighter weight and higher strength it brings cost-effectiveness distribution and efficiency.

II. Medical Applications

The strong structure of PETG means that it can survive aggressive damage, which makes it flawless for medical plants and the packaging of medical equipment and pharmaceutical.

III. Retail Stands and Displays

Polyethylene terephthalate glycol is excessively used in retail outlets and displays. As it is colored, it can also be suitable for signs.

IV. Machine Guards

PETG is also implemented to make machine guards. Clear plastic is easy to make and provides protection. PETG guards are commonly used in food processing as they are easier to build than polycarbonate and last longer than acrylic.

CHAPTER 5

RESULT AND DISCUSSION, AND PERFORMANCE ANALYSIS

5.1. TEST REPORT

Telefax : 044 - 2250 0127, 2250 0523 Mobile : 94442 55041 E-mail : omega_ial@outlook.com Web : www.omegalab.in		 SINCE 1989		 ISO 17025 ACCREDITED		 ANAS-9001 ACCREDITED	
OMEGA INSPECTION & ANALYTICAL LABORATORY T.S. No. 57,58 & 35, 36, GUINDY INDUSTRIAL ESTATE, GUINDY, CHENNAI - 600 032, TN, INDIA.							
ISO/IEC 17025:2017 Accredited Laboratory, For Chemical, AAS, Mechanical, Metallography, Water, Salt Spray, DSC, UV-Weatherability, building Materials. On Site Test : NDT (Metals & Civil), Mobile Spectro, PMI, Hardness, Surface Roughness, Paint Peel Off, Salt Contamination, Conductivity Testing etc..							
TR No.: OIAL/21-22/03/16038				Test Report		Page 1 of 1	
TOCR No:21-6857 , Dt:07-Mar-2022				Report Date: 08-Mar-2022			
Customer : SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, Rajiv Gandhi Salai, Semmancheri Chennai - 600119				Test Started On: 07-Mar-2022 Test Completed on: 08-Mar-2022 Sample Drawn By: CUSTOMER			
Customer Ref. : Letter Dt.07.03.2022 Nature of Test : MECHANICAL TEST Test References : ASTM D 2240, ASTM D 790, ASTM D 638, ASTM D 256, ASTM D 695							
Sample Details : PETG Sample							
Test Results							
NAME : Mr.S.MUKESH ARAVIND, Mr.S.SUKESH KUMAR							
EQUIPMENT USED : UTM.Make : TMC. Model : UTM 10. SR No.: OIAL/ME 33 (R.TEMP : 27°C)							
TENSILE STRENGTH IN MPa : 24.54							
ELONGATION AT BREAK IN % : 7.11							
FLEXURAL STRENGTH IN MPa : 47.78							
COMPRESSION STRENGTH IN MPa : 191.15							
IZOD IMPACT STRENGTH IN JOULES : 0.25							
SHORE D* HARDNESS : 65, 67, 68							
=====CONCLUDED=====							
 P.DINESH CHEMIST Tested / Verified By				 P.DHANASEKARAN DY. QUALITY MANAGER Authorised Signatory			
Note : Certified that the test enumerated above have been carried out in conformity with standard Testing procedures and relevant specifications. The Certificate refers ONLY to the particular sample(s) submitted for Test. Sample description is not verified in all cases and is given as described by Customer. All Complaints about this should be communicated in writing within 15 days from the date of issue of this report. The report shall not be reproduced except in full, without the written approval of OIAL.							
Form No.:QF-5-10-01A							

Fig 5.1: Test Report

5.2. TEST RESULTS

The test values of fabricated steering wheel shown in Table5.1.

Table 5.1. Test Result of 3D Printed Sample

SL.NO	PROPERTIES	UNIT	TEST METHOD	PETG
1.	TENSILE STRENGTH	MPa	ASTM D638	24.54
2.	ELONGATION AT BREAK	%	ASTM D638	7.11
3.	FLUXURAL STRENGTH	MPa	ASTM D 790	47.78
4.	COMPRESSION STRENGTH	MPa	ASTM D 695	191.15
5.	IZOD IMPACT STRENGTH	JOULES	ASTM D 256	0.25
6.	SHORE D HARDNESS	N/mm ²	ASTM D 2240	65,67,68

CHAPTER 6

CONCLUSIONS

Finally, we completed our design. We have developed a car steering system that explains all the features and selected the best options for making it and converted it into a complete car project with standard steering features. We started work investigating this type of vehicle and just the steering wheel of the car. This project has made us learn a lot of information and builds a way to make the steering wheel more economical. The mechanical properties of polymer materials are 10 times stronger than steel. It has the same durability and low weight. The most important of all is the low rotation effect on the improved effect of the steering system and as a result. The modern steering wheel of ultra slim polymer material is a unique piece that gives a special look to the four wheels.

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