An Overview on 3D Printing Technology

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ABSTRACT: 3D printing, also known as additive manufacturing, has been called the next big thing, with the potential to be as widely used as the cellular phone industry. 3D printers convert a digital blueprint into a real three-dimensional item. Plastic, metal, nylon, and over a hundred more materials are used in the printing process, which is done layer by layer (additive manufacturing). Manufacturing, industrial design, jewelry, footwear, architecture, engineering and construction, automotive, aerospace, dentistry and medical industries, education, geographic information systems, civil engineering, and many more fields have found 3D printing to be beneficial. In every area of application, it has shown to be a quick and cost-effective solution. 3D printing's uses are growing all the time, and it's proving to be a really interesting technology to keep an eye on. We will look at how it works as well as present and prospective uses of 3D printing in this article.

KEYWORDS: Additive Manufacturing, Ceramics, 3D printing, Laminated, Photo polymerization.

1. INTRODUCTION

By successively adding material to a geometrical representation, 3D printing may produce actual things. In recent years, the popularity of this 3D technique has skyrocketed. Charles Hull was the first to commercialize 3D printing techniques in 1980. Currently, 3D printing is mainly employed to create artificial objects. PGA rocket engine, steel bridge in Amsterdam, heart pump, jewelry collections, 3D printed cornea, PGA rocket engine, steel bridge in Amsterdam as well as other goods linked to the aviation and culinary industries. The layer-by-layer manufacturing technique of three-dimensional objects gave rise to 3D printing (3D)[1]. Structures derived straight from a computer-aided design (CAD) drawing 3D printing is a cutting-edge technology. has established itself as a flexible technological stage. It offers up new options and provides businesses hoping to enhance their production efficiency fresh hope. Thermoplastics, ceramics, and graphene-based materials The materials that can currently be produced utilizing 3D printing technology include materials and metal [2].

3D printing is a technique for creating three-dimensional objects Technology has the ability to transform industries and alter the manufacturing process. 3D printing's acceptance Technology will speed up manufacturing while lowering expenses. At the same time, consumer demand is increasing. will be able to exert greater control over output. Consumers have a larger say in the final product and may make specific requests. It was made according to their requirements. In the meanwhile, 3D printing technology facilities will be closer together. enabling for a more flexible and responsive production process, as well as higher quality control. Furthermore, the use of 3D printing technology reduces the requirement for worldwide transportation. diminished. This is due to the fact that when production locations are closer to the final destination, all distribution may be done locally[3]. This was accomplished with the use of fleet monitoring technology, which saves both energy and time. Finally, the use of 3D printing technology may be beneficial. reorganize the company's logistics Companies' logistics departments can handle the whole procedure and provide additional options. Services that are complete and end-to-end [4]. 3D printing is now extensively utilized all around the globe.

The usage of 3D printing for mass production is becoming more common. modification and manufacturing of open source designs in the fields of agriculture, healthcare, and automobiles sector, as well as the aerospace industry. However, there are a number of drawbacks to using 3D printing technology in production[4]. Industry The employment of 3D printing technology, for example, has the effect of reducing the usage of manufacturing labor. This will have a significant impact on the economies of nations that depend heavily on low-wage employment. Furthermore, users may create a variety of items utilizing 3D printing technology, such as knives and weapons. as well as potentially hazardous things As a result, the usage of 3D printing should be restricted to a select group of individuals in order to prevent terrorists from using it. Criminals also smuggle weapons into the country undetected. Those who get a blueprint, on the other hand, will be able to Counterfeit goods are simple to find. This is because 3D printing technology is easy to use; all you have to do is sketch and configure the parameters. Data in the machine-printed form may be used to create 3D objects[5]. To summarize, 3D printing has developed as a versatile and powerful method in recent years. Industry of advanced manufacturing This technique is widely utilized in various nations, particularly in the United States. Industry of manufacture As a result, this article provides an overview of the many kinds of 3D printing technology, as well as the advantages and disadvantages of each. Muse of 3D printing technology, and finally, the materials utilized in manufacturing using 3D printing technology industry.[6]

1.1 Types of 3D Printing:

Various 3D printing methods have been created, each with its own set of capabilities. Binding jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination, and vat photo polymerization are among the seven 3D printing methods classified by ASTM Standard F2792. There are no disagreements about whether equipment or technology performs better since each has its own set of uses. 3D printing technologies are no longer restricted to prototype but are rapidly being utilized to create a wide range of goods.

- *Jetting of Binder:*

Binder jetting is a fast prototyping and 3D printing technique that involves selectively depositing a liquid binding agent to connect powder particles. Binder jetting technique forms the layer by spraying a chemical binder over the distributed powder. Binder jetting is used to make casting patterns, raw sintered goods, and other large-volume products from sand. Metals, sands, polymers, hybrids, and ceramics are among the materials that binder jetting can print. Some materials, such as sand, may not need further processing. Binder jetting is also easy, quick, and inexpensive since powder particles are bonded together. Finally, binder jetting allows for the printing of extremely big objects[7].

- *Deposition of Directed Energy:*

Directed energy deposition (DED) is a more complicated printing technique that is often used to repair or add material to existing components. Directed energy deposition provides a high degree of grain structure control and can create high-quality objects. In theory, directed energy deposition is similar to material extrusion, except that the nozzle is not locked to a single axis and may travel in any direction. The technique may also be utilized with ceramics and polymers, although it is most often employed with metals and metal-based hybrids in the form of wire or powder. Laser deposition and laser engineered net shaping (LENS) are two examples of this technique. Laser deposition is a new technique that may be used to make or repair components with dimensions ranging from millimeters to meters[8]. Because of its scalability and varied capabilities in a single system, laser deposition technology is gaining momentum in the manufacturing, transportation, aerospace, and oil and gas industries. Meanwhile, laser LENS may use heat energy to melt metal during the casting process, resulting in finished components.

- *Extrusion of materials:*

Plastics, food, and live cells may be printed in multi-materials and multi-colors using material extrusion-based 3D printing technology. This method is frequently utilized, and the expenses are minimal. Furthermore, this technique may provide completely functioning product components. The earliest example of a material extrusion system is fused deposition modeling (FDM). FDM was created in the early 1990s and is based on the use of polymer as the primary material. By heating and extruding thermoplastic filament, FDM creates components layer by layer from the bottom to the top.

➢ FDM's activities are as follows:

i. A semi-liquid thermoplastic is heated and deposited in ultra-fine beads along the extrusion route.
ii. Where support or buffering is required, the 3D printer deposits a removable scaffolding material. For example, in order to create a 3D bone model, FDM utilizes hard plastic material.

- *Jetting of Materials:*

Material jetting, according to ASTM Standards, is a 3D printing method in which construction material is selectively placed drop by drop. A printhead distributes droplets of a photosensitive substance that hardens and builds a component layer by layer under ultraviolet (UV) light in material jetting. Material jetting produces components with an extremely smooth surface finish and excellent dimensional accuracy at the same time. Material jetting offers multi-material printing and a broad variety of materials such as polymers, ceramics, composites, biologicals, and hybrids.

- *Fusion in a Powder Bed:*

The electron beam melting (EBM), selective laser sintering (SLS), and selective heat sintering (SHS) printing techniques are all used in the powder bed fusion process. To melt or fuse the material powder together, this technique utilizes an electron beam or a laser. Metals, ceramics, polymers, composites, and hybrids are examples of materials utilized in this procedure. Powder-based 3D printing technique is most often known as selective laser sintering (SLS). In 1987, Carl Deckard invented SLS technology. SLS is a 3D printing technique that is functionally quick, accurate, and has a variety of surface finishes [21]. Metal, plastic, and ceramic items may all be made with selective laser sintering. SLS created a 3D object by sintering polymer particles with a high-powered laser.
SHS technology, on the other hand, is a kind of 3D printing that utilizes a head thermal print to melt thermoplastic material and produce 3D printed objects. Finally, electron beam melting improves the efficiency of an energy source used to heat the material.

- *Lamination of sheets:*

Sheet lamination, as defined by ASTM, is a 3D printing technique in which sheets of materials are bonded together to create a portion of an item. Laminated object manufacturing (LOM) and ultrasonic additive manufacturing (UAM) are two examples of 3D printing technologies that utilize this method. Sheet lamination has the benefits of being able to print in full color, being reasonably cheap, simple material handling, and the ability to recycle surplus material. Laminated object manufacturing (LOM) allows for the production of complex geometrical components at a cheaper cost and with less downtime. Ultrasound additive manufacturing (UAM) is a cutting-edge technique that combines layers of metal taken from featureless foil material using sound. Photo polymerization, which refers to the curing of photo-reactive polymers with a laser, light, or ultraviolet (UV), is the most often utilized 3D printing method.

Stereo lithography (SLA) and digital light processing are two examples of photo polymerization-based 3D printing technologies (DLP). The photo initiator and irradiate exposure settings, as well as any dyes, pigments, or other additional UV absorbers, all affected the SLA. Meanwhile, digital light processing is a photopolymer-based technique comparable to stereolithographic. The main distinction is the source of light. A more traditional light source, such as an arc lamp with a liquid crystal display screen, is used in the Digital Light Process. It can cover the whole surface of a photopolymer resin vat in a single pass, making it quicker than Stereo lithography. The duration of exposure, wavelength, and quantity of power supply are all essential factors in Vat Photo polymerization. The materials utilized at first are liquid, but when subjected to UV radiation, they solidify. Photo polymerization is ideal for creating a premium product with fine features and a high surface quality.

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1.2 Materials Used for 3D Printing Technology:

- *Metals:*

Because of the benefits offered by this technique, metal 3D printing technology has gotten a lot of interest in the aerospace, automotive, medical, and industrial industries .Metal materials offer outstanding physical characteristics, and they may be utilized in a wide range of applications, from printing human organs to aircraft components. Aluminum alloys, cobalt-based alloys, nickel-based alloys, stainless steels, and titanium alloys are examples of these materials. In 3D printed dental applications, a cobalt-based alloy is appropriate. Because of its high specific stiffness, durability, high recovery capacity, elongation, and heat-treated conditions, it has a high specific stiffness. Furthermore, utilizing nickel base alloys, 3D printing technology can manufacture aircraft parts. In hazardous settings, 3D-printed objects made of nickel base alloys may be utilized. This is because to its excellent corrosion resistance and heat temperature tolerance of up to 1200 degrees Celsius. Finally, titanium alloys may be used to create the item utilizing 3D printing technology. Titanium alloys offer unique characteristics including ductility, corrosion resistance, oxidation resistance, and low density. It's utilized in aircraft components and the biomedical sector for high strains, high operating temperatures, and high stresses.

- *Polymers:*

3D printing is extensively utilized to manufacture polymer components, ranging from prototypes to functioning constructions with complex geometry. It may create a 3D printed via the deposition of consecutive layers of extruded thermoplastic filament, such as polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polypropylene (PP), or polyethylene (PE) using fused deposition modeling (FDM). Thermoplastic filaments with higher melting temperatures, such as PEEK and PMMA, have recently been utilized as 3D printing materials. Due to their cheap cost, low weight, and processing flexibility, 3D printing polymer materials in the liquid state or with a low melting point are extensively utilized in the 3D printing industry. Polymer materials, for the most part, played a significant role in biomaterials and medical device products as inert materials, contributing to device efficiency and providing mechanical support in many orthopedic implants.

- *Ceramics:*

Through the adjustment of settings and the establishment of excellent mechanical characteristics, 3D printing technology can now create 3D printed objects utilizing ceramics and concrete without big pores or any fractures. Ceramic is a robust, long-lasting, and fire-resistant material. Ceramics, because of their fluid condition before setting, may be used in almost any geometry and form, making them ideal for future construction and architecture. Ceramic materials are helpful in dentistry and aeronautical applications, according to Alumina, bioactive glasses, and zirconia [are examples of these materials. 3D Printing technology, for example, has the ability to process alumina powder. Alumina is a versatile ceramic oxide that may be used in a variety of applications, including catalysts, adsorbents, microelectronics, chemicals, aerospace, and other high-tech industries. The curing complexity of alumina is high. Complex-shaped alumina components with a high density after sintering and a high green density may be produced using 3D printing technology[9]. Furthermore, a stereolithographic (SLA) machine was utilized to produce glass-ceramic and bioactive glass into dancing parts in a subsequent experiment. It improves the bending strength of these materials considerably[10]. The increased mechanical strength opens up the possibility of using bioactive glass in therapeutic structures like scaffolds and bone. It is possible to manufacture solid bulk ceramics with high densities, extremely homogenous microstructures, strong compression strength, and bending utilizing Stereolithographic Ceramic Manufacturing (SLCM) . Meanwhile, zirconia is the most used building material in nuclear power plants, where it is used for element tubing. Because of its low sensitivity to radiation and low thermal neutron absorption, hafnium-free zirconium is ideal for this purpose.

- *Composites:*

Composite materials have revolutionized high-performance sectors with their remarkable flexibility, low weight, and tailorable characteristics. Carbon fiber reinforced polymer composites and glass fiber reinforced polymer composites are two examples of composite materials. Because of their high specific stiffness, strength, corrosion resistance, and fatigue performance, carbon fiber reinforced plastics composite structures are extensively utilized in the aerospace sector. Glass fiber reinforced polymer composites, on the other hand, are extensively utilized for different purposes in 3D printing and have a broad range of prospective applications owing to their cost efficiency and excellent performance. Fiberglass has a low coefficient of thermal expansion and a high thermal conductivity. Furthermore, fiberglass does not burn and is unaffected by manufacturing process curing temperatures, making it ideal for usage in 3D printing applications.

- *Ingenious materials:*

Smart materials are those that have the ability to change the geometry and form of an item in response to external factors such as heat and water. Self-evolving structure and soft robotics system are two examples of 3D printed objects made using smart materials. 4D printing materials may also be classed as smart materials. Shape memory alloys and shape memory polymers are examples of group smart materials. Some shape-memory alloys, such as nickel-titanium, may be utilized in applications ranging from biomedical implants to microelectromechanical systems. The importance of transformation temperatures, repeatability of microstructure, and density in the manufacture of 3D printed nickel-titanium products cannot be overstated. Shape memory polymer (SMP) is a kind of functional material that reacts to stimuli such as light, electricity, heat, and certain chemicals, among others. The complex form of shape memory polymer may be readily and conveniently produced utilizing 3D printing technology. The dimensional correctness, surface roughness, and component density are used to assess the material's quality.

2. DISCUSSION

The panorama of 3D printing in the industrial sector is explored in depth in this study. At the moment, 3D printing technology is gaining traction in the manufacturing industry, and it provides many advantages to individuals, businesses, and governments. As a result, more data is required to make progress on methods to improve the use of 3D printing technology. More knowledge on 3D printing technology will aid companies and governments in upgrading and improving the technology's infrastructure. As a result, the purpose of this article is to provide an overview of the many kinds of 3D printing technologies, as well as the materials used in 3D printing technology in the manufacturing sector and the applications of 3D printing technology. In the future, researchers may investigate the many types of 3D printing machines as well as the appropriate materials for each kind of machine.

3. CONCLUSION

3D printing is widely acknowledged to be a transformative force in production, whether in a good or bad way. Despite worries about counterfeiting, several businesses are already using the technology to manufacture complex components in a repeatable manner, such as in the automotive and aerospace industries. As 3D printers grow more cheap, they will undoubtedly be utilized for small-scale, local production, obviating the need for supply chains for a wide range of products. Consumer units for home use will be possible, enabling customers to easily download and print a design for the product they need. The traditional manufacturing sector will have significant difficulties in adapting to these developments. However, the technological and technical possibilities are obviously vast, and the creative possibilities in product design and printing material composition are almost limitless.

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