

**STRENGTH IMPROVEMENT OF ACRYLONITRILE
BUTADIENE STYRENE FILAMENT USED IN THE 3D PRINTER**

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Mehtab Alam



Department of Mechanical Engineering
Faculty of Mechanical Engineering
INTEGRAL UNIVERSITY, LUCKNOW, INDIA

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Name: **Dr. Mohd Anas**

Designation: Associate Professor

Address: Department of Mechanical Engineering, Integral University, Lucknow

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Mehtab Alam

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TABLE OF CONTENTS

Title Page	i
Certificate (Supervisor).....	ii
Certificate (Co-Supervisor).....	iii
Declaration	iv
Table of Contents.....	v-vii
List of Table	viii
List of Figure.....	ix
Abstract	x
CHAPTER-01 INTRODUCTION	1
1.1. FUSED FILAMENT FABRICATION	2
1.1.1 Types of Enclosure	3
1.1.2 Extruder Placement Types.....	3
1.2. ABS FILAMENT	3
1.3. 3D PRINTER	4
1.4. TYPE OF 3D PRINTING.....	6
1.4.1. Binder Jetting.....	6
1.4.2. Material Extrusion	6
1.4.3. Material Jetting	6
1.4.4. Powder Bed Fusion	7
1.4.5. Sheet Lamination	7
1.4.6. VAT Photo polymerization	7
1.5. BENEFITS OF USING ABS FILAMENT IN 3D PRINTING.....	7
1.5.1. Great Mechanical Properties	7
1.5.2. Get Good Results	8

1.5.3. Easy To Process	8
1.6. TO MAKE DURABLE 3D PRINTS	8
1.6.1. Increase the density of the infill.....	8
1.6.2. Increase the thickness of the walls.....	9
1.6.3. Layers should be thinner	10
1.6.4. Make Use of a Sturdy Infill Pattern	10
1.6.5. Change the Flow Rate	12
1.6.6. Make a change to the line width.....	12
1.6.7. Reduce the Amount of Cooling	13
CHAPTER-02 REVIEW OF THE LITERATURE.....	14
2.1. FUSED DEPOSITION MODELING (FDM).....	14
2.2. ACRYLONITRILE BUTADIENE STYRENE (ABS).....	15
2.3. CARBON FIBER REINFORCEMENT (CFR) / LOADING IN 3D PRINTING.....	16
2.4. RASTER ANGLE'S IMPACT	16
2.5. IMPACT OF BUILD DIRECTION.....	17
2.6. BOND FORMATION MECHANISM.....	18
2.7. EFFECT OF PATTERNS OF INFILL.....	19
CHAPTER-03 METHODOLOGY.....	22
3.1. RESEARCH DESIGN AND SAMPLE	22
3.3.3D-PRINTING.....	25
3.3.1.3D-Printer Software Preparation.....	25
3.4. MANUFACTURING TENSILE-TEST SAMPLES	26
3.5. PROPERTY OF ABS MATERIAL	27
3.5.1. Physical Properties	27
3.5.2. Mechanical Property	27
3.5.3. Thermal Property	27
3.6. UNIVERSAL TESTING MACHINE	28
3.6.1. Components of Universal Testing Machine	29
CHAPTER-04 RESULT AND DISCUSSION	30
4.1. ULTIMATE TENSILE STRENGTH OF ABS FILAMENT	31

4.2. TENSILE TEST	32
4.2.1. Tensile Test for Rectangular Pattern.....	32
4.2.2. Tensile Test for Triangular Pattern	33
4.2.3. Tensile Test for Hexagonal Pattern.....	33
4.3. PEAK LOAD	34
4.4. PEAK STRESS	36
4.5. BREAK LOAD	37
4.6. BREAK STRESS	39
4.7. Tensile Strength	40
CHAPTER-05 CONCLUSION.....	42
REFERENCE	43

LIST OF TABLE

Table-3.1.-Comparison Groups.....	23
Table-3.2: Melt Flow Index (grams/10 minutes)	24
Table-3.3: Physical Property.....	27
Table-3.4: Mechanical Property.....	27
Table-3.5: Thermal Property.....	28
Table-4.1: Temperature and Percentage of the Infill Density of the filament	30
Table-4.2: Ultimate Tensile Strength of ABS Filament	31
Table-4.3: Tensile Test for Rectangular Pattern.....	32
Table-4.4: Tensile Test for Triangular Pattern.....	33
Table-4.5: Tensile Test for Hexagonal Pattern	34
Table-4.6: Peak Load.....	35
Table-4.7: Peak Stress.....	36
Table-4.8: Break Load	38
Table-4.9: Break Stress.....	39
Table-4.10: Tensile Strength.....	41

LIST OF FIGURE

Figure-1.1: A typical FFF 3D printer.	2
Figure-1.2: ABS FILAMENT [5].....	4
Figure-1.3: Typical 3D printer setup	5
Figure-1.4: Increase the density of the infill [23].....	9
Figure-1.5: Increase the thickness of the walls.	9
Figure-1.6: Layers should be thinner.....	10
Figure-1.7: Make Use of a Sturdy Infill Pattern.....	10
Figure-1.8: Triangular Pattern.....	11
Figure-1.9: Rectangular Pattern.	11
Figure-1.10: Hexagonal Pattern.	12
Figure-1.11: Make a change to the line width [12].	13
Figure-2.1: Fused deposition modeling schematic diagrams.....	19
Figure-3.1: UTM.	28
Figure-3.2: Component of UTM.	29
Figure-4.1: Ultimate Tensile Strength of ABS Filament.....	32
Figure-4.2: Peak Load of ABS Filament.	35
Figure-4.3: Peak Stress of ABS Filament.	37
Figure-4.4: Break Load of ABS Filament.....	38
Figure-4.5: Break Stress of ABS Filament.	40
Figure-4.6: Tensile Strength of ABS Filament.	41

ABSTRACT

In this research work, we have studied about improving the strength of the Acrylonitrile butadiene styrene (ABS) filament of the 3D printer. We know that at the default setting of the 3D printer, the strength of the all models which are created by the 3d printer is almost same when we are using the Acrylonitrile butadiene styrene (ABS). But in this research work, we are numerical analyze the models which will be created by using the Acrylonitrile butadiene styrene filament in the 3D printer at the different temperature such as 225 °C, 230 °C, 235 °C, 240 °C, 245 °C, 250 °C, 255 °C, and 260 °C, and using the three different pattern to analyze these models such as the rectangular, triangular, and hexagonal pattern at layer of the each models.

The area Acrylonitrile butadiene styrene (ABS) filament is kept constant which are 40 mm². These all models which will be prepared by the 3D printer, we will check strength of the all models at different temperature such as 225 °C, 230 °C, 235 °C, 240 °C, 245 °C, 250 °C, 255 °C, and 260 °C and using three different pattern of the layer such as rectangular, triangular, and hexagonal pattern by using the Universal Testing Machine (UTM). We will check the strength of the all these models on the basis if the selected parameter such as the ultimate tensile strength, peak load, peak stress, break load, break stress, and tensile strength.

CHAPTER-01

INTRODUCTION

Income from 3D-printer vending and services quadrupled between 2009 and 2013, and maintain to expand significantly by Park et. al. (2014). Despite the fact that these technologies "were initially meant primarily for (heavy) industrial usage," "continuous cost reductions have brought them within reach of [subject matter experts] SMEs and individual entrepreneurs". In 2018, twenty fifth of the world's creators can release some assortment of 3D printer, with excellent 3D printers cost bookkeeping however \$2,000. More information regarding the mechanical qualities of filaments from manufacturers and third-party distributors would be beneficial to consumers. Fused Deposition Modeling (FDM), a subset of 3D printing, was "invented by Stratasys in Eden Prairie, Minnesota". Each layer of an object's shell, as well as its interior structure or infill, is made up of extruded strands. Through software settings and material selection, the mechanical aspect of a 3D-printed product may be altered [1].

Since sure 3D composed components could likewise be expected to persevere through such burdens, enduringness is a significant material element. For instance, opposite directions (e.g., one layer expelled at a 45 degree point and subsequently the resultant layer requested at +45 degrees) yield higher ductile outcomes. in addition, carbon filaments don't stick well to ABS, and analysts like Li and Zhang et. al. have needed to upgrade this adherence by covering the strands with surface synthetics like water fortis (HNO₃) [3]. An "earnest should expand the strength of FDM manufacturing plant made unadulterated thermoplastic parts" (Ning et al. 2015). The success of any [Rapid Prototyping] RP process depends on quality features such as strength and accuracy. "Techniques used to swiftly produce physical models" are referred to as rapid prototyping (RP) [2]. 3D composed expelled strands of plastic fiber embedded inside the district of shell strands (infrequently during a predefined example or) not entirely set in stone by the product bundle that works the 3D printer [3].

Carbon fibre reinforced (CFR) ABS, according to firms like 3DXTech (2017), has a better tensile strength than non reinforced ABS. There hasn't been sufficient examination done on lastingness changes upheld fortifications applied to strong 3D composed objects created in unambiguous infill directions. For A Model Being 3D

Printed with CFR ABS, producers don't determine that infill direction is really great for strands to be organized concerning lastingness [3].

1.1. FUSED FILAMENT FABRICATION.

Fused Filament fabrication (FFF), furthermore alluded to as joined statement displaying (FDM) for specially molded plastic parts, is one among the chief in style and cost-proficient AM processes [4]. However there region unit many varying sorts of FFF 3D printers, the printing could likewise be normalized, as incontestable in Figure one.7. A moving engine pulls the substance compound fiber to a hot completion to begin the printing. The fiber is liquefied by the new completion, and furthermore the liquified fiber is then taken care of onto the printing stage by means of a spout. The print-head moves inside the XY plane kind} the necessary structure [5]. At the point when each layer is finished, the technique is perpetual for the ensuing one. When the composed things contain overhanging regions, layer-by-layer creating on a level development stage needs a help system [5]. These help structures are composed with one fiber or with additional substance that is conventionally eliminated utilizing a dissolvable. Therefore, things made double-dealing each cycles need post-handling, which may be long [6].

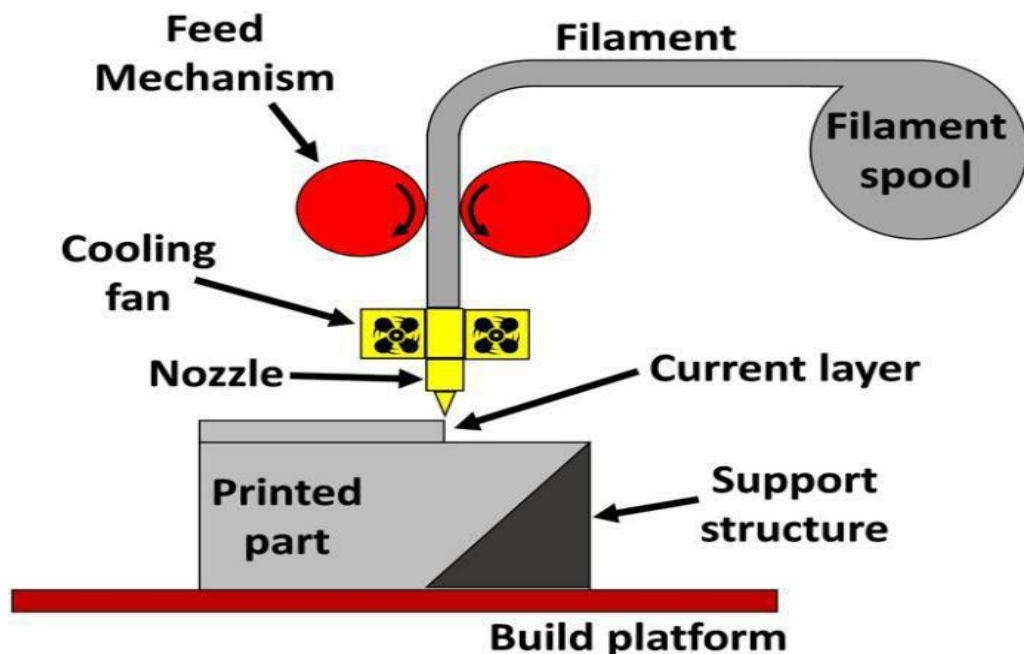


Figure-1.1: A typical FFF 3D printer.

The printed part's adherence to the build platform is also a critical consideration. The construction platform can take several forms, but the most common is a glass surface. To improve adhesion between the component and the platform, the surface should be treated [6]. Furthermore, because most filament materials require a heated build platform to prevent separation of the component from the platform due to warping, most printers are built with this functionality as standard [6].

The majority of FFF 3D printers have a chilling fan to cool the manufactured item, which is necessary after printing the majority of materials. Because the form volume increases and limits the print aim, wider spouts are necessary. By adjusting these limits, it is possible to print products with mechanical strength esteem infused formed components [7].

1.1.1 Types of Enclosure.

Since FFF 3D printing could be an ascendible methodology, it will be utilized in an enormous fluctuate of printers, from modest work area printers to gifted, processing plant size printers [7]. Most work area printers need partner degree enclosure to keep up a normalized close temperature all through printing, while talented FFF 3D printers by and large have partner degree enclosure with a controlled cool-down sum. partner degree enclosure could be an ought to for printing materials that square measuredelicate to cooling rates, as they will recoil significantly all through cooling [8].

1.1.2 Extruder Placement Types

Bowden and direct-drive extruders compete for space inside the driving engine. Since the engine is not installed inside the print head, the majority of the extruder carriage is not dependent on the immediate drive variation. Because to the shorter latency of the carriage, instrument way modifications may be made more quickly and precisely [8].

1.2. ABS FILAMENT.

For a scope of reasons, ABS fiber could be an inescapable 3D printing material. ABS fiber could be a thermoplastic that is outstandingly strong. It's ordinarily acclimated check item influence obstruction and solidness in fast prototyping and added substance creating possibilities. ABS is partner degree electrically protection [8].



Figure-1.2: ABS FILAMENT [5].

1.3. 3D PRINTER

Three-layered (3D) printing is partner degree added substance creating method that transforms a pc style into a genuine issue. The system includes spreading down thin layers of texture, similar to fluid or pummeled plastic, metal, or concrete, then intertwining them along [09].

Hideo Kodama's initial add optical maser restored rosin speedy prototyping was achieved in 1981, expanding on Ralf Baker's add the Twenties for creating ornamental item. In 1987, 3D Systems' Chuck Hull made the essential 3D printer that utilized the sound system lithography philosophy. Different costly 3D printing procedures were made inside the Nineties and 2000s, but their costs sliced definitely once the licenses ended in 2009 [09].

Researchers in Japan created 3-D printing, a relatively new technique, in the late 1980s. The most popular 3D printers on the market today construct prototypes layer by layer using thermoplastic filament. The quality and usability of 3D printers have quickly improved while their costs have dropped significantly thanks to technological advancements [10].

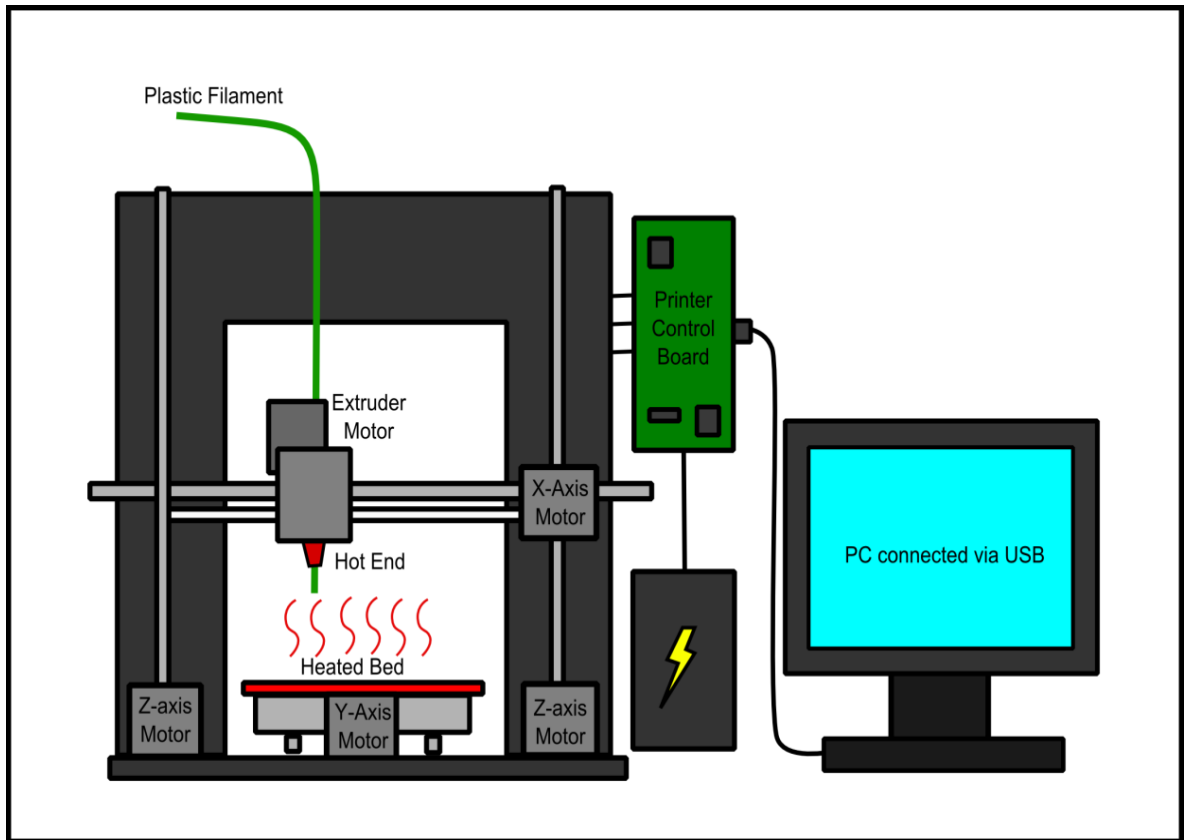


Figure-1.3: Typical 3D printer setup

The most common materials currently used in 3D printers are Acrylonitrile Butadiene Styrene (ABS), Polylactic Acid (PLA), Polycarbonate, and Nylon. These filament style printers work by utilizing software to break the designs down into discrete layer slices, which are then printed using design specifications set by the user [10]. The control parameters are print temperature, print speed, layer height, number of perimeters, top and bottom infill pattern, and infill percentage for non-solid layers. Within solid layers infill patterns are typically concentric or rectilinear patterns, with infill angle changing from 0 to 180 degrees. The infill angle of during prints on parts with rectilinear infill has been studied by Arivazhagan et al. This study found that the highest strength was achieved at alternating infill angles of 30 and 60 degrees. 3D printers work by building parts layer by layer using a small extruder to extrude filament to fill in all gaps in the part [11].

1.4. TYPE OF 3D PRINTING

There are seven types of 3D printing used, which are given below:

1. Binder Jetting.
2. Direct Energy Deposition.
3. Material Extrusion.
4. Material Jetting.
5. Powder Bed Fusion.
6. Sheet Lamination.
7. VAT Polymerization.

1.4.1. Binder Jetting

It includes keeping a very low layer of supercharged material onto the form stage, similar to metal, compound sand, or fired, trailed by drops of glue applied by a print head to tie the particles along. This builds the half layer by layer, and around then, post-handling could likewise be expected to finish the turn of events [11]. Metal things could likewise be thermally structure or penetrated with an infrequent edge of freezing over metal like bronze as tests of post process, though full-variety compound or artistic components could likewise be immersed with cyanoacrylate stick [12].

1.4.2. Material Extrusion

A spool of fiber is prepared to an expulsion head with a warmed spout in material expulsion, furthermore called fused filament fabrication (FFF) [13]. The warmed material is warmed, relaxed, and organized down at preset spots, any place it cools to make a layer of texture. The form stage then slides directly down to make space for following layer [12].

This method is modest and has quick lead times, but it's poor layered precision and consistently needs post handling to encourage a smooth end [14]. This strategy also delivers anisotropic parts, that are more fragile in one course and hence unsatisfactory for urgent applications [14].

1.4.3. Material Jetting

Material jetting is a 3D printing technique that allows for the production of full-variety components in a very kind of materials. It is practically equivalent to inkjet printing, then again as opposed to partitioning down ink on a page, it stores layers of

fluid material from one or extra print heads. Substance spurting requires the use of help structures, which may be manufacturing plant, made of a solvent material and cleaned away once the venture is finished [15].

1.4.4. Powder Bed Fusion

Powder bed fusion (PBF) is a process that uses heat, such as from an optical device or a lepton bar, to decisively fuse different powder bed regions to create layers that are subsequently layered to form a section. It's important to remember that PBF includes both the sintering and dissolving processes [15].

In light of the characteristics created, specific optical gadget sintering (SLS) is frequently used for the manufacture of compound parts. The shortfall of help structures (the powder bed capacities as a help) considers the occasion of things with refined shapes [16]. Because of the things made could have a farinaceous look and inside consistence, post process is normally required [16].

1.4.5. Sheet Lamination

Laminated-object-manufacture (LOM) and supersonic added substance delivering are 2 varying kinds of sheet overlay (UAM). UAM consolidates thin sheets of metal with supersonic securing, while LOM utilizes substituting layers of texture and paste to shape item with visual and tasteful allure [17]. UAM might be a low-temperature, low- energy strategy for machining nuclear number 13, chrome steel, and metallic component [17].

1.4.6. VAT Photo polymerization

A technique called powder bed fusion (PBF) involves using heat, such as from an optical device or a lepton bar, to use determination to fuse different powder bed regions into layers that are subsequently stacked to form a section. The fact that PBF includes both the sintering and dissolving processes is important to notice [17].

1.5. BENEFITS OF USING ABS FILAMENT IN 3D PRINTING

Here are some of the benefits of using ABS plastic in 3D printing. Read on below.

1.5.1. Great Mechanical Properties

ABS is known to be strong and durable material. It is resistant to heat and everyday chemicals [18]. It can also endure more to stress, heat and pressure comparing with

other 3D printing materials. Because of that, ABS is a great choice for “wear and tear” 3D prints [18].

1.5.2. Get Good Results

As long as the settings are right, you will get good results when using ABS filament. With this material, you can even print overhangs around 45°. This filament oozes and strings lesser compared to other filaments and give models smoother finish [19].

1.5.3. Easy To Process

ABS material is easy to process with acetone and glue parts. You can even file off some materials and painted it with acrylic colors [20].

1.6. TO MAKE DURABLE 3D PRINTS

The structural integrity of 3D prints is critical since they must not collapse while in use. Because of the high quality it produces, 3D printing is a widely used manufacturing technology [21]. Many factors come into play when it comes to increasing the robustness of 3D printed objects [21].

1.6.1. Increase the density of the infill.

One method to increase a 3D print's resilience is to increase its interior density. The inner density ranges from 0% to 100%, with 100% representing total solidity and 0% representing utter hollowness. Almost all designers have found that anything beyond 70% has less of an impact on how strong your print will be [22].

Note: For strength, use at least a 20% infill density and, if feasible, adjust the wall thickness (described below) before increasing the infill density [22].

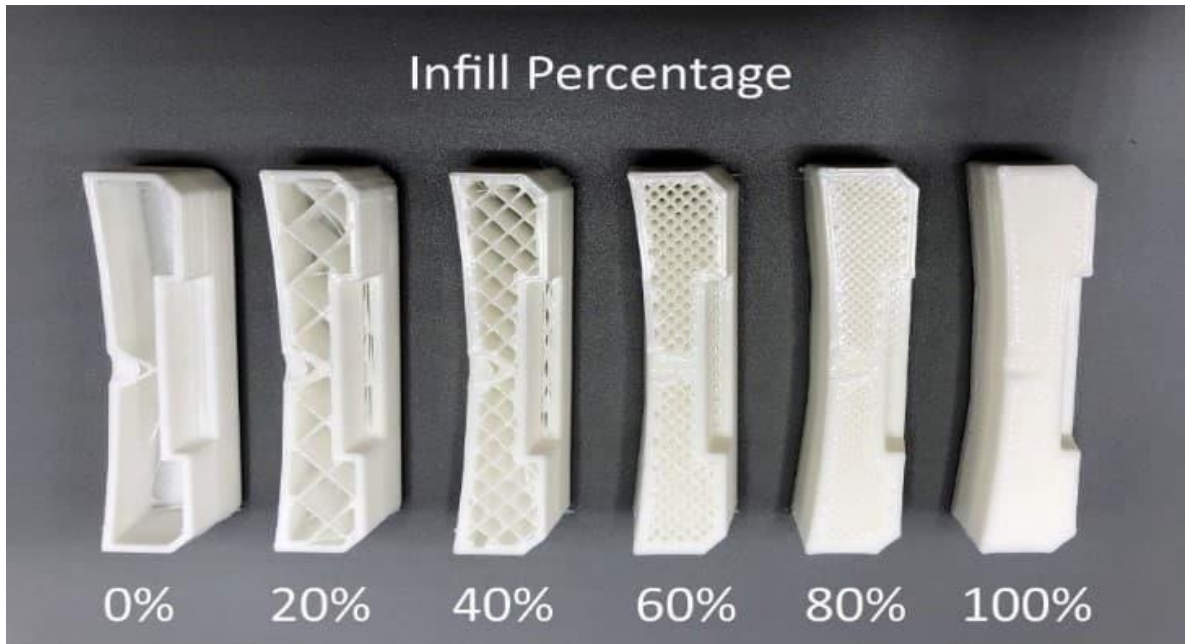


Figure-1.4: Increase the density of the infill [23].

1.6.2. Increase the thickness of the walls

The "Wall Line Count" and "Outer Line Width" parameters are used to calculate a 3D printed object's wall thickness. It shows how thick the wall is and how to raise it to create sturdy 3D prints. Increased wall thickness enhances water tightness and overhangs (complicated geometric shapes in 3D models), in addition to strengthening the printed material [23].

Note: A normal product must have a wall thickness of at least 1.2mm. Then you may boost it for additional power.

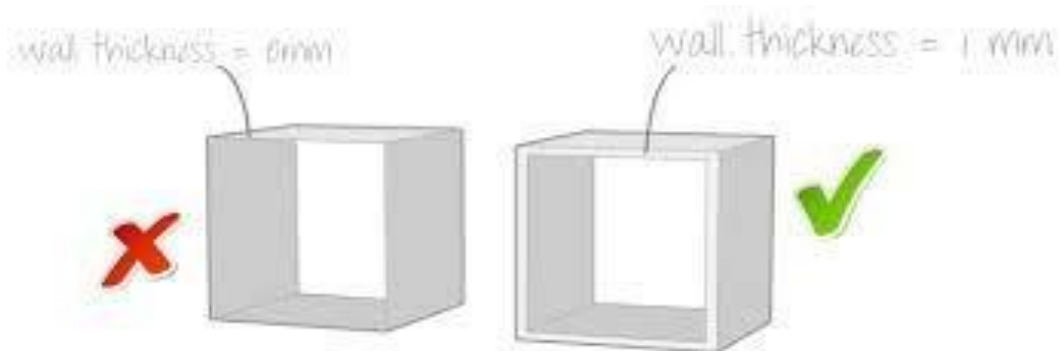


Figure-1.5: Increase the thickness of the walls.

1.6.3. Layers should be thinner.

A thin layer helps the adhesion and density between subsequent layers, making 3D printed objects more durable. As tiny as 0.1mm (100 microns), according to designers, would optimise strength, but there is a commensurate increase in printing time [24].

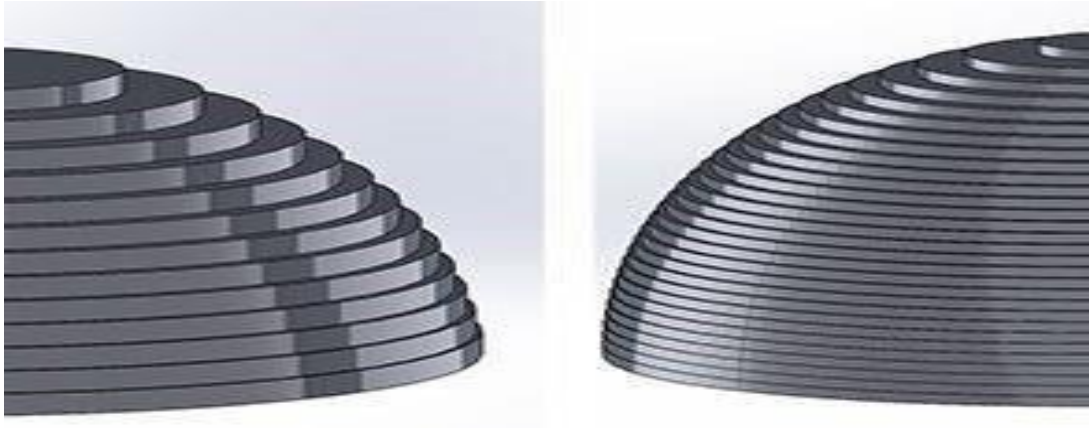


Figure-1.6: Layers should be thinner.

1.6.4. Make Use of a Sturdy Infill Pattern

For 3D printing, infill patterns and infill density work together to create an inner support structure. Additionally, they provide the print area some stiffness and stop the wall from deforming. A thick infill pattern of 30–50% is advised when employing infill patterns to create reliable 3D printing [24].

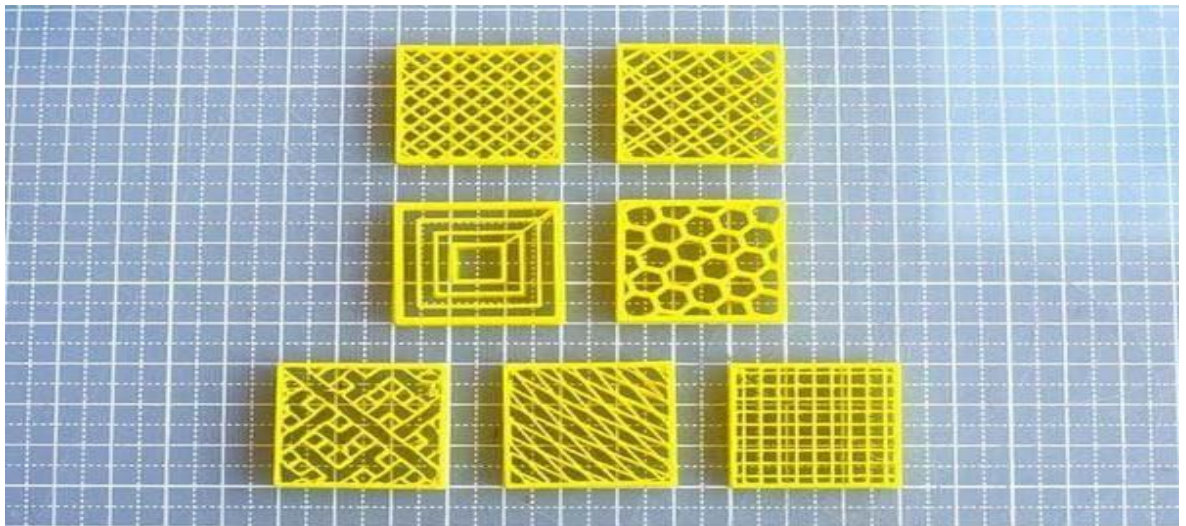


Figure-1.7: Make Use of a Sturdy Infill Pattern.

The strength of your 3D print is also determined by the sort of infill pattern you employ. The following are three infill's to consider:

Triangular Pattern: Triangular infill patterns are sturdy because they are less likely to distort and give the best structural support. Triangles are the strongest shape, according to most 3D fans [25].

Due of the print head's straight-line movement, using a triangular infill also boosts print speed. As a result of their robustness and speed, many 3D enthusiasts choose triangular infill's [25].

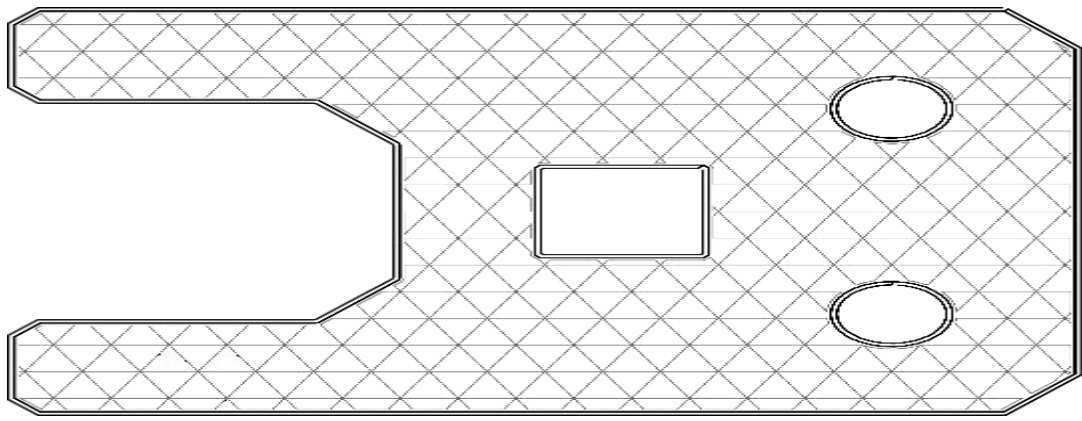


Figure-1.8: Triangular Pattern.

Rectangular Pattern: Because of its grid of parallel and perpendicular extrusions, rectangular infills may attain 100% infill density [26]. Due to the print head's straight-line movement, it has a high print speed, just like the triangular infill [26].

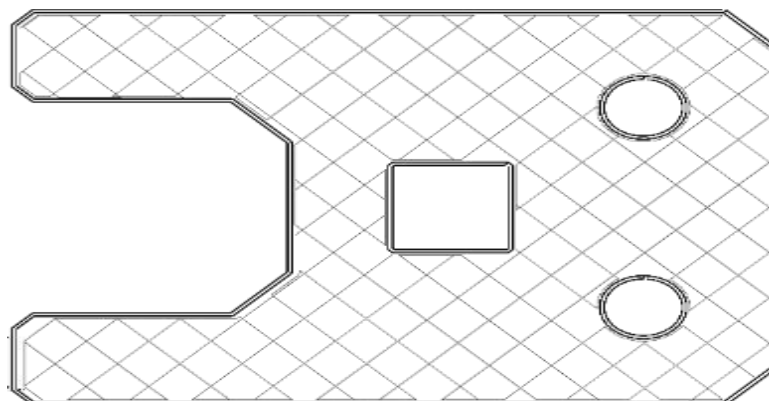


Figure-1.9: Rectangular Pattern.

Hexagonal Pattern: They have the strongest strength-to-weight ratio and tessellated hexagons [27]. Printing is slower than the previous two infill patterns because the print head is continually changing directions, yet they are excellent in strengthening 3D designs.

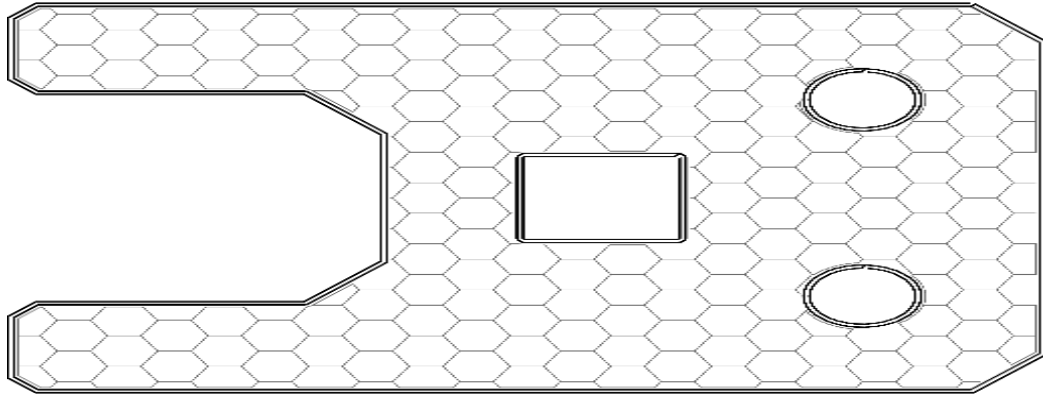


Figure-1.10: Hexagonal Pattern.

1.6.5. Change the Flow Rate

Another useful method for increasing the durability of 3D printed objects is to change the flow rate. When utilising this method, you must take care to avoid under- or over-extrusion. Most designers make careful to make only modest adjustments, and most people try to address additional 3D printing issues including accuracy and volumetric flow [28].

1.6.6. Make a change to the line width.

You may reinforce your 3D prints by setting the line width to an even multiple of the layer height, according to Cura, a popular slicer. However, you must exercise caution since this option is linked to extrusion, i.e., a large change in line width can result in excess and under extrusion [29].

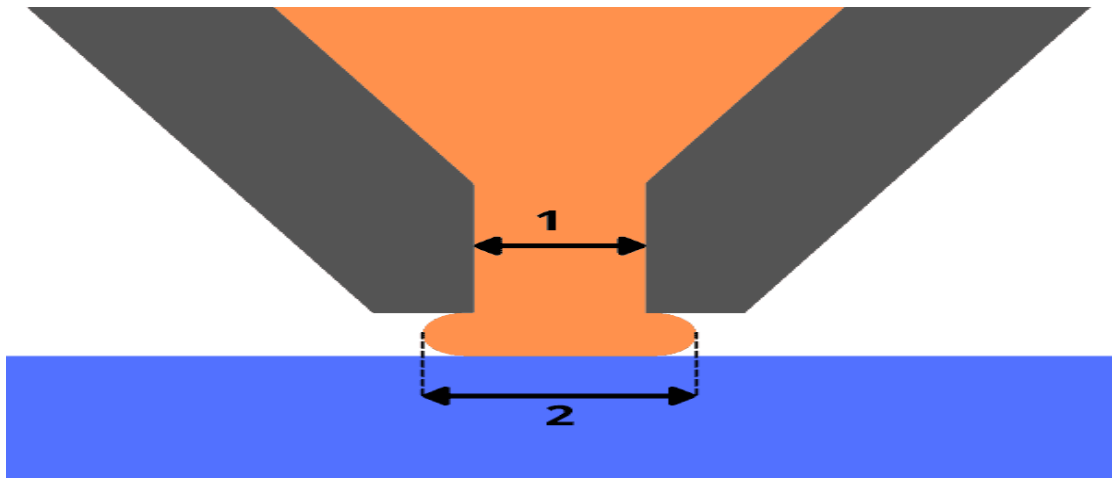


Figure-1.11: Make a change to the line width [12].

1.6.7. Reduce the Amount of Cooling.

In 3D printing, cooling is a crucial phase since it affects the adhesion of layers after they have been established. Conversely, cooling depends on the substance you're dealing with. For instance, PLA works best when it is cooled by a strong fan [30].

CHAPTER-02

REVIEW OF THE LITERATURE

Fused deposition modeling (FDM), ABS with discussion of tensile strength, carbon fiber reinforcing in ABS with discussion of tensile strength, producers of CFR ABS, and tensile strength changes dependent on orientation of 3Dprinted strands have all been explored in relevant literature.

2.1. FUSED DEPOSITION MODELING (FDM).

More companies are embracing the notion of developing a machine or material for one, which has resulted in a sharp decline in the price of commercial 3D printers. FDM was first introduced in the 1980s by S. Scott Crump, who also cofounded Stratasys, and is still being developed today. To serve a wider spectrum of clientele, businesses may now use a variety of materials [31]. A wide range of products, including "prototyping, tooling, and manufactured goods," may be made using fused deposition modelling (FDM) from a variety of materials, including paper, nylon, wax, resins, metals, and ceramics. This is an advantage of FDM since it "needs no special equipment or ventilation and contains no harmful chemicals or byproducts, unlike certain additive production processes." Furthermore, FDM parts eliminate costly components like tooling and are ready for use with "relatively little delay and labour." A 3D computer-aided design (CAD) model is used to create real goods directly using 3D printing technology through a layered manufacturing process. The flat thin cut of a 3D-printed item is created using spooled thermoplastic fibres that are generally 1.07 inches (1.75 mm) or 1.2 inches (3 mm) wide [31]. The fibre is heated to a certain temperature before being released through a small spout (with a roundabout opening usually.). If the model is said to be constructed with a strong interior, interior localities are typically moulded of strands laid down at a specified point, such as $+45^\circ$ to the buildplatform's x axis, which runs left and right (Novakova Marcincinova and Kuric et. al. 2012).

Supports are also created when there are necessary shades in a 3D-printed material or if the layer underneath a superior layer is ineffectively supporting it in some places. Once the model is large, pontoons, overflows, and supports are discarded. Throughout the expulsion process, the texture layers by layers mimics the cross-sectional structure of the CAD model, eventually transforming into the finished product [31].

2.2. ACRYLONITRILE BUTADIENE STYRENE (ABS)

The invention of ABS plastic dates to the middle of the 1940s. Because butadiene (C₄H₆) was left out of the original formulation, the acrylonitrile styrene copolymer had issues [32]. In order to create the terpolymer we now know as ABS, this rubber monomer was combined with other materials to create bulletproof armour during World War II. ABS is a highly sought after thermoplastic in engineering, according to Ghanbari et. al. (2014), because of its numerous desirable attributes, which include but are not limited to: "acceptable mechanical properties, chemical resistance, and adequate processing characteristics."



Numerous far and wide properties semiconductor diode to the reception of ABS in fields like trim, any place parts like lines were made, in accordance with Olivera et al. (2016). Inside the Nineteen Fifties, ABS made its methodology into fields like as "materials, style, toys, and private purposes." ABS was starting used in 3D printing inside the Nineties, as a result of added substance delivering systems. "Common ABS consolidates a dissolving or mellowing reason somewhere in the range of 401 and 473 degrees Gabriel Daniel Fahrenheit (205 and 245 degrees Celsius), that considers direct utilization in many business 3D printers," Satches et. al. (2015) composes [33]. "ABS is available in several different synthetic structure types, including expulsion grade, plating grade, and shaped grade (Matweb et. al. 2017). A suitable compound ABS synthesis should be chosen for a particular expulsion application. Relax stream file, water absorption, durability, and warm conduction area few of the characteristics that might prevent these presents from being given.

Examples of solid ABS three-dimensional construction with a 45-degree infill point ranged in rigidity from 3,190 psi (22 MPa) to 5,221 psi (36 MPa). In their 2016 study, Vairis, Petousis, Vidakis, and Savvakis et al. looked at the effect of strain rate on the durability of ABS and ABS models. They discovered that the least difficult alternative for better durability was a specialist layer thickness (in contrast to any or all other different models evaluated) [34].

2.3. CARBON FIBER REINFORCEMENT (CFR) / LOADING IN 3D PRINTING.

Carbon fibres are anisotropic and contain at least 92 wt percent carbon (Huang et.al. 2000). Graphite fiber is a fibre that contains at least 99 percent carbon by weight. Anisotropic properties may improve the strength of 3D printing materials in particular orientations [35]. Some physical characteristics of carbon fibers that refer to anisotropy include, but are not limited to, being brittle or easily damaged, not absorbing water, not changing dimensions in humid environments (Vasiliev & Morozov et.al. 2013), and "yields different values of mechanical and thermal characteristics in the longitudinal and transverse directions."

These researchers "examined the potential for load bearing components in particular...results reveal that composites with highly dispersed and highly orientated carbon fibres may be manufactured using the FDM technique [36]," according to the researchers. They discovered that within test samples, fibres are primarily orientated in the direction in which the material is deposited on the 3D printer build platform, enhancing tensile strength [36].

As indicated by Tekinalp et al. (2014), carbon filaments have a brilliant potential for load support, though the thermoplastic framework ties, encompasses, and safeguards the carbon strands while conjointly moving the strain to them. Carbon fiber incorporates a more grounded lastingness than ABS (Fernandez Vicente, Calle et.al. 2014) and would so legitimately work to help it once extra to its science. "One of the possible methods is embedding reinforced materials (like carbon strands) into plastic materials to make thermoplastic framework carbon fiber fortified plastic (CFRP) composites," Carbon fiber fortifications in thermoplastics square measure utilized in area designing, the auto area, medical procedure/other clinical activities, and property drives, per Biron (as referenced in Ning et al., 2015) [37].

2.4. RASTER ANGLE'S IMPACT

Utilizing symmetrical shape plan Taguchi L9 and ABS plastic material, Nidagundi et al. (2015) [38] concentrated on three levels of the screen point boundary, which are 0 degrees, 30 degrees and 60 degrees [38]. The consequences of the SN report show that as the level point expands, the last elasticity of the individuals diminishes. The creators reached the resolution that 0 degree cross over point, joined with 0.1 mm layer

thickness and 0 degree part direction, is the best level for elasticity. Utilizing the most minimal upsides of the three recently given boundaries, a greatest rigidity of 27,67 MPa was gotten [39].

Like Nidagundi et al., Panda et al. (2009) [39] and Sood et al. (2010) took a gander at a similar three raster point levels (2015). Both of their examination used ABS plastic, and their preliminaries were completed using a focal composite plan. Nonetheless, it was found that a raster point of very nearly 60 degrees was ideal as far as malleable and influence strength. As indicated by Panda et al. (2009) [40], the edge point of 5.7311 degrees is great for expanding the bowing opposition of individuals. Without a doubt, the more drawn out weft, which goes about as the pressure concentrator, is made by the lower weft point. Thusly, this outcomes in more fragile bonds and lower mechanical execution [41].

The specified screen point levels are 0 degrees and 45 degrees. Important findings demonstrate a negative relationship between the screen point and the printed part's flexibility. Expanding the case point causes the two tomahawks to get out of alignment, making the people more brittle and stiff. A 90 degree route has 9.16 MPa of mean elasticity, whereas a 0 degree cross over point has a mean elasticity of 25.15 MPa.

Utilizing five levels of the boundary (0 degrees, 35 degrees, 45 degrees, 60 degrees and 90 degrees), Ertan (2014) [42] additionally inspected the impacts of weft point on the pliable and flexural qualities of the filaments. ABS parts. Their discoveries appear to be in concurrence with other examination which guarantees that a higher weft length worth of 0 levels of weft builds the mechanical strength of FDM items [43].

2.5. IMPACT OF BUILD DIRECTION

The part's elasticity is mainly affected by the development direction boundary (72.1 percent). In a research, Vishwas et al. looked at how growth direction affected plastic components. It was discovered that a clear stiffness was most notable for ABS printed leaves behind 0.1 mm layer thickness, 15 degree direction, and 1.2 mm shell thickness (26,41 MPa).

In a recent study, Onwubolu and Rayegani et al. investigated the significance of screen point on the elasticity of FDM printed items made of ABS. To determine the appropriate measure of interaction boundaries, two screen point levels—0 degrees and 45 degrees—have been selected. The mechanical strength of ABS components is

evaluated using malleable, compressive, and flexural strength estimates. The essential discoveries demonstrate that a maximum stiffness of 10.8 MPa is possible when the XY plane is involved at 90 degrees. It should be noted that the malleable property only slightly increases (2.05 MPa) as the value of the cross over point rises. The only significant difference between previous tests was the length of the segments in the z-pivot between L and H. Wang et al. [44] focused on the effect of the growth direction boundary on the stiffness of ABS components using the Taguchi L18 symmetrical cross section plan and Gray's theory. Out of the six interaction factors examined, an ANOVA research revealed that the major structural orientation had an overall influence on the part's elasticity (77.16 percent commitment).

When choosing the highest degree of stiffness and separating the pile of printed pieces, development direction is taken into consideration. The base mean elasticity is recorded using degrees X0 and Y90 (1.71 MPa). Three levels of control—0 degrees, 60 degrees, and 90 degrees—are used by Liu et al. (2016). The results of the Taguchi L27 configuration analysis demonstrated that the optimal development direction for FDM components is at a 0 degree angle.

2.6. BOND FORMATION MECHANISM

Frenkel's (1945) and Pokluda, et al. (1997) [45] for tube shaped fibers were accounted for by Pavan, et al. (2014). This model decides the time-subordinate property of the neck size between two successive strands, and the powerful neck district is determined utilizing a few neck shapes that occur in the division. The obstruction of the printed part can then be determined utilizing the heap upheld by this compelling neck district. Sintering and thick dissemination are two of the cycles remembered to be engaged with this antiquated turn of events. The reason for adjoining layer sintering is by all accounts to diminish the free energy however much as could be expected. This outcomes in less surface region and the energy acquired from the more modest surface region is then lost through thick stream. As per Frenkel et.al. (1945), thick sintering is a significant piece of the neck advancement process. Moreover, combination holding between thermoplastic polymers requires a higher handling temperature than the glass change temperature. Surface contact and intermolecular dissemination of polymeric parts on wet surfaces are the following two phases of bond arrangement. In like manner, the strength of the combination bond made between two not entirely set in stone by the

making of this wetting connection point as well as the level of intermolecular dispersion.

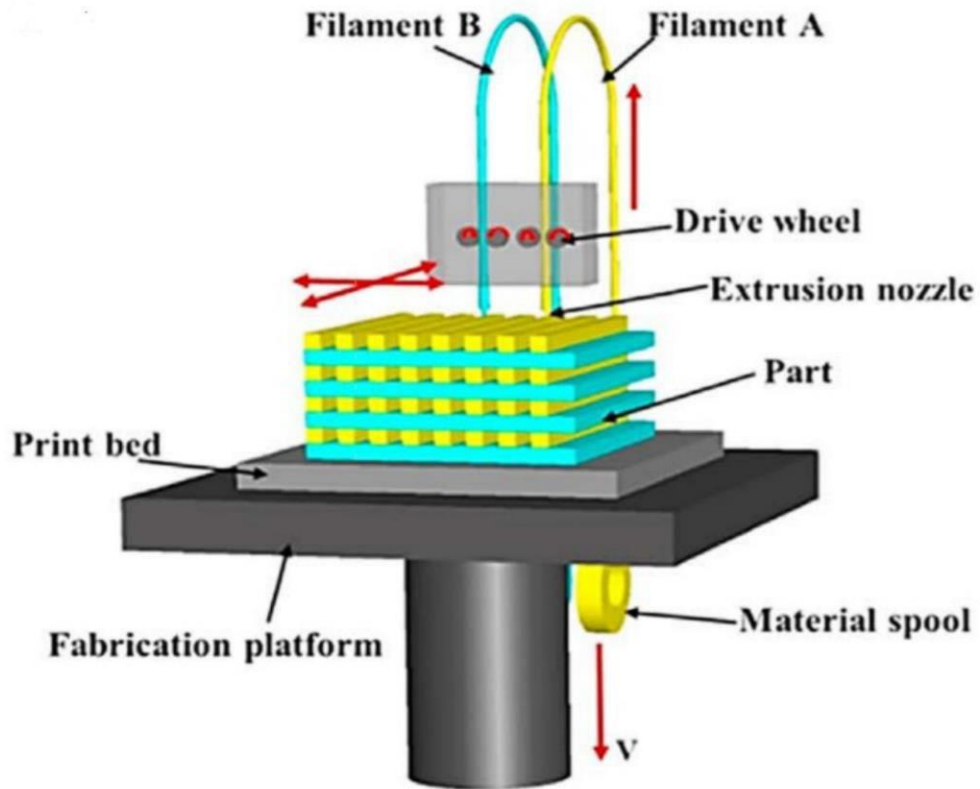


Figure-2.1: Fused deposition modeling schematic diagrams.

2.7. EFFECT OF PATTERNS OF INFILL

The effect of the infill design on the compressive strength of the part was inspected by Alayoldi, et al. (2020) [46]. It was found that though quartercubic infill showed a much lower strength of 27 MPa, three-sided, matrix, and hexagonal infilled segments had comparable extreme elastic qualities (56-72 MPa). Because of its exceptional layer structure, in which the infill layers are crossed one on top of the other, it was additionally found that the lattice design had the most extreme elasticity. With regards to quarter cubic examples, where there is a balanced between the layers, this was not seen. This offset segment wasn't upheld by the layers above it when the part was stacked, subsequently it bowed like a cantilever. In general strength is accordingly diminished to 27 MPa [46].

With its short courses, Hilbert's infill design demonstrated the best contribution to the elastic explicit strength. A vital increase in strength results from increasing the infill to 100%. However, the circular infill design with modified heap application and fibre testimony orientations produced better outcomes for all infill densities [47].

The aftereffects of Cwikla, et al. (2017) [48] who tried whether the ABS segment loaded up with a honeycomb design displayed strength similar to that of concentric infill and 0 percent thickness are in struggle with Akhoundi, et al. (2019's) discoveries with respect to the honeycomb design. Because of its balanced shape and diminished torsional firmness, the concentric model isn't suggested for twist applications. Be that as it may, the customary network and line format adversely affects mechanical quality. It appears to be that more exploration is expected to decide what ink designs mean for the mechanical nature of added substance producing (AM) parts given the clashing outcomes. The way of behaving of new stacking models under various burden situations ought to likewise be examined as they become accessible [49].

Problem Statement

After studied the above all research paper, we found that strength of all model created by the 3D printer is almost same and some time its change by adding the some chemical substance. But if in the future, we need sufficient strength of the model by using the 3D printer then how can we achieve it. So In this work we will increase and decrease the temperature of the abs filaments and suing the different shape of the pattern such as the rectangular, triangular and hexagonal pattern.

CHAPTER-03

METHODOLOGY

Research system and style, material readiness and qualities, 3D printer planning, delivering tests with determined infill directions, elastic testing tests as indicated by Associate in Nursing ASTM ordinary, and information examination are all encased inside the strategy. When it includes lastingness, the point of the strategy was to gather and esteem lastingness information that then showed the impact of carbon fiber on ABS and infill point on 3D composed objects.

3.1. RESEARCH DESIGN AND SAMPLE

The essential effects of 2 independent factors (material kind and infill point) on the lastingness of examples in sync with the sort one detail of ASTM ordinary D638: typical check procedure for Tensile Properties of Plastic were examined utilizing a between-bunch exploratory style. In sync with ASTM (2012), "7.2 10 examples, 5 customary to, and 5 lined up with, the principal pivot of property, for each example inside the instance of aeotropic materials" ought to be analyzed [50]. There have been fifteen pairwise examinations potential with six degrees of infill point. because of a Bonferroni change was required, a total of fifteen really take a look at examples (180 examples) were made each exploratory bunch, with 3 further examples planned in the event that a clever example inside the group must be dismissed ($180+36=216$ aggregate). Without any backings, pontoons, or overflows, examples were created with their faces lined up with the improvement stage. At six infill points, all examples were composed on the Flashforge Creator proficient 3D printer with ABS and CFR ABS fiber from 3DXTech (2017). As a result, twelve groups of fifteen examples were designed (Table-3.1).

Tablel-3.1.-Comparison Groups

Infill Angle (degrees)	Type of Material	
	ABS (count)	CFR ABS (count)
Fifteen	Fifteen	Fifteen
Thirty	Fifteen	Fifteen
Forty Five	Fifteen	Fifteen
Sixty	Fifteen	Fifteen
Seventy Five	Fifteen	Fifteen
Ninty	Fifteen	Fifteen

3.2. MATERIAL.

Only one carbon fibre reinforced ABS supplier was available at the time of this investigation. The ABS utilised (called "Natural ABS" by 3DXTech, 2017) is identical to the ABS used with the carbon fibre reinforcements; having ABS that is also part of the CFR ABS is desired for consistency and comparability in outcomes. 3DXTech provided natural ABS filament and 15 wt percent carbon fibre reinforced ABS (both .07 inch (1.75 mm).002 inch (.05 mm) diameter) (2017). The ABS (CAS No. 9003569) is "manufactured in the USA utilising 100 percent virgin resin and colourants accurately extruded onto 2.2 lb (1 kilogramme) spools," according to 3DXTech (2017). To preserve the filament from moisture, it is vacuum packed with desiccant" (3DXTech, 2017). It's worth noting that ABS is hygroscopic, which means it needs to be kept as dry as possible. 3DXTech's (2017) carbon fibre (CAS No. 308063 674) reinforced ABS (CAS No. 9003569) is "manufactured with 15% wt% HighModulus Carbon Fiber" (not carbon powder or milled carbon fiber). Made in the United States of America using quality Sabic MG94 ABS" (2017) The particular tensile strength of the fibres employed in this study's carbon fibre reinforced ABS composite was not stated [51]. In this trial, the CFR ABS was coiled into 1.1 lb (500g) spools according on what was requested. Both materials are compatible with the Flashforge 3D printer line, according to 3DXTech (2017).

The ABS material provider, 3DXTech (2017), offered no information on the chemistry, melt flow index, or manufacturer of the ABS original resin. Appendix B contains technical information on natural ABS. The melt flow of natural ABS was tested using a Tinius Olsen™ MP 987 extrusion plastometer (in accordance with ASTM D1238 (2013)); the results are given in Table 3.2. The CFR has more information regarding the ABS.

Table-3.2: Melt Flow Index (grams/10 minutes)

Natural ABS	ABS within CFR ABS	CFR ABS
2.5 g/10 min	11.7 g/10 min	3.5 g/10 min

These melt flow index values are within the range of extrusion grade material, indicating that they will function well in 3D printing. Because of the lower CFR ABS value, slower nozzle travel speeds may be considered. Melt flow index values, according to hypothesis, might have a role in bonding difficulties between carbon fibre and ABS [51].

The natural ABS derived from them has a tensile strength of 5,946 psi, according to 3DXTech (2017) (41 MPa). The melt flow index and density of the Sabic ABS utilised in the Carbon Fiber Reinforced ABS composite are available on Matweb. Sabic ABS has a stated tensile strength of 5,076 psi (35 MPa). There is technical information on carbon fibre reinforced ABS.

The reinforced ABS has a tensile strength of 6381 psi, according to 3DXTech (2017) (44 MPa). 3DXTech did not provide the tensile strength of the carbon fibre utilised in the reinforced composite (2017). Appendices C and respectively include safety information for each materials [51].

In this examination, the heft of one two.2 pound (1 kg) spool of ABS was utilized, besides as 3 one.1 pound (500 g) spools of carbon fiber reinforced ABS, however exclusively a tad bit of the third spool was utilized. The spools of texture were clear from the 3D printer and solid in sealable Mylar stuff with sicative once the examination was finished and though the machine wasn't being used [51].

3.3.3D-PRINTING

3.3.1.3 D-Printer Software Preparation.

A stereolithography (.STL) file was used to import the electronic file of the specimen developed in a 3D graphical environment into Simplify3D (Version 4.0.0, 2017). The following were used as build parameters:

- Nozzle temperature: 446 Fahrenheit (230 Celsius).
- Build-platform temperature: 230 Fahrenheit (110 Celsius).
- Extrusion speed: 141.73 in/min (3600.0 mm/min).
- Infill percentage: 100.
- number of perimeter shell layers: 2.
- Layer height: .2 mm.

The default setting, that sets the underlying layer level to 90th of the normal, worn out layer level, has been acclimated to 100%. This revision involves stacking sixteen even.008 inch (.2 mm) thick layers to prompt a.126 in. (3.2 mm) thick example. The 3Dprinter's default programming framework settings is likewise viewed as here.

The examples were made with Simplify3D (Version four.0.0, 2017) programming framework and a Flashforge Creator proficient 3D printer. A spout with a breadth of.016 in. (0.4 mm) was used. A 0.25 inch (6.35 mm) treated glass stage was acclimated cowl the form stage [52]. To brighten up beginning layer adherence, this was delicately covered with Associate in Nursing ABS in dissolving specialist reply and reapply expert re nata. prior to the essential form for each trial group, the buildplatform was evened out with a.003 inch (.07 mm) thick evening out card given by Flash for geusa (2017), i.e., the underlying distance of the build platform to the spout was laid out, and furthermore the build platform was set lined up with the X/Y hub of the spout development. to get around 90th surface inclusion by ABS, the underlying spout level was laid out by visual examination of the essential form layer. Examples were plant made each in turn, face down, with their longitudinal pivot lined up with the printer's x hub. The form chamber temperature was raised higher than temperature abuse the 3D printer's acrylic packaging [53]. Before a form, the spout and fabricate stage were warm with sufficient opportunity to oblige for uniform warming circulation on the glass construct stage [53].

Most of the ASTM D 63802: ordinary investigate method for Tensile Properties of Plastics strategies and guidelines were kept. it's feasible to view as the ductile testable bone (on the grounds that to its structure). "6.1.3 reinforced Composites - The investigate example for reinforced composites. should stick to the size of the sort I example," ASTM (2012) states. (ASTM D 638). each example was estimated to seethat it met ASTM pliable testing measures, then, at that point, named Associate in Nursingd fixed in a sealed shut pack with drying specialist. when not being used, the improvement materials were flop Associate in Nursingd put in an impenetrable sack with drying specialist [54].

3.4. MANUFACTURING TENSILE-TEST SAMPLES.

The programmed transferred the file and related nozzle routes to the machine after it was preheated. When each sample was finished, the specimen was removed from the machine and a new layer of ABS/Acetone slurry was applied before starting the next 3D print. After each 3D print, the eighteen specimens in the experimental group were identified and placed in an airtight bag with desiccant. The top/bottom of the specimens were labelled, as well as the physical order within the groupings [55].

When the next orientation was started on both ABS and CFR ABS, minor changes to the wingnuts beneath the build platform were required to help construct a solid and tested specimen (i.e., within the constraints of the ASTM standard). The buildtray was levelled using a levelling card that came with the 3D printer; nevertheless, without additional modifications to the height of the buildtray, certain strands would not cling to another strand that had been deposited totally perinfillangle. A starter 3Dprint of the essential example at stretches each group was won't to conquer this [55]. The cohesiveness between the strands was outwardly checked once the essential layer was expelled onto the advancement surface. On the off chance that the strands' union was pitifully, holes would appear among them, and consequently the stage would be contacted closer or farther distant from the spout (considering a great deal of or less "crush" of the texture to stick) [55]. The example's consistency was disappeared with the strands not sticking as expected. pitifully strands were place opposite to something like each other layer by layer, prompting openings. Assuming there region unit blemishes inside the example, it's not strong inside the feeling that this concentrate needs. A subsequent layer was suitable to print in the event that the cohesiveness was

alright and there have been no clear holes between the strands. On the off chance that the spout scratched against the example on the grounds that the subsequent layer was expelled on prime of the essential, the stage was marginally brought down (permitting more space between the spout and in this manner the form surface) and a subsequent fundamental print was performed to ensure the strands were all the while sticking along adequately and no scratching was occurring on the following layer [56].

3.5. PROPERTY OF ABS MATERIAL

In this section, we will know in the details about the physical, mechanical, and thermal property.

3.5.1. Physical Properties

The physical property of the ABS materials is given in the table 3.3:

Table-3.3: Physical Property

Serial Number	Property	Value
1	Density	1.04 g/cc
2	Melt Flow	18 - 23 g/10 min

3.5.2. Mechanical Property

The mechanical Property of the ABS material are given below in the table-3.4:

Table-3.4: Mechanical Property

S.Number	Property	Value
1	Hardness	103 - 112
2	Tensile Strength	42.5 - 44.8 MPa
3	Elongation at Break	23 - 25 %
4	Flexural Modulus	2.25 - 2.28 GPa
5	Flexural Yield Strength	60.6 - 73.1 MPa

3.5.3. Thermal Property.

The thermal property of the ABS fillmane of the 3D Printer is given below in the table-3.5

Table-3.5: Thermal Property.

S.Number	Property	Value
1	Maximum Service Temperature	88 - 89 °C
2	Deflection Temperature at 1.8 MPa (264 psi)	88 - 89 °C
3	Vicat Softening Point	100 °C

3.6. UNIVERSAL TESTING MACHINE

By applying tensile, compressive, or transverse stresses, this apparatus is used to evaluate the mechanical characteristics (tension, compression, etc.) of a specific test specimen. The machine's name refers to the variety of tests it can run on many types of materials. With the use of UTM, a variety of tests, including peel, flexural, tension, bend, friction, and spring tests, may be carried out [56].

This machine is used testing the tensile strength of the ABS filament.



Figure-3.1: UTM.

3.6.1. Components of Universal Testing Machine

A universal testing machine consists of two main parts:

1. Loading Unit
2. Control Unit

The loading unit holds the configuration of the test specimen and the load's exertion.

The control unit provides the changes in load application and the related test result [56].

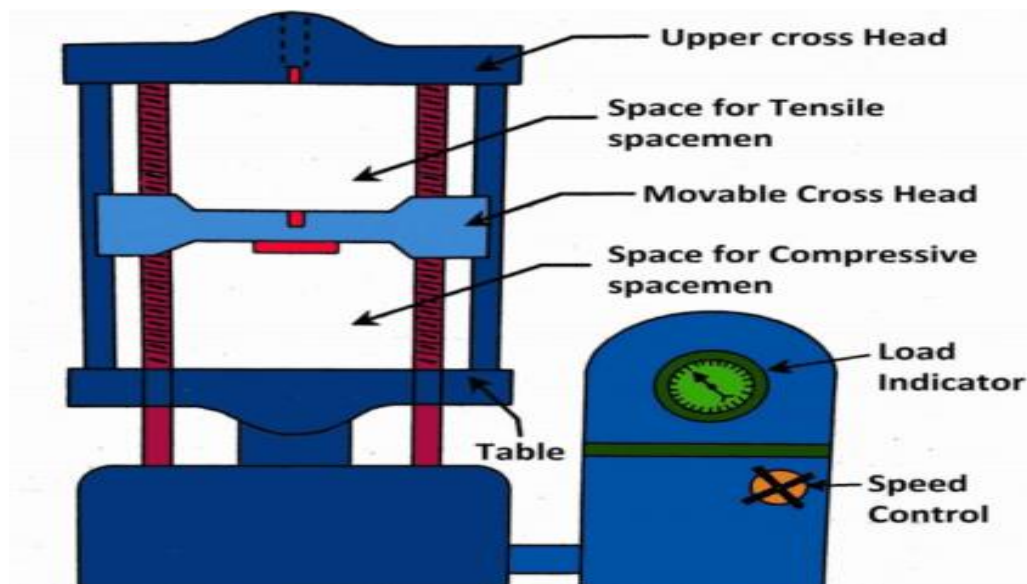


Figure-3.2: Component of UTM.

CHAPTER-04

RESULT AND DISCUSSION

In this result and discussion chapter, we have studied the about the improving the strength of abs filament by changing the temperature of the filament, using different pattern for creating the model. In this research work we have kept minimum temperature 225 degree Celsius which is minimum for melting the filament and maximum temperature is 260 degree Celsius and using three different patterns for creating same models. The details of the temperature and percentage of the infill density are given below in the form of the table.

The amount of filament used during printing determines the infill density, which in turn affects the print's strength, weight, and printing time. Without altering the print's weight or the filament used, different 3D print infill types, or infill patterns, can change an object's ultimate strength.

Table-4.1: Temperature and Percentage of the Infill Density of the filament

Serial Number	Type of Sample	Temperature (°C)	Percentage of infill density
1	S-1	225	10.0
2	S-2	230	25.0
3	S-3	235	50.0
4	S-4	240	100.0
5	S-5	245	10.0
6	S-6	250	25.0
7	S-7	255	50.0
8	S-8	260	100.0

4.1. ULTIMATE TENSILE STRENGTH OF ABS FILAMENT

The Ultimate tensile strength (UTS), often shortened to tensile strength (TS), is the maximum stress that a material can withstand while being stretched or pulled before breaking.

In this ultimate tensile strength of the abs filament is achieved by the using different temperature to create it and using the different pattern at the layer of the models such as the rectangular, triangular, and hexagonal pattern.

There are eight model created with the help of the 3D printer by using three different patterns such as rectangular, triangular, and hexagonal pattern.

The ultimate tensile strength of the ABS filament are given below in the form table as well as graph:

Table-4.2: Ultimate Tensile Strength of ABS Filament

Serial Number	Sample Number	Rectangular Pattern (MPa)	Triangular Pattern (MPa)	Hexagonal Pattern (MPa)
1	S-1	16.07	26.87	20.12
2	S-2	18.11	28.23	23.65
3	S-3	20.28	30.76	25.23
4	S-4	22.23	32.41	27.04
5	S-5	24.09	35.12	30.11
6	S-6	25.51	35.44	30.63
7	S-7	26.24	35.56	30.98
8	S-8	26.75	35.79	31.43

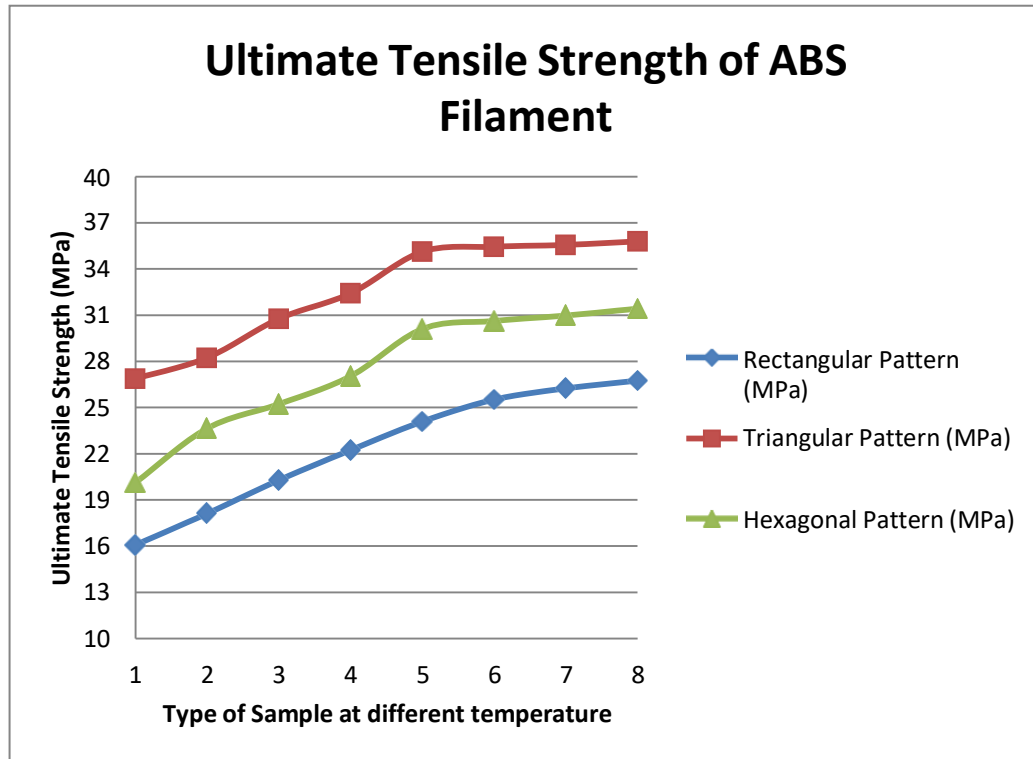


Figure-4.1: Ultimate Tensile Strength of ABS Filament

4.2. TENSILE TEST

After analyzing the result, there are three type of the pattern used to create the model by using the 3D printer at the different temperature, calculated peak load, peak stress, break load, break stress, tensile strength.

4.2.1. Tensile Test for Rectangular Pattern

In this tensile test, we are using the rectangular pattern to create model with help of the 3D printer from the temperature 225 to 260 degree Celsius. After completing tensile test on this sample, the result are given below in the form of the table:

Table-4.3: Tensile Test for Rectangular Pattern

Serial Number	Type of Sample	Peak Load (N)	Peak Stress (MPa)	Break Load (N)	Break Stress (MPa)	Tensile Strength (MPa)
1	S-1	733.3	15.98	734.51	16.04	16.01
2	S-2	768.1	18.07	770.01	18.67	18.12
3	S-3	811.4	20.01	812.21	20.76	20.23

4	S-4	847.8	21.97	848.30	22.45	22.11
5	S-5	914.1	23.84	915.09	24.35	23.94
6	S-6	969.12	25.03	970.12	25.68	25.34
7	S-7	982.4	25.76	983.19	26.03	25.91
8	S-8	998.9	26.23	999.45	26.13	26.52

4.2.2. Tensile Test for Triangular Pattern

In this tensile test, we are using the Triangular pattern to create model with help of the 3D printer from the temperature 225 to 260 degree Celsius. After completing tensile test on this sample, the result are given below in the form of the table:

Table-4.4: Tensile Test for Triangular Pattern

Serial Number	Type of Sample	Peak Load (N)	Peak Stress (MPa)	Break Load (N)	Break Stress (MPa)	Tensile Strength (MPa)
1	S-1	804.34	25.67	805.02	26.04	26.09
2	S-2	835.97	27.23	836.13	27.83	27.89
3	S-3	867.13	29.12	867.54	29.91	29.98
4	S-4	913.98	31.34	914.18	31.87	31.94
5	S-5	949.87	33.67	950.34	34.11	34.18
6	S-6	1011.43	34.45	1012.04	34.67	34.74
7	S-7	1023.01	35.03	1023.87	35.23	35.31
8	S-8	1038.12	35.48	1039.08	35.67	35.78

4.2.3. Tensile Test for Hexagonal Pattern

In this tensile test, we are using the Hexagonal pattern to create model with help of the 3D printer from the temperature 225 to 260 degree Celsius.

After completing tensile test on this sample, the result are given below in the form of the table:

Table-4.5: Tensile Test for Hexagonal Pattern

Serial Number	Type of Sample	Peak Load (N)	Peak Stress (MPa)	Break Load (N)	Break Stress (MPa)	Tensile Strength (MPa)
1	S-1	784.13	19.45	785.01	19.78	19.82
2	S-2	813.01	22.76	813.56	23.03	23.07
3	S-3	835.87	24.56	836.04	24.86	24.91
4	S-4	872.12	26.34	872.61	26.67	26.73
5	S-5	939.04	28.97	939.51	29.12	29.25
6	S-6	998.12	29.54	998.78	29.74	29.81
7	S-7	1012.34	30.12	1012.67	30.35	30.41
8	S-8	1026.21	30.51	1026.98	30.73	30.82

4.3. PEAK LOAD

Limit loads (the maximum loads that can be expected in service) and ultimate loads (the greatest loads that can be expected in service) are used to specify strength requirements (limit loads multiplied by prescribed factors of safety) [57].

In terms of aircraft construction and design, the ultimate load is the maximum load that can be given to a component before it fails. However, the likelihood of it occurring is not zero, and if it does, the relevant structure in the aircraft faces a high risk of breakage [57].

There are eight model created with the help of the 3D printer by using three different patterns such as rectangular, triangular, and hexagonal pattern. The peak load of all these models is given below in the form of the table as well as graph:

Table-4.6: Peak Load

Serial Number	Type of Sample	Peak Load of Rectangular Pattern (N)	Peak Load of Triangular Pattern (N)	Peak Load of Hexagonal Pattern (N)
1	S-1	733.3	804.34	784.13
2	S-2	768.1	835.97	813.01
3	S-3	811.4	867.13	835.87
4	S-4	847.8	913.98	872.12
5	S-5	914.1	949.87	939.04
6	S-6	969.12	1011.43	998.12
7	S-7	982.4	1023.01	1012.34
8	S-8	998.9	1038.12	1026.21

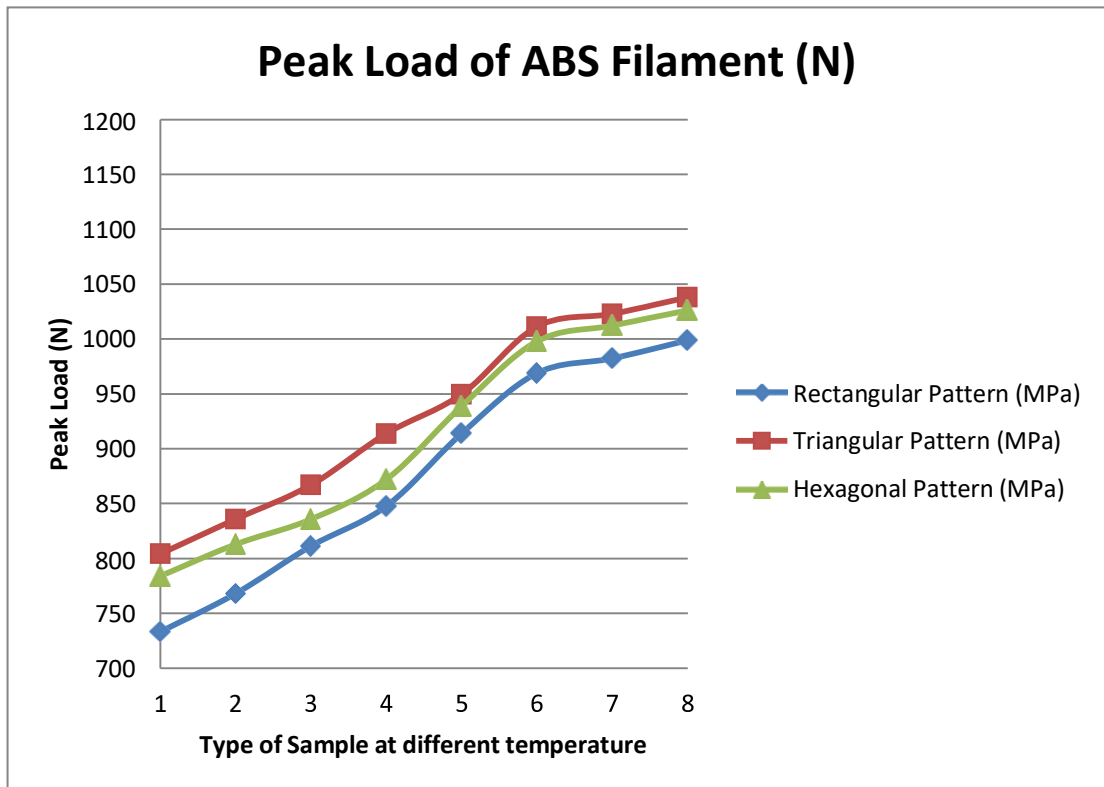


Figure-4.2: Peak Load of ABS Filament.

4.4. PEAK STRESS

The highest stress that a specific material can bear under an applied force is referred to as ultimate tensile stress (UTS).

Metals that are subjected to stress levels higher than the UTS value are more prone to develop stress corrosion cracking characteristics [58].

It's critical to keep the rate of UTS in metals that are regarded as appropriate for a certain application under control.

This allows corrosion experts to better assess the rate of stress corrosion cracking, which is significant since SCC and the lifespan of metal is directly related [58].

There are eight model created with the help of the 3D printer by using three different patterns such as rectangular, triangular, and hexagonal pattern.

The table as well as graph of the peak stress for three different pattern of the models with different temperature is given below:

Table-4.7: Peak Stress

Serial Number	Type of Sample	Peak Stress of Rectangular Pattern (MPa)	Peak Stress of Triangular Pattern (MPa)	Peak Stress of Hexagonal Pattern (MPa)
1	S-1	15.98	25.67	19.45
2	S-2	18.07	27.23	22.76
3	S-3	20.01	29.12	24.56
4	S-4	21.97	31.34	26.34
5	S-5	23.84	33.67	28.97
6	S-6	25.03	34.45	29.54
7	S-7	25.76	35.03	30.12
8	S-8	26.23	35.48	30.51

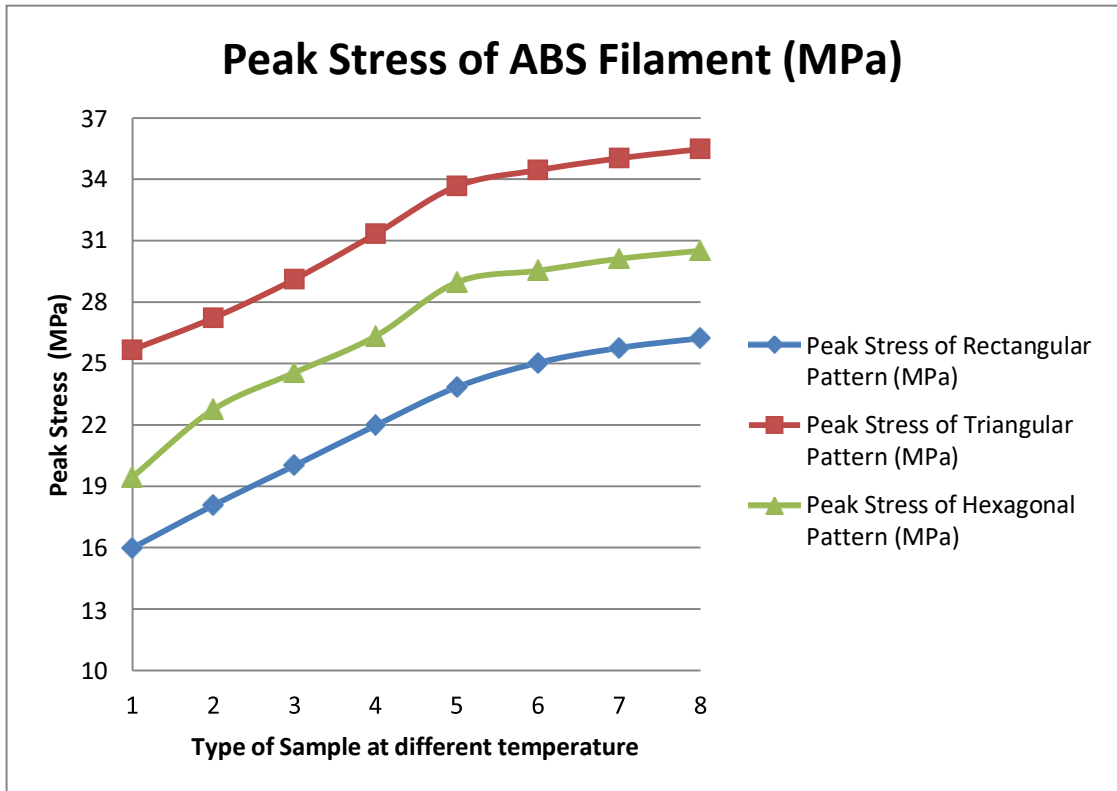


Figure-4.3: Peak Stress of ABS Filament.

4.5. BREAK LOAD

The load causes fracture in a tensile, compression, flexure, or torsion test. In tensile tests of textiles and yarns, breaking load also is called breaking strength [59].

At this load, the ABS filament gets breaks at the different pattern such as rectangular, triangular, and hexagonal pattern at the different temperature [59].

There are eight model created with the help of the 3D printer by using three different patterns such as rectangular, triangular, and hexagonal pattern. The break load of all these models is given below in the form of the table as well as graph:

Table-4.8: Break Load

Serial Number	Type of Sample	Break Load of Rectangular Pattern (N)	Break Load of Triangular Pattern (N)	Break Load of Hexagonal Pattern (N)
1	S-1	734.51	805.02	785.01
2	S-2	770.01	836.13	813.56
3	S-3	812.21	867.54	836.04
4	S-4	848.30	914.18	872.61
5	S-5	915.09	950.34	939.51
6	S-6	970.12	1012.04	998.78
7	S-7	983.19	1023.87	1012.67
8	S-8	999.45	1039.08	1026.98

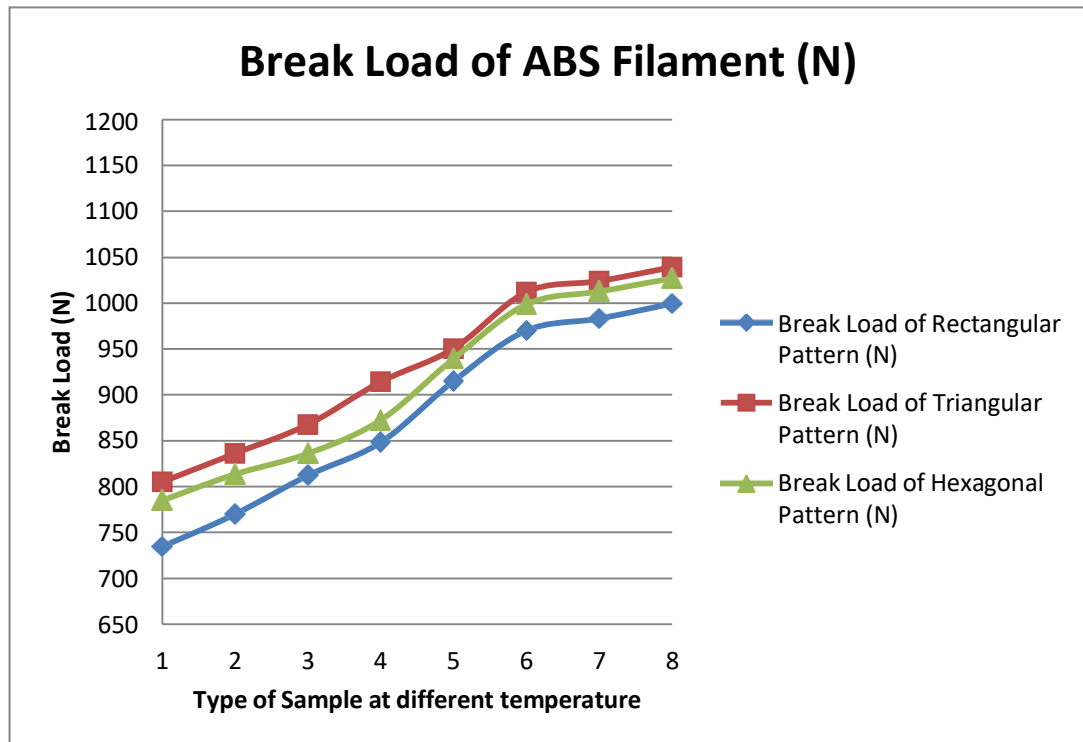


Figure-4.4: Break Load of ABS Filament.

4.6. BREAK STRESS

The stress which causes fracture in a tensile, compression, flexure, or torsion test. In tensile tests of textiles and yarns, breaking stress also is called breaking stress [60]. At this stress, the ABS filament gets breaks at the different pattern such as rectangular, triangular, and hexagonal pattern at the different temperature [60]

There are eight model created with the help of the 3D printer by using three different patterns such as rectangular, triangular, and hexagonal pattern. The break stress of all these models is given below in the form of the table as well as graph:

Table-4.9: Break Stress

Serial Number	Type of Sample	Break Stress of Rectangular Pattern (MPa)	Break Stress of Triangular Pattern (MPa)	Break Stress of Hexagonal Pattern (MPa)
1	S-1	16.04	26.04	19.78
2	S-2	18.67	27.83	23.03
3	S-3	20.76	29.91	24.86
4	S-4	22.45	31.87	26.67
5	S-5	24.35	34.11	29.12
6	S-6	25.68	34.67	29.74
7	S-7	26.03	35.23	30.35
8	S-8	26.13	35.67	30.73

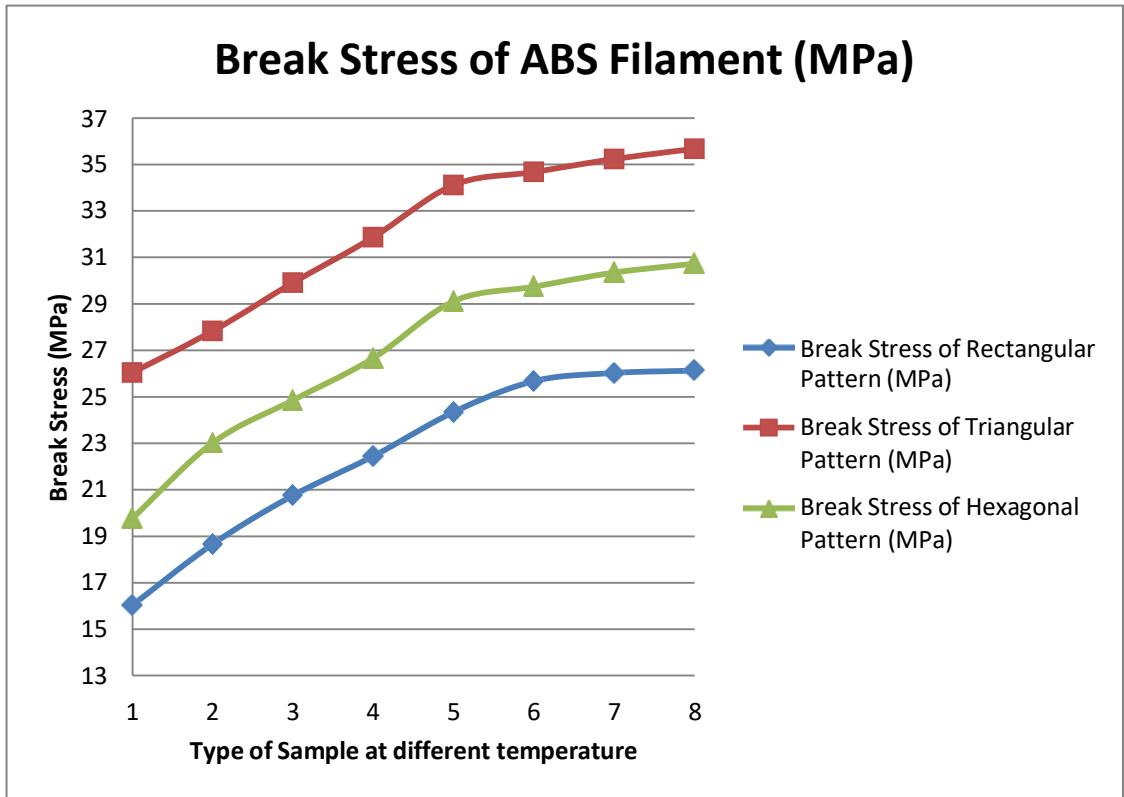


Figure-4.5: Break Stress of ABS Filament.

4.7. Tensile Strength

The tensile strength of these three patterns of the models which are created by the 3D printer at the different temperature are given below in the form of the table as well as graph:

There are eight model created with the help of the 3D printer by using three different patterns such as rectangular, triangular, and hexagonal pattern. The tensile strength of all these models is given below in the form of the table as well as graph:

Table-4.10: Tensile Strength

Serial Number	Type of Sample	Tensile Strength of Rectangular Pattern (MPa)	Tensile Strength of Triangular Pattern (MPa)	Tensile Strength of Hexagonal Pattern (MPa)
1	S-1	16.01	26.09	19.82
2	S-2	18.12	27.89	23.07
3	S-3	20.23	29.98	24.91
4	S-4	22.11	31.94	26.73
5	S-5	23.94	34.18	29.25
6	S-6	25.34	34.74	29.81
7	S-7	25.91	35.31	30.41
8	S-8	26.52	35.78	30.82

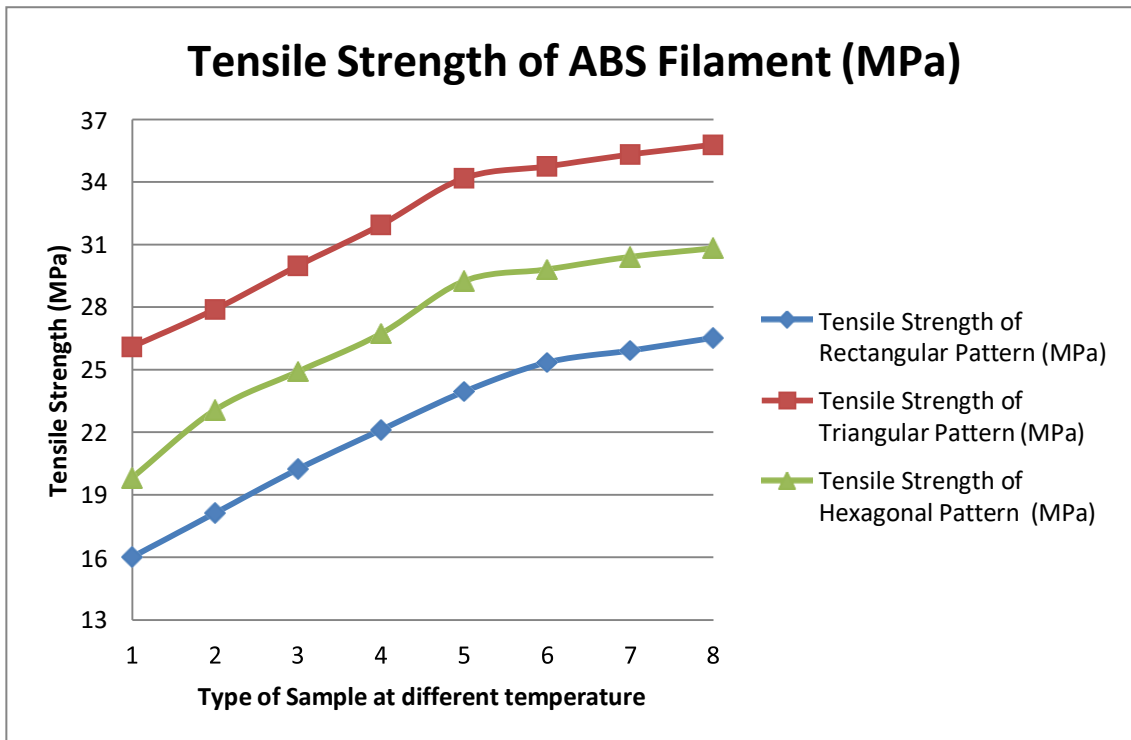


Figure-4.6: Tensile Strength of ABS Filament.

CHAPTER-05

CONCLUSION

In this research work, we are numerically analyzing the 8 model which are created with the help of the 3D printer at the different temperature by using three patterns to analyze the models such as the rectangular, triangular, and hexagonal pattern. After analyzing the result and discussion chapter on the basis of the ultimate tensile strength, tensile test such as peak load, peak stress, break load, break stress, and tensile strength, the conclusion are given below:

- In the ultimate tensile test, the maximum ultimate tensile strength is achieved by the triangular pattern. It's because the area of the cross section of the triangular pattern is minimum as compared to the other two patterns such as the rectangular and hexagonal pattern. The ultimate tensile strength of the triangular pattern is approximately 40.195% higher than rectangular pattern of the layer, and 25.12% higher than hexagonal pattern.
- In the tensile test of the ABS filament, there are mainly five parameter taken as the peak load, peak stress, break load, break stress and tensile strength. The value of the peak load and peak stress is exist in the triangular pattern of the layer, which is approximately 1038.12 N and 35.67MPa respectively at the temperature 260 degree Celsius. The value of the peak load of the triangular pattern is approximately 3.78 % higher than rectangular layer of the pattern, and 1.15% higher than hexagonal pattern of the layer of the models at the 260 degree Celsius. The peak stress of the triangular pattern is approximately 26.07% higher than rectangular, and 14% higher as compared to the hexagonal pattern of the layer.
- From all these analysis of the result, we found that the maximum strength of the ABS filament can be achieved by using the triangular pattern at the model's layer, but we increasing the temperature above 245 degree Celsius then strength of the abs filament are increasing very slowly.

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LIST OF PUBLICATIONS

Alam, M., and Anas M. (2022). Improving the Strength of Acrylonitrile Butadiene Styrene using 3d Printer. International Research Journal of Engineering and Technology, 9(6),1-5

STRENGTH IMPROVEMENT OF ACRYLONITRILE BUTADIENE STYRENE FILAMENT USED IN THE 3D PRINTER

Mehtab Alam¹, Mohd Anas²

¹M.Tech, Production and Industrial Engineering, Integral University, Lucknow, India.

²Associate Professor, Department of Mechanical Engineering, Integral University, Lucknow, India.

Abstract

In this research work, we have studied about improving the strength of the Acrylonitrile butadiene styrene (ABS) filament of the 3D printer. We know that at the default setting of the 3D printer, the strength of the all models which are created by the 3d printer is almost same when we are using the Acrylonitrile butadiene styrene (ABS). But in this research work, we are numerical analyze the models which will be created by using the Acrylonitrile butadiene styrene filament in the 3D printer at the different temperature such as 225 °C, 230 °C, 235 °C, 240 °C, 245 °C, 250 °C, 255 °C, and 260 °C, and using the three different pattern to analyze these models such as the rectangular, triangular, and hexagonal pattern at layer of the each models. The area Acrylonitrile butadiene styrene (ABS) filament is kept constant which are 40 mm². These all models which will be prepared by the 3D printer, we will check strength of the all models at different temperature such as 225 °C, 230 °C, 235 °C, 240 °C, 245 °C, 250 °C, 255 °C, and 260 °C and using three different pattern of the layer such as rectangular, triangular, and hexagonal pattern by using the Universal Testing Machine (UTM). We will check the strength of the all these models on the basis if the selected parameter such as the ultimate tensile strength, peak load, peak stress, break load, break stress, and tensile strength.

Keyword: ABS filament, 3D printer, tensile strength, temperature, rectangular, triangular, Hexagonal Pattern.

1.INTRODUCTION

The technology of additive manufacturing is very young; it was created in the 1980s and has rapidly advanced over the past 20 years. A growing number of manufacturing, educational, and domestic contexts are embracing and using additive manufacturing technology, sometimes known as 3D printing [1]. substance extrusion The most popular piece of 3DP equipment uses a technique in which a polymeric filament is extruded and deposited layer by layer until a 3D object is formed. This process is comparable to the patented fused deposition modelling (FDM) technology. However, due to the fact that the mechanical strength of FDM printed items is often lower than that of injection moulded products due to their weak areas between the layers, there are only a few applications for this type of 3D printing. The 3D printing industry has a lengthy history using ABS (Acrylonitrile Butadiene Styrene) [1]. One of the earliest plastics to be utilised with commercial 3D printers was this substance. Thanks to its inexpensive cost and

Improving the Strength of Acrylonitrile Butadiene Styrene Filament Used in the 3D Printer: A Review

Mehtab Alam¹, Mohd Anas²

¹M.Tech, Production and Industrial Engineering, Integral University, Lucknow, India.

²Assistant Professor, Department of Mechanical Engineering, Integral University, Lucknow, India.

Abstract - This review paper studied to increase the strength of the Acrylonitrile Butadiene Styrene filament with a different technique, and a summary of all research papers is available in the literature survey. With the increasing 3D printing user domain, the demand for 3D printable materials has escalated. Since the development of this technology, several materials have been used to experiment with the printing process. The feasible materials for printing, range from various polymers to organic tissues. According to a study conducted by Forbes in 2018, plastics are the highest consumed 3D printing materials, accounting for about 88% of all the materials used at a global level. This is because plastics are economically cheap and readily available. The processability of plastics is relatively higher than other 3D printing materials.

The thermoplastic nature of ABS makes it suitable for 3D printing. Because of its composition, ABS has distinguished mechanical properties like good toughness, impact resistance, rigidity, and strength. This makes ABS find its applications ranging from common household items to automotive parts and intricate medical devices. This increase in demand and usage of the material resulted in the question of its recycling and disposal. Any improper disposal of ABS can be a very serious threat to the environment. Thus, this creates an increased scope for research on the recycling trends of ABS.

Key Words: 3D printer, filament, Strength, Acrylonitrile Butadiene Filament, the strength of the filament.

1. INTRODUCTION

Market statistics suggest that income from 3D-printer vending and services quadrupled between 2009 and 2013, and maintain to expand significantly (Park, 2014). Even though these technologies "were initially meant primarily for (heavy) industrial usage," "continuous cost reductions have brought them within reach of [subject matter experts] SMEs and individual entrepreneurs". Moreover, client markets uncover Associate in Nursing expanding propensity by and large deals in organizations like Staples and Walmart (Rayna and Striukova, 2016). on-line retailers like 3DXTech (2017a), Stratasys (2017), and Makerbot (2017) sell restrictive materials along with their synthetic substances, while Amazon, eBay, and various merchants sell outsider materials and 3D printing administrations to ordinary clients and huge

producers (Rayna and Striukova, 2016). 3D printing uses computer-aided design (CAD) to create three-dimensional objects through a layering method. Sometimes referred to as additive manufacturing, 3D printing involves layering materials, like plastics, composites, or bio-materials to create objects that range in shape, size, rigidity, and color. The figure of the 3D printer are given below:

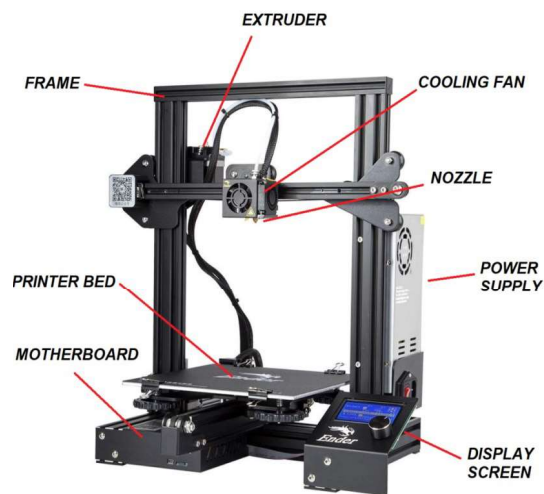


Figure-1: 3D Printer

1.1. Principle of Working

3D printers are part of the additive manufacturing family and use similar methods to a traditional inkjet printer- albeit in 3D. It takes a combination of top-of-the-line software, powder-like materials, and precision tools to create a three-dimensional object from scratch.

1.2. ABS Filament

ABS is made from monomers Acrylonitrile, 1,3-Butadiene, and Styrene with petroleum as the basis. This kind of plastic is known for its sturdiness and impact resistance. This filament will allow you to print durable 3D parts that can hold up plenty of usages and wear.

STRENGTH IMPROVEMENT OF ACRYLONITRILE BUTADIENE STYRENE FILAMENT USED IN THE 3D PRINTER

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