Study, Design and Manufacture of a 3D Printer Prototyping

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ABSTRACT

Desktop fabrication is another name for 3D printing. It is a procedure where a structure is created from a 3D model. The three-dimensional model is saved in STL format and then sent to a three-dimensional printer. In 3D printing variety of materials, like composites, ABS and PLA. A rapidly evolving and economically advantageous method of fast prototyping is 3D printing. The 3D printer creates an actual thing by layer by layer printing the CAD design. Inkjet desktop printers that use numerous deposit jets and printing material that is built up layer by layer from CAD 3D data are the origin of the 3D printing technology. Mass production techniques will face considerable challenges in the future thanks to 3D printing. This particular printing is anticipated.

***Keywords:** Rapid Prototyping, 3d printing, ABS, PLA*

1. INTRODUCTION

Desktop fabrication is another name for 3D printing. Through a method known as rapid prototyping, a physical product can be produced from a 3D design. A CAD model is used by a 3D printing device for rapid prototyping. Desktop fabrication, sometimes known as 3D printing, is a prototype technique where a structure is created from a 3D model. The three-dimensional design is saved in STL file and then sent to the three-dimensional printer. In 3D printing variety of materials required composites, ABS and PLA. One fast evolving and cost-effective technology used for rapid prototyping is 3D printing. The CAD design is printed using a 3D printer layer by layer to create an actual object. The 3D printing method is derived from inkjet desktop printers that print using a variety of deposit jets that are built up layer by layer from CAD3D data. Our lives are becoming more diverse and swifter thanks to 3D printing, which makes it easier and quicker to synthesis things with different qualities. Similar to how earlier technologies like photocopying affected the transfer of information, three-dimensional (3D) printing has the potential to do the same. This 3D printing involve techniques, necessary software, and applications. Companies can extract and invent fresh ideals and numerous design replications using 3D printing without spending any money or effort on tools. The use of 3D printing may one day complicate industrial mass production. Numerous industries, including the automotive, architectural, educational, medical, commercial, and consumer industries.

2. GENERAL PRINCIPLES

- **Modelling**

Models for 3D printing can be produced using 3D scanners or CAD design software. Method sculpting is akin to the manual modelling procedure used to provide geometric data for 3D computer graphics. Analyzing and gathering information about an object's form and appearance is the process of 3D modelling. For typical consumers, creating 3D printed models manually or automatically is highly challenging. Because of this, a number of markets have sprung up globally in recent years. Shape ways, Thing poetry, My Mini Factory, and Threading are the most well-liked.

- **Printing**

A "slicer" is a piece of software that breaks down 3D models into a number of small layers before to printing them. This procedure creates a G-code file from a.STL file that contains instructions for a printer. Slic3r, Slicer, and Cura are just a few examples of open source slicer software. A model is constructed using a succession of cross-sections by the 3D printer by following G-code instructions to lay down successive layers of liquid, powder, or sheet material. The final shape of a model is formed by joining or fusing these layers, which represent the virtual cross sections from the CAD model. The primary benefit of this method is its capacity to produce virtually any a geometrical shape or model. Depending on the approach utilised, the size, and the intricacy of the model, building a model might take anywhere from a few hours to days. It varies greatly depending on the type of equipment being used, the size and quantity of models being made, and additive methods may often cut this time to only a few hours.

- **Finishing**

Even if the resolution that the printer produces is enough for many applications, printing an object slightly larger than necessary in standard resolution and then deleting material with a higher-resolution method can produce results with greater precision. Similar to the Press Release for the iD-20 aircraft and other devices. International Manufacturing Technology demonstrates that several additive manufacturing processes can produce items utilising a variety of materials.

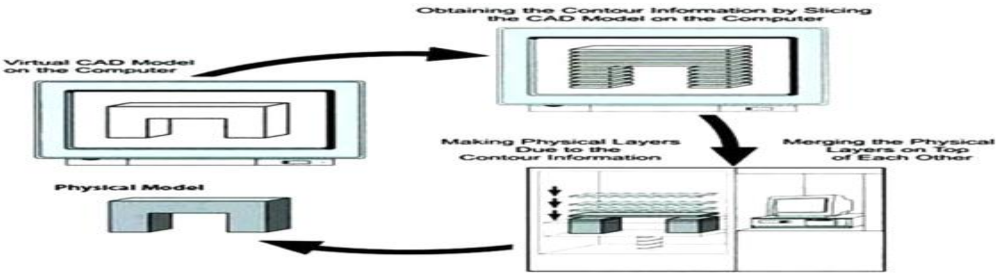

Figure 1. Printing procedure

3. PROCESSES

Since the late 1970s, a wide range of 3D printing techniques and technologies have been developed. In the beginning, the printers were quite expensive and big in size. There are now a lot of additive manufacturing processes accessible. Selective laser melting (SLM), selective laser sintering (SLS), and fused deposition modelling (FDM) are some of the techniques that melt or soften the material to create the layers, whereas stereo lithography (SLA) and laminated item production use other technologies to cure liquid materials (LOM).

- **Selective Laser Sintering**

Under the assistance of DARPA, Dr. Carl Deckard and his academic advisor Dr. Joe Beaman at the University of Texas created and patented selective laser sintering (SLS) in the middle of the 1980s. [2] Deckard was a part of the start-up business that was created as a result, DTM, to design and construct the selective laser sintering machines. The largest rival of DTM, 3D Systems, purchased DTM in 2001. The most current selective laser sintering patent from Deckard was granted in January 1997 and expired in January 2014. Selective laser sintering is a 3D printing technique that uses a laser as the power source to fuse powdered material (mostly metal) by directing the laser at specific locations in space that are identified by a 3D model. The resulting solid structure is then formed from the sintering of the material. Selective Similar principles are used in laser melting, however in SLM the material is entirely melted before being sintered, giving rise to distinct characteristics (crystal structure, porosity). SLS is a relatively new technique that has thus far been mostly utilised for low-volume item production and additive manufacturing. As the commercialization of additive manufacturing technology advances, production positions are expanding.

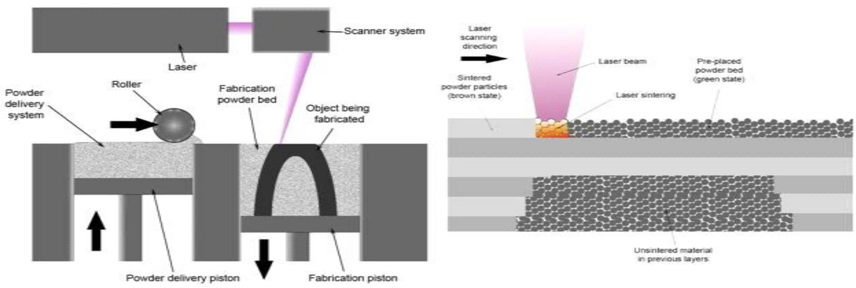

Figure 2. Selective laser sintering

- **Fused Deposition Melting**

A sizable open source development community formed once the patent on this technology expired, and commercial versions using this kind of 3D printer soon followed. As a result, since its inception, the cost of FDM technology has decreased by two orders of magnitude. This method involves extruding tiny beads of material that harden into layers to create the model. To provide material to an extrusion nozzle head, a coil of thermoplastic wire or filament is unwinding. The material is heated to a specific temperature by the nozzle head, which also controls the flow. The extrusion head is often moved in the z-direction by stepper motors, which are also used to control the flow to meet specifications. The mechanism is controlled by a computer-aided manufacturing (CAM) software programme operating on a micro controller, and it may be moved both horizontally and vertically.

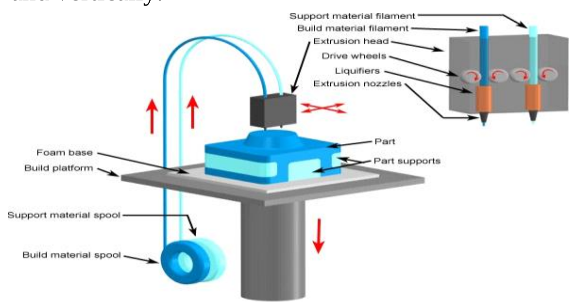

Figure 3. Fused deposition modeling

- **Stereolithography**

A pioneering and extensively used 3D printing process is stereolithography. Engineers may now produce prototypes of their own designs more quickly and efficiently thanks to the development of 3D printing. As early as 1970, the technology first became available. The present multilayer method of stereolithography was first developed by Dr. Hideo Kodama, a Japanese researcher, who used UV radiation to cure photosensitive polymers. Before Chuck Hull submitted his own patent application in July 1984, Alain Le Mehaute also submitted a stereolithography patent application. The French General Electric Company and CILAS ignored the patent application of the French inventor (The Laser Consortium). Le Mehaute thinks that France has a difficulty with innovation because of abandonment.Through the process of photopolymerization, which involves the use of light to link together chains of molecules to produce polymers, stereolithography is a sort of 3-D printing technology used to build models, prototypes, and patterns layer by layer.

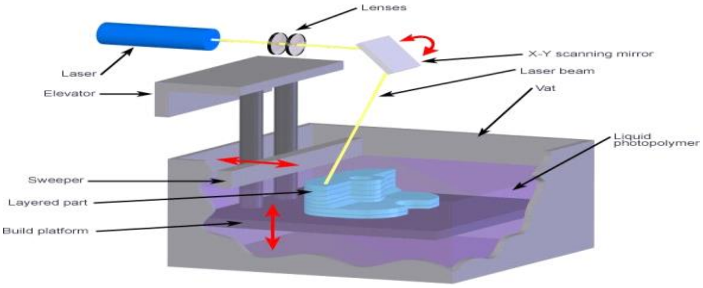

Figure 4. Stereo lithography

- **Laminated Object Manufacturing**

The 3D printing technique in question was created by Helisys Inc. (now Cubic Technologies). It involves the sequential joining and laser-cutting of layers of adhesive-coated paper, plastic, or metal laminates into the desired shape. This method of printing allows for the additional modification of objects by post-print machining. The material feed stock determines the normal layer resolution for this process, which typically ranges in thickness from one to multiple copies of a sheet of paper.

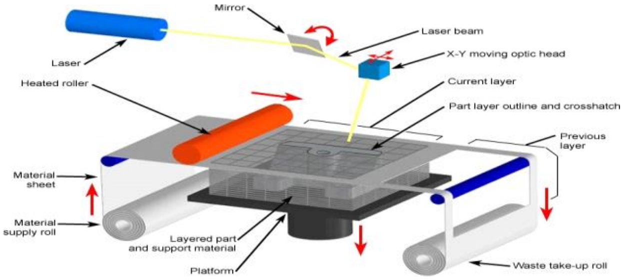

Figure 5. Laminated Object Manufacturing

4. 3D PRINTER MATERIAL

Following are the materials which can be used with the Aircraft i250 and their properties.

- **Acrylonitrile Butadiene Styrene [ABS]**

One of the materials that has been utilised the most since 3D printing first became popular. This substance is ideal for 3D printing since it is lightweight, slightly flexible, and extremely robust. Compared to PLA, another common 3D filament, it extrudes with less force. For small pieces, extrusion is facilitated by this characteristic. The fact that ABS demands a higher temperature is a drawback. Its glass transition temperature is approximately 105°C, and temperatures between 210 and 250°C are often employed for ABS printing. Another negative of this material is the printing process, which produces strong fumes that can be harmful to animals or humans with breathing problems. Thus, 3D printers must be installed in an area with good ventilation. Good advice is also good advice is to avoid breathing in fumes during printing considering the cost of 3D materials ABS is the cheapest, which makes it favorite in printing communities until now.

Technical Specifications:

Density- 1-1.4 gm/cm3

Dielectric constant- 3.1 to 3.2

Dielectric Strength [Breakdown Potential]- 15-16 kV/mm [0.59-0.63 V/mil]

Elastic modulus- 2 to 2.6 GPa

Elongation at break- 3.5 to 50%

Flexural modulus- 2.1 to 7.6 GPa

Flexural strength- 72 to 97 MPa

Heat deflection temperature at 1.82 MPa -76 to 110°C

Heat deflection temperature at 455 KPa- 83 to 110°C

Strength to weight ratio- 37 to 79 kN-m/kg

Tensile strength: 37 to 110 MPa

Thermal expansion- 81 to 95 µm/m-K

Material Properties of Acrylonitrile Butadiene Styrene [ABS]

Temperature - 225°C

Flow Tweak - 0.93

Bed Temperature - 90°C

Bed Preparation - apply glue stick 2 layer & then abs glue 1 layer

- **Poly Lactic Acid [PLA]**

Poly lactic acid (PLA) (is derived from corn and is biodegradable) is another well-spread material among 3D printing enthusiasts. It is a biodegradable thermoplastic that is derived from renewable resources. As a result PLA materials are more environmentally friendly among other plastic materials. The other great feature of PLA is its biocompatibility with a human body. The structure of PLA is harder than the one of ABS and material melts at 180 – 220°C which is lower than ABS. PLA glass transition temperature is between 60 – 65 ° C, so PLA together with ABS could be some good options for any of your projects.

Technical Specifications

Density - 1.3 g/cm³ (81 lb/ft³)

Elastic (Young's, Tensile) Modulus - 2.0 to 2.6 GPa (0.29 to 0.38 x 10³ psi)

Elongation at Break - 6.0 %

Flexural Modulus - 4.0 GPa (0.58 x 10^6 psi)

Flexural Strength - 80 MPa (12 x 10³ psi)

Glass Transition Temperature - 60 °C (140 °F)

Heat Deflection Temperature At 455 kPa (66 psi) - 65 °C (150 °F)

Melting Onset (Solidus) - 160 °C (320 °F)

Shear Modulus- 2.4 GPa (0.35 x 10^6 psi)

Specific Heat Capacity - 1800 J/kg-K

Strength to Weight Ratio - 38 kN-m/kg

Tensile Strength : Ultimate (UTS) - 50 MPa (7.3 x 10³ psi)

Thermal Conductivity - 0.13 W/m-K

Thermal Diffusivity - 0.056

Material Properties of Poly Lactic Acid [PLA]

Temperature - 180°C

Flow Tweak - 0.95

Bed Temperature - 60°C

Bed Preparation - apply glue stick 2 layer

- **High Impact Polystyrene [HIPS]**

  HIPS fiber is produced using a High Effect Polystyrene material and it is one more illustration of help 3d materials. This material is very much spread in food industry for bundling. It is likewise used to pack Cd plates and to deliver plate in medication normally this fiber has radiant white tone and it is likewise biodegradable so there is no unfavorable impact when it is placed in close contact with a human or creature body. HIPS fibers have twisting and grip issues, which can be diminished by utilizing a warmed bed during the printing. HIPS material that can likewise be utilized as help structure during the printing and afterward broke up in a dreary fluid hydrocarbon Arrangement. Tech Specifications

Thickness - 1.0 g/cm³ (62 lb/ft³)
Dielectric Strength (Breakdown Potential) -18 kV/mm (0.7 V/mil)
Elastic (Young's, Tensile) Modulus-1.9 GPa (0.28 x 10^6 psi)
Stretching at Break - 40 %
Flexural Strength - 62 MPa (9.0 x 10³ psi)
Glass Change Temperature - 100 °C (210 °F)
Intensity of Ignition (HOC) - 43 MJ/kg
Restricting Oxygen Record (LOI) - 18 %
Poisson's Proportion - 0.41
Explicit Intensity Limit - 1400 J/kg-K
Solidarity to Weight Proportion - 32 kN-m/kg
Rigidity: Extreme (UTS) - 32 MPa (4.6 x 10³ psi)
Warm Conductivity - 0.22 W/m-K
Warm Diffusivity - 0.16
Warm Extension - 80 µm/m-K
Vicat Mellowing Temperature - 110 °C (230 °F)
Water Assimilation Following 24 Hours - 0.08%
Material Properties of High Effect Polystyrene [HIPS]
Temperature - 225°C
Stream Change - 0.91
Bed Temperature - 90°C
Bed Readiness - apply stick 2 layer and then, at that point, abs stick 1 layer

5. ADVANTAGES

• Time-to-Market: 3D printing permits thoughts to grow quicker. Having the option to print an idea around the same time it was planned psychologists an improvement cycle from what could have been a long time to various days, assisting organizations with remaining one stride in front of the other.

• Set aside Cash: Prototyping infusion shape devices and creation runs are costly speculations. The 3D printing process permits the making of parts as well as instruments through added substance producing at rates a lot of lower than conventional machining.

• Relieve Hazard: Having the option to check a plan prior to putting resources into a costly embellishment device merits its weight in 3D printed plastic, to say the very least. It is far less expensive to 3D print a test model than to update or change a current form.

• Criticism: With a model, you can test the market by disclosing it at a tradeshow, showing it to purchasers or raising capital by pre-selling on Indigo or Kick-starter. Getting purchaser's reaction to the item before it really goes into creation is a significant method for checking the item has market potential.

• Get the Vibe: One thing you can't get an image or virtual model on the PC screen is the manner in which something feels in your grasp. To guarantee the ergonomics and attack of an item are perfect, you should really hold it, use it and test it.

- Customize It: With standard large scale manufacturing, all parts fall off the mechanical production system or out of the form something similar. With 3D printing, one can customize, tweak a section to particularly meet their requirements, which considers custom fits in the clinical enterprises and assists set individuals with explaining their thought in new world

6. DISADVANTAGES

1.Intellectual property issues: The ease with which replicas can be created using 3D technology raises issues over intellectual property rights. The availability of blueprints online free of cost may change with for-profit organizations wanting to generate profits from this new technology.
2.Limitations of size: 3D printing technology is currently limited by size constraints. Very large objects are still not feasible when built using 3D printers.
3.Limitations of raw material: At present, 3D printers can work with approximately 100 different raw materials. This is insignificant when compared with the enormous range of raw materials used in traditional manufacturing. More research is required to devise methods to enable 3D printed products to be more durable and robust.

7. APPLICATIONS

The Aeronautics and Aerospace industries push the limits of geometric design complexity; the evolution and consistent improvement of the vehicles demand that the parts become more efficient and accurate even as the size of the vessels become smaller. This is why design optimization is essential to the progression of the industry. Optimizing a design can be challenging when using traditional manufacturing processes, and that's why most engineers have turned to 3D Printing.
To support new product development for the medical and dental industries, the technologies are also utilized to make patterns for the downstream metal casting of dental crowns and in the manufacture of tools over which plastic is being vacuum formed to make dental aligners.
For the jewellery sector, 3D printing has proved to be particularly disruptive. There is a great deal of interest and uptake based on how 3D printing can, and will, contribute to the further development of this industry. From new design freedoms enabled by 3D CAD and 3D printing, through improving traditional processes for jewelry production all the way to direct 3D printed production eliminating many of the traditional steps.

8. CONCLUSION

The brief history of 3D printing is discussed in the introduction. In the following section, we have a description of 3D printing, the procedures employed, and the characteristics of the materials used in 3D printing. The primary benefits and drawbacks of 3D printing technology are described in the third part. One might get the conclusion that the 3-D printing technology is becoming more and more significant and has an increasing societal impact on current society. The use of 3D printing technologies may evolutionist society. The way we create items and generate goods around the world may alter and improve dramatically as a result of advances in 3D printing technology. Computer-aided design software is used to scan or create an object, which is then divided into thin layers so that it may be printed to produce a sturdy three-dimensional object. As evidenced, 3D printing may be used to fulfil practically all of Maslow's categories of human wants. While it might not be able to fill a lonely, unloved heart, it will offer businesses and individuals quick and simple production in any size or scale as long as they have the imagination to do so. On the other hand, 3D printing offers a quick, dependable, and repeatable way to create customized goods that can still be produced at a low cost because of the automation of processes and the spread of manufacturing requirements.

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