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A Review Paper on 3D-Printing Processes Used in the 3D-Printing

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Abstract*: The use of 3D printing In the future, devices will become more and more popular, as will the different materials used in 3D printing and their characteristics. 3D printing employs a layering technique in computer-aided design to produce three-dimensional objects. These days, 3D printing is used all over the world. The use of 3D printing technology is growing in the automotive, locomotive, aviation, healthcare, and agricultural sectors for mass customization and production of any kind of open source design. The first step is to explain what 3D printing is, how it works, and its importance. We research the 3D printing process and the materials used to create 3D printed items, choosing the best materials that are appropriate for 3D printing machine*

Keywords: 3d-Printing;AdditiveManufacturing and Rapid Prototyping

I. INTRODUCTION

The process of creating a 3D object of any shape from a 3D model or other electronic data sources using additive processes—in which successive layers of material are laid down under computer controls—is known as 3D printing or additive manufacturing (AM). [1] Most people agree that the first solid object printed from a digital design was created by Hideo Kodama of the Nayoga Municipal Industrial Research Institute. Nonetheless, Charles Hull, who created the first 3D printer in 1984 while employed by the business he founded, 3D Systems Corp., is usually given the credit. Stereolithography, a solid imaging technique, and the STL (stereolithographic) file format, which is still the most popular format in 3D printing today, were both invented by Charles A. Hull.[2] Since Charles W. Hull of 3D Systems Corp. created and manufactured the first 3D printer in 1984, the technology has advanced and these devices have grown in utility while also becoming more reasonably priced.

Rapid prototyping is used today in many different areas of human endeavor, including research, engineering, the medical field, the military, construction, architecture, fashion, education, and the computer industry, among many others. Stratasys created the plastic extrusion technology most commonly linked to "3D printing" in 1990 under the name fused deposition modeling (FDM). Sales of 3D printers have increased significantly since the turn of the twenty-first century, and their cost has been dropped gradually.

By the early 2010s, the terms additive manufacturing and 3D printing had developed into two different umbrella terms for AM technologies. One was used in the media and by consumer-maker communities, while the other was used formally by manufacturers of AM machines, industrial AM end-use parts, and international technical standards organizations. The simple fact that all of the technologies have sequential-layer material addition/joining throughout a 3D work envelope under automated control is reflected in both terms.

Agile tooling on-demand manufacturing, desktop manufacturing, and rapid manufacturing were other terms that had been used as synonyms for AM. The 2010s were the first decade in which metal end-use parts, like engine brackets and large nuts, were grown in-house (either prior to or instead of machining) instead of being machined from plate or bar stock as was required.

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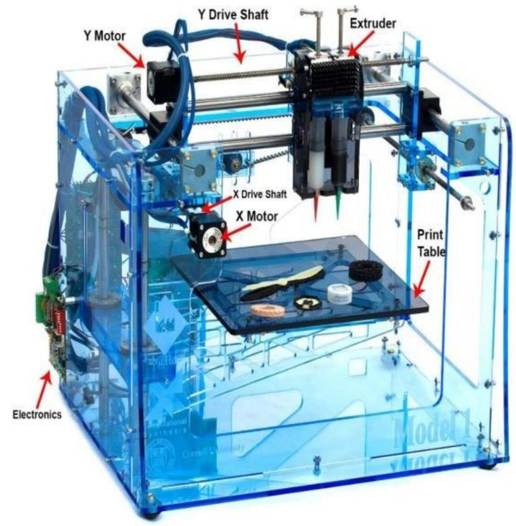

Fig.1.3 D-printe

II. GENERAL PRINCIPLES

Modelling

CAD design software or a 3D scanner can be used to create 3D printable models. Method sculpting is comparable to the manual modeling process used to prepare geometric data for 3D computer graphics. The process of examining and gathering information about an object's form and appearance is known as 3D modeling. 3D models of the scanned object can be created using this data. The average consumer finds it extremely challenging to create 3D printed models, both manually and automatically. For this reason, a number of marketplaces have appeared globally in recent years. Shape ways, Thing verse, My Mini Factory, and Threading are the most well-liked.

Printing

A piece of software known as a "slicer" must process a 3D model from a.STL file before it can be printed. It does this by breaking the model up into a number of thin layers and creating a G-code file from the.STL file that contains instructions for a printer. Slic3r, KISSlicer, and Cura are a few of the open source slicer programs available. To create a model from a number of cross-sections of a model, the 3D printer applies successive layers of liquid, powder, or sheet material in accordance with the G-code instructions. The final shape of a model is created by joining or fusing these layers, which represent the virtual cross sections from the CAD model. The primary benefit of this method is that it can produce nearlyDepending on the machine type, size, and quantity of models being produced, additive systems can usually cut this time down to a few hours.

Finishing

Printing a slightly enlarged version of the object in standard resolution and then removing material with a higher-resolution process can achieve greater precision, even though the printer-produced resolution is adequate for many applications. Press release for the Accucraft iD-20 and other machines. According to International Manufacturing Technology, certain additive manufacturing processes can use a variety of materials to create parts.

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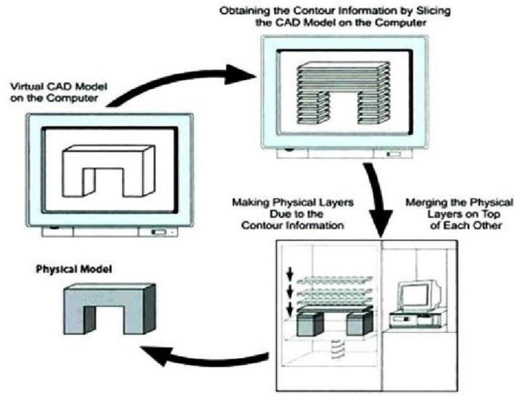

III. PROCESSES

Since late 1970, numerous 3D printing technologies and processes have been developed. When they first started out, the printers were very big and costly. There are now many different additive manufacturing techniques available. Some techniques, like selective laser melting (SLM), selective laser sintering (SLS), and fused deposition modeling (FDM), melt or soften the material to create the layers, while other techniques, like stereolithography (SLA) and laminated object manufacturing (LOM), cure liquid materials using various other technologies.

Selective Laser Sintering

Under DARPA's sponsorship, Dr. Carl Deckard and Dr. Joe Beaman, his academic adviser, developed and patented selective laser sintering (SLS) at the University of Texas in the middle of the 1980s.[2] In order to design and construct the selective laser sintering machines, Deckard was a part of the resulting start-up business, DTM. The largest rival of DTM, 3D Systems, purchased DTM in 2001. Deckard's selective laser sintering technology was the subject of the most recent patent, which was granted in January 1997 and expired in January 2014. Selective laser sintering is a 3D printing method that binds powdered material (usually metal) to form a solid structure by using a laser as the power source and aiming the laser at specific locations in space specified by a 3D model. A similar idea is used in selective laser melting (SLM), but in SLM, the material is completely melted before being sintered, allowing for different properties (porosity, crystal structure). SLS is a relatively new technology that has mostly been utilized for low-volume part production and additive manufacturing thus far. As additive manufacturing technology becomes more commercialized, production roles are growing.

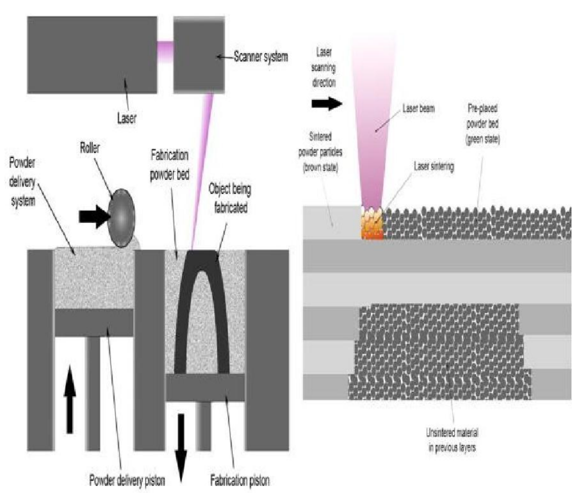

Fig.3.Selective laser sintering

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Fused Deposition Melting

S. Scott Crump created the fused deposition modeling (FDM) technique in the late 1980s, and Stratasys designed it in 1990. Following the technology's patent expiration, a A sizable open source development community produced this kind of 3D printer, and commercial versions of it also surfaced. Consequently, since its inception, the cost of FDM technology has decreased by a factor of two. Using this method, tiny beads of material are extruded to create the model, which then solidifies into layers. To supply material to an extrusion nozzle head, a coil of thermoplastic wire or filament is unwinding.The nozzle head activates and deactivates the flow after heating the material to a specific temperature. Stepper motors are typically used to move the extrusion head in the z-direction and modify the flow to meet specifications. A computer-aided manufacturing (CAM) software program that runs on a microcontroller controls the mechanism and allows the head to move both horizontally and vertically.

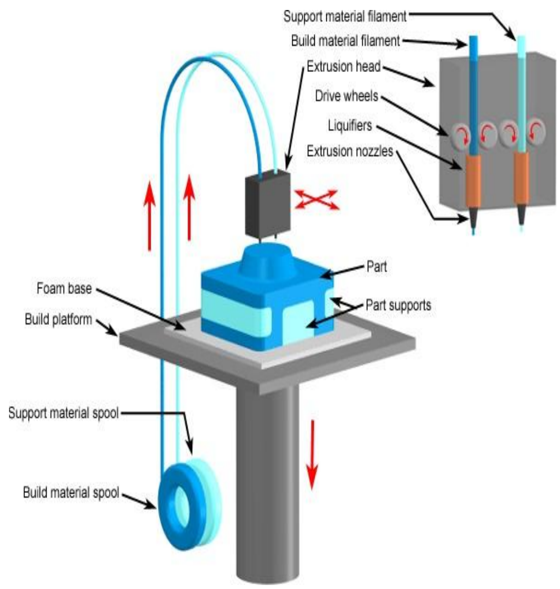

Fig.4. Fused deposition modeling

Stereolithography

One of the earliest and most popular 3D printing technologies is stereolithography. The goal of 3D printing's invention was to enable engineers to produce prototypes of their own designs more quickly and efficiently. In 1970, the technology made its debut. The modern layered approach to stereolithography was initially developed by Japanese researcher Dr. Hideo Kodama, who used UV light to cure photosensitive polymers. Prior to Alain Le Mehaute filing a patent for the stereolithography process in July 1984, Chuck Hull filed his own. Both CILAS (The Laser Consortium) and the French General Electric Company disregarded the French inventor's patent application. According to Le Mehaute, abandonment is a sign of a problem with French innovation. Using photo polymerization—a process where light causes chains of molecules to link together to form polymers—stereolithography is a type of 3-D printing technology used to create models, prototypes, and patterns layer by layer. [1] The body of a three-dimensional solid is then composed of those polymers. Although there had been research in the field since the 1970s, Charles (Chuck) W. Hull came up with the term in 1986 when he patented the method. Then, in order to market his patent, he founded 3D Systems Inc.

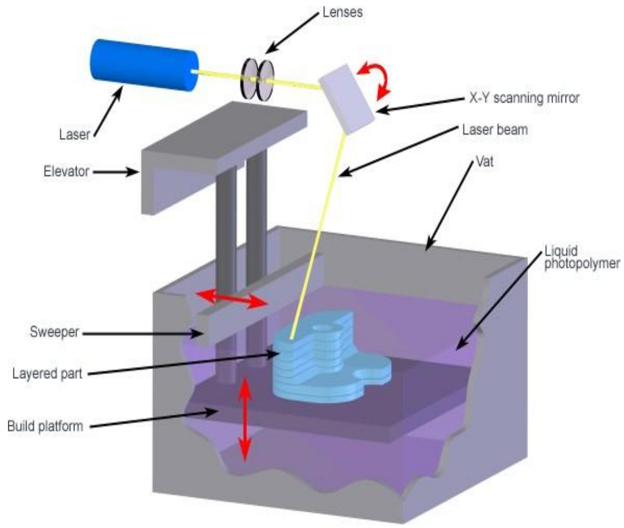

Fig.5.Stereolithography

Laminated Object Manufacturing

Helisys Inc. (now Cubic Technologies) created this 3D printing technology. It involves progressively joining layers of adhesive-coated paper, plastic, or metal laminates and using a laser cutter to cut them to the proper shape. Following printing, items created using this method can be further altered by machining. The material feedstock determines the typical layer resolution for this process, which typically varies in thickness from one to several sheets of copy paper.

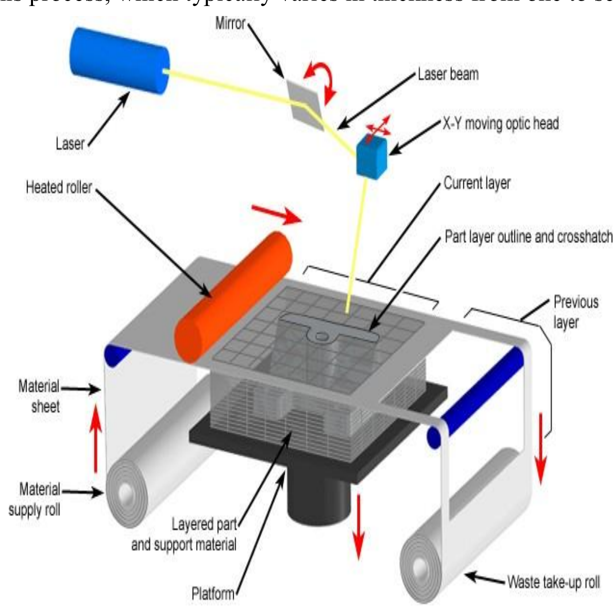

Fig.6.Laminated Object Manufacturing

3D PRINTER MATERIAL

The materials that work with the Accucraft i250 and their characteristics are listed below.

Acrylonitrile Butadiene Styrene[ABS]

since the beginning of 3D printing, one of the most popular materials. This material is ideal for 3D printing because it is lightweight, extremely durable, slightly flexible, and easily extruded. Compared to PLA, another well-liked 3D filament, it extrudes with less force. For small parts, extrusion is made easier by this fact. ABS has the drawback of requiring a higher temperature. Its glass transition temperature is roughly 105°C, and printing with ABS materials typically requires temperatures between 210°C and 250°C.Another disadvantage of this material is that it produces strong fumes when printed, which can be harmful to pets or those who have respiratory issues. Therefore, 3D printers must be positioned in an area with adequate ventilation. Also, given the price of 3D materials, it's a good idea to avoid breathing in fumes while printing. Because ABS is the least expensive, printing communities continue to favor it.

Technical Specifications:
Density: 1-1.4 gm/cm^3
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 layers & then ABS glue 1 layer

Poly Lactic Acid[PLA]
Another popular material among fans of 3D printing is polylactic acid (PLA), which is biodegradable and derived from corn. This thermoplastic is biodegradable and made from renewable resources. Therefore, compared to other plastic materials, PLA materials are more environmentally friendly. The biocompatibility of PLA with the human body is another excellent characteristic. PLA has a harder structure than ABS, and it melts at a lower temperature—between 180 and 220°C—than ABS. Because PLA glass has a transition temperature of 60 to 65 degrees Celsius, PLA and ABS may work well together for any of your projects.

Technical Specifications
Density-1.3 g/cm^3(81lb/ft^3)
Elastic (Young's,Tensile)Modulus- 2.0 to2.6GPa(0.29to0.38x10^{3}psi)
ElongationatBreak-6.0%
Flexural Modulus-4.0GPa(0.58x10^{6}psi)
Flexural Strength-80 MPa(12 x10^{3}psi)
GlassTransitionTemperature-60°C(140 °F)
HeatDeflectionTemperatureAt455kPa(66psi)-65 °C(150°F)
MeltingOnset(Solidus)-160°C(320 °F)
ShearModulus-2.4GPa (0.35x10^{6}psi)
Specific Heat Capacity-1800J/kg-K
Strength to Weight Ratio-38kN-m/kg
Tensile Strength: Ultimate(UTS)-50 MPa(7.3x10^3 psi)
ThermalConductivity-0.13W/m-K
ThermalDiffusivity-0.056

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Material Properties of Poly Lactic Acid[PLA]
Temperature-180°C
Flow Tweak-0.95
Bed Temperature -60°C
Bed Preparation-apply gluestick2 layer

High Impact Polystyrene[HIPS]

Another type of support 3D material is HIPS filament, which is composed of High Impact Polystyrene. In the food industry, this material is widely used for packaging. It is also used to make medical trays and to pack CD discs. This filament is naturally bright white and biodegradable, so it won't harm a person or an animal when it comes into close contact with their body. Using a heated bed during printing can help minimize the curling and adhesion issues that HIPS filaments have. HIPS material that can be dissolved in a colorless liquid hydrocarbon solution after serving as a support structure during printing.

Tech Specifications
Density-1.0 g/cm³(62lb/ft³)
Dielectric Strength (Breakdown Potential) -18 kV/mm(0.7V/mil)
Elastic (Young's, Tensile) Modulus-
1.9GPa(0.28x10^6psi)
Elongation at Break-40%
Flexural Strength-62 MPa(9.0 x10^3psi)
Glass Transition Temperature-100°C(210°F)
Heat of Combustion(HOC)- 43MJ/kg
Limiting Oxygen Index(LOI)-18 %
Poisson's Ratio-0.41
Specific Heat Capacity-1400J/kg-K
Strength to Weight Ratio-32 kN-m/kg
Tensile Strength: Ultimate(UTS)-32 MPa (4.6 x10^3 psi)
ThermalConductivity-0.22W/m-K
ThermalDiffusivity-0.16
Thermal Expansion -80µm/m-K
Vicat SofteningTemperature-110°C(230 °F)
Water Absorption After 24Hours-0.08%
Material Properties of High Impact Polystyrene[HIPS]
Temperature-225°C
FlowTweak-0.91
Bed Temperature -90°C
Bed Preparation-applyglue stick2 layer &thenabsglue1layer

ADVANTAGES

1. Time-to-Market: Concepts can evolve more quickly thanks to 3D printing. The ability to print a concept the same day it is designed reduces the development process from months to a few days, which helps businesses stay ahead of the competition.
2. Save Money: Production runs and injection mold tool prototyping are costly endeavors. Compared to traditional machining, the 3D printing process enables additive manufacturing to produce parts and/or tools at substantially lower rates.
3. Reduce Risk: Using 3D printed plastic makes it possible to confirm a design before spending a lot of money on a moulding tool. Redesigning or modifying an existing mold is much more expensive than 3D printing a test prototype.

4. Feedback: By showcasing a prototype at a trade show, presenting it to potential customers, or raising money through pre-sale on Indigo or Kick-starter, you can test the market. One useful method of confirming that a product has market potential is to get feedback from buyers before it is put into production.
5. Get the Feel: The way something feels in your hands is something that a picture or virtual prototype cannot replicate on a computer screen. Holding, using, and testing a product is the best way to make sure its fit and ergonomics are perfect.
Personalize It: With standard mass-production, all parts come off the assembly line or out of the mould the same. With 3D printing, one can personalize, customize a part to uniquely fit their needs, which allows for custom fits in the medical industries and helps set people to elaborate their idea in a new world.
6. Develop your imagination: The opportunities in the current explosion of digital art and design are not only growing but also boundless. Almost anything can now be 3D printed after being virtually or otherwise drawn up. An idea, concept, dream, or invention can transform from a simple thought to a manufactured part in a comparatively short amount of time.
7. Square Holes? No Problem: The limitations of standard machining have constrained product design for years. With the advancements in AM, the potential is now limitless. Unrealistic overhangs and holes that change direction are examples of geometry that was previously challenging to construct but is now feasible and even easy to do so.
8. Fail Fast, Fail Cheap: Product developers can use 3D printing to make relatively cheap early breakthroughs that result in better products and less costly dead ends..

DISADVANTAGES

1. Intellectual property concerns: The ease with which 3D technology can be used to create replicas gives rise to concerns regarding intellectual property rights. With for-profit companies hoping to make money off of this new technology, the free online blueprints may no longer be available.
2. Size restrictions: At the moment, 3D printing technology is constrained by size restrictions. The use of 3D printers to create very large objects is still impractical..
3. Raw material limitations: Currently, 3D printers are capable of using about 100 distinct raw materials. Considering the vast array of raw materials utilized in conventional manufacturing, this is negligible. To develop strategies that will make 3D printed goods more robust and long-lasting, more research is needed.
4. Printer cost: The average householder still cannot afford to purchase a 3D printer due to its high cost. Additionally, in order to print different kinds of objects, different 3D printers are needed. Additionally, color-capable printers are more expensive than monochrome printers.
5. Reduced Manufacturing Jobs: Manufacturing jobs will decline as a result of all new technologies. Third-world economies, particularly China's, which rely heavily on low-skilled labor, may be significantly impacted by this disadvantage.
6. Unrestricted manufacturing of dangerous goods: Liberator, the first functional 3D-printed gun, demonstrated how simple it was to make one's own weapons as long as one had access to a 3D printer and the design. Governments will have to come up with strategies to curb this risky trend.

APPLICATIONS

1. The aerospace and aeronautics sectors push the boundaries of geometric design complexity; as vessels get smaller, the parts must become more accurate and efficient to support the vehicles' continuous development. For this reason, design optimization is crucial to the industry's advancement. Because it can be difficult to optimize a design using conventional manufacturing methods, the majority of engineers have resorted to 3D printing.
2. The technologies are also used to create patterns for the downstream metal casting of dental crowns and to manufacture tools over which plastic is vacuum formed to create dental aligners, supporting the development of new products for the medical and dental industries.
3. 3D printing has proven to be especially disruptive for the jewelry industry. A lot of interest is present.

adoption based on the ways in which 3D printing can and will support the growth of this sector. From enhancing conventional jewelry production methods to directing 3D printed production and removing numerous conventional steps, 3D CAD and 3D printing have allowed for new design freedoms.

4. A common use of 3D printing techniques for creating precise demonstration models of an architect's vision is the creation of architectural models. Using 3D CAD, BIM, or other digital data that architects use, 3D printing provides a reasonably quick, simple, and cost-effective way to create detailed models.

5. One industry, known for its experimentation and wild claims, has gained prominence as 3D printing techniques have improved in terms of resolution and more flexible materials. Naturally, we are discussing fashion. Accessories made with 3D printing, such as bags, hats, headdresses, and shoes, have appeared on international catwalks.

II. CONCLUSION

A brief history of 3D printing is covered in the introduction section. In the following section, we have illustrated 3D printing, its processes, and the characteristics of the materials used in 3D printers. We have outlined the primary benefits and drawbacks of 3D printing technology in the third section. It is possible to draw the conclusion that 3-D printing technology is becoming more and more significant on a daily basis, affecting modern society, the economy, and human lives.

The world might undergo a revolution thanks to 3D printing technology. Technological developments in 3D printing have the potential to drastically alter and enhance how we produce goods and manufacture products globally. To create a solid three-dimensional product, an object is scanned or designed using computer-aided design software, then divided into thin layers that can be printed out.

As demonstrated, 3D printing can be used in practically every one of Maslow's categories of human needs. Although it might not be able to fill a void in an unloved heart, it will give businesses and individuals quick and simple manufacturing in any size or scale that is only constrained by their creativity. However, by automating processes and distributing manufacturing needs, 3D printing can provide a quick, dependable, and repeatable way to create custom products that are still affordable..

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