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A Review on 3D Printed Products Manufactured By Fused Deposition Modeling

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ABSTRACT

3D Printing or additive manufacturing is one of the most promising methods of production used in every aspect of our daily lives. In addition to rapid prototyping, the primary advantages of 3D printing are easily modifiable designs, material savings, and the ability to fabricate complex structures, as well as the ability to produce easily modified designs. One of the most significant advantages of this technology is the ability to manufacture various products in tiny quantities. Fused Deposition Modeling (FDM) is a popular Additive Manufacturing (AM) technique for processing thermoplastic materials. In the course of my investigation, I will produce a planter using 3D printing, an increasingly popular technique for rapid prototyping. The improvement of mechanical properties in conventional thermoplastic polymers has generated considerable academic interest.

KEYWORDS: FDM, 3D PRINTING, COMPOSITES, MECHANICAL TESTING

1. INTRODUCTION

3D printing is a manufacturing technology utilized by technically savvy individuals from all over the globe. We have been using 3D printing technology for the past two decades. This methodology is the subject of ongoing study and advancement. Therefore, we are perpetually incorporating new features to improve this methodology. 3D printing is also referred to as computer-aided printing or modeling. Human participation is required only for process control. 3D printers are capable of printing in three dimensions [x, y, and z axis]. 2D printers use ink to reproduce data in two dimensions [x and y only] on paper. Applications of 3D printing are not limited to a single discipline of engineering, but encompass all branches, including civil, mechanical, biomedical, aerospace, etc. Additive manufacturing [AM] is a synonym for 3D printing.AM is a process that generates elements directly from a three-dimensional model by forming layers. This machine is used to materialize the 3D structures that a person can create using a computer. To accomplish this, they use liquid plastic (or other materials) instead of the ink to which we are accustomed, which solidifies and forms the object after the impression. Principal advantages of AM or 3D printing include the ability to configure, mass-customize, minimize waste, and produce complex structures, as well as produce rapid prototypes.AM is often referred to as workstation fabrication. It is a rapid prototyping technique by which an actual product can be created from a 3D model. A 3D printer system employs a CAD model for rapid prototyping.

2. 3D PRINTING METHODS

Methods for 3D printing can be roughly put into the following groups-

a. FDM "Fused Deposition Modeling."

b. Powder Bed Fusion

c. stereo Lithography

d .Inkjet Printing

e. LOM "Laminated Object Manufacturing."

f. Direct Energy Deposition

TABLE 1 THE CATEGORIZATION OF 3D PRINTING METHODS

Methods	Materials	Applications	Benefits	Drawbacks
Fused deposition modelling	Continues filaments of thermoplastic polymers Continuous fibre-reinforced polymers	Rapid prototyping Toys advanced composite parts	Low cost High speed Simplicity	Weak mechanical properties Limited materials (only thermoplastics) Layer-by-layer finish
Powder bed fusion (SLS, SLM, 3DP)	Compacted fine powders Metals, alloys and limited polymers (SLS or SLM) ceramic and polymers (3DP)	Biomedical Electronics Aerospace Lightweight structures (lattices) Heat exchangers	Fine resolution High quality	Slow printing Expensive High porosity in the binder method (3DP)
Inkjet printing and contour crafting	A concentrated dispersion of particles in a liquid (ink or paste) Ceramic, concrete and soil	Biomedical Large structures Buildings	Ability to print large structures Quick printing	Maintaining workability Coarse resolution Lack of adhesion between layers Layer-by-layer finish
Stereolithography	A resin with photo-active monomers Hybrid polymer-ceramics	Biomedical Prototyping	Fine resolution High quality	Very limited materials Slow printing Expensive
Direct energy deposition	Metals and alloys in the form of powder or wire Ceramics and polymers	Aerospace Retrofitting Repair Cladding Biomedical	Reduced manufacturing time and cost Excellent mechanical properties Controlled microstructure Accurate composition control Excellent for repair and retrofitting	Low accuracy Low surface quality Need for a dense support structure Limitation in printing complex shapes with fine details
Laminated object manufacturing	Polymer composites Ceramics Paper Metal-filled tapes Metal rolls	Paper manufacturing Foundry industries Electronics Smart structures	Reduced tooling and manufacturing time A vast range of materials Low cost Excellent for manufacturing of larger structures	Inferior surface quality and dimensional accuracy Limitation in manufacturing of complex shapes

3. FDM -Fused Deposition Modeling

The FDM method of 3D printing is very popular and extensively used. Fused Deposition Modeling is also known as Fused Filament Fabrication [FFF]. It produces segments from a thermoplastic polymer that is typically supplied as a robust fiber. The component that cares for the fiber is called the extruder, and it consists of several stuff wheels that apply a caring force to the fiber via static erosion. The fiber is advanced to the hot-end, which contains a liquefier that dissolves the polymer and a nozzle that expel the material. The testimony of expelled fragments, known as strands, constructs a three-dimensional object [1]. FFF refers to the extrusion of a thermoplastic polymer through a temperature-controlled nozzle-equipped head. The extrusion follows a raster design, and the cycle is repeated layer-by-layer to create complex shapes, in a manner that vastly enhances design adaptability as compared to conventional assembly techniques and with minimal material waste. When another layer is expelled on top of the previous one, the material is in a semi-liquid state, and its surface remits the previous layer to form a polymer [2].

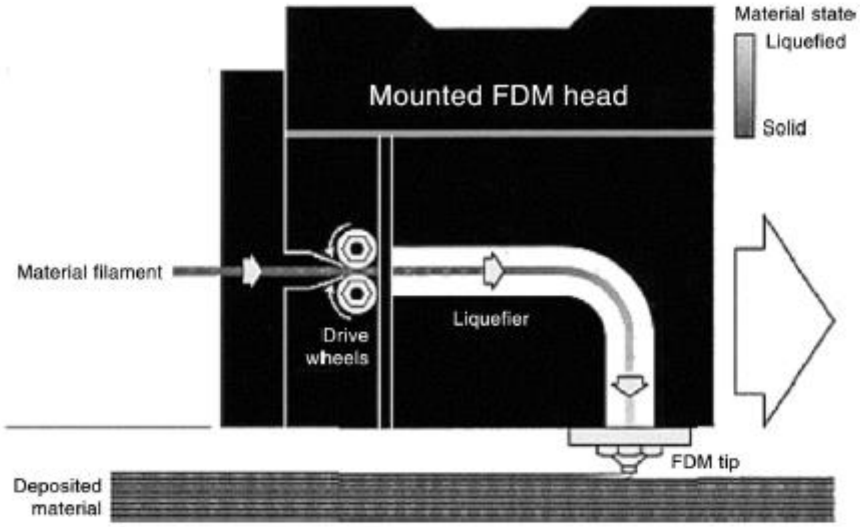

FIG1. FFF

4. LISTING OF MATERIALS EMPLOYED IN 3D PRINTING

a. METALLIC MATERIALS

b. POLYMERS

c. CERAMICS

d. COMPOSITES

a. **METALLIC MATERIALS**

Metals have exceptional physical properties and can be used in a variety of applications, to printing human organs to aviation parts. Al alloys, CO-based alloys, Ni-based alloys, SS and Ti alloys are some examples.

b. **POLYMERS**

3D printing is extensively utilized for the construction of polymer parts, ranging from models to functional structures with complex calculations. By utilising FDM, a 3D-printed object can be constructed from successive layers of expelled thermoplastic fiber, such as thermoplastic filaments, PLA, ABS, PP, and PE.

c. **CERAMICS**

Presently, 3D printing technology can produce 3D printed objects using ceramics production as well as cement without porosity or cracks by enhancing the boundaries and arranging the excellent mechanical properties. Artistic is durable and resistant to flame. Due to its liquid state prior to hardening, pottery can be applied in virtually any geometry and shape, making it an ideal material for future development and construction.

d. **COMPOSITES**

Composite components with exceptional adaptability, low weight, as well as modifiable properties are transforming elite endeavors. Carbon fiber reinforced polymer composites and glass fiber reinforced polymer composites are examples of composite materials. Due to their high specific rigidity, tensile strength, corrosion resistance, and fatigue performance, carbon fiber-reinforced polymer composite structures are widely employed in the aerospace industry. Simultaneously, glass fiber reinforced polymer composites are widely used for a variety of 3D printing applications and have enormous potential applications due to their cost-effectiveness and superiority. Additionally, fiberglass has a high thermal conductivity and a low coefficient of thermal expansion. Moreover, fiberglass cannot combust and is unaffected by the resetting temperatures used in assembly procedures; consequently, it is an ideal material for 3D printing [4].

5. LITERATURE REVIEW

MARCIN P. SERDECZNY et al. [2020] provides insight into the rheological and thermal effects of polymer movement through the hot-end in material expulsion AM. The purpose of this exploratory arrangement was to examine the effect of the fiber taking care of rate, the outflow width, the liquefier length, and the liquefier temperature on the fiber taking care of power and extradited expansion. The calculations were conducted with PLA and ABS fibers, which are commonly used in material expulsion AM. The model is devoid of the weight decrease due to temperature equilibrium inside the cylinder portion of the hot-end. In accordance with our investigations, the anticipated maximum handling rates were found to be acceptable. The proposed model can be beneficial for both designing the hot-end and determining the printing boundaries.

S. BARONE et al. [2020] demonstrate the crucial capacity of the proposed covering cycles to expand the purview of applications for FFF 3D-printed composite materials. This study investigates the effects of two distinct coatings, a UV-relieved acryl ate gum and an acrylic stain, on the moisture retention of FFF 3D-printed polyamide specimens reinforced with short carbon filaments. The outcomes demonstrated a significant decrease in CI and Operation with both the acrylic and UV pitch coatings, as well as significant enhancements in the mechanical properties of these specimens.

SUSHIL U.KANDEKAR et al. [2020] build a machine are used to transform the 3D structures that an individual can create with the aid of a computer into an actual object. To accomplish this, they use liquid plastic (or other materials) as opposed to the ink we are accustomed to, which solidifies and forms the object after the impression. They are typically enormous devices that can cost up to $5,000, but advances in technology have made them readily accessible to the general public.

N. SHAHRUBUDINA et al. [2019] paper will outline the types of 3D printing innovations, the materials used for 3D printing technology in the manufacturing industry, and the applications of 3D printing technology. Later, specialists can examine the type of 3D printing machines and the appropriate materials for use with each type of machine.

CHETAN M. THAKAR et al. [2020] model demonstrates that refuse paper can be used as a printing material as opposed to using prefabricated fibers, which is eco-friendly and theoretically reduces climatic pollution. The remarkable nature of 3D printing, which creates a section layer by layer as opposed to subtractive methods of assembly, allows for reduced raw material costs. Medicines are possibly one of the most stimulating areas of application.

TUAN D. NGO et al. [2018] provides a review of 3D printing, highlighting its benefits and drawbacks as a standard for future innovative work. The primary advantages of added substance producing (AM) or 3D printing are design flexibility, mass customization, waste reduction, the capacity to produce complex structures, as well as rapid prototyping. Introduction to the current status of materials development, including metal amalgams, polymer composites, pottery, and cement.

LAI JIANG et al. [2020] model summarizes the exceptional research performed on mixtures of various bio fibers and pitch frameworks used in various 3D printing innovations, including powder-based, material expulsion, solid sheet, and fluid based frameworks. Bio fibers are useful for enhancing the mechanical properties of 3D-printed components, and the biodegradability of components made with these eco-friendly materials is also greatly enhanced.

AUBREY L. WOERN et al. [2018] research reveals an open-source 3-D printable pelletize chopper for the controlled pelletizing of both single thermo polymers and composites for 3-D printing applications. The infrastructure was effectively developed using open-source plan systems and created using open-source 3-D printers that required minimal effort. The innovation produced thermo polymer granules of varying diameters that were suitable for use in a FGF printer as well as recyclebot reformulation of 3-D printing fiber.

R.DINESH BABU et al. [2019] investigated in depth the breakdown of AM measures utilized for the production of dental and muscular health inserts. In addition, we included the depiction approaches utilized in additively produced nano composites and testing challenges. This paper presents cutting-edge research on the use of polymeric nano composites in clinical embed blends for additive manufacturing. To fully utilize AM techniques for biomedical applications, multidisciplinary research is required.

AUBREY L. WOERN et al. [2018] study uncovered a low-effort, open-source 3-D printable pelletizer processor for precisely controlled pelletizing of both single thermo polymers and composites for 3-D printing applications. The framework was effectively developed using open-source design techniques and manufactured using open-source 3-D printers that required minimal effort. The innovation produced thermo polymer granules of varying diameters that are suitable for use in a FGF printer as well as recyclebot reformulation of 3-D printing fiber.

SORAN HASSANI FARD et al. [2019] model, the effects of part fabrication orientations or raster directions on the strain-life exhaustion boundaries of 3D-printed FDM-prepared PLA, PC, and Ultem 9085 were investigated. Examining the effects of different burden proportions on PC material revealed that the variation in burden proportion had no significant impact on the fatigue boundaries and frailty change lives. A correlation between the effects of ductile and turning buckling exhaustion of PLA in the XY plane revealed that the layering type influenced the tensile strength coefficient of 3D-printed components.

RYOSUKE MATSUZAKI et al. [2016] developed a method for the three-dimensional (3D) printing of continuous fiber-reinforced thermoplastics based on combined evidence exhibiting. The procedure enables direct 3D creation without the use of moulds and has the potential to become the standard modern composite creation method. Independently supplied to the 3D printer were a thermoplastic fiber and constant strands, with the strands being impregnated with the fiber inside the printer's heated nozzle prior to printing. As the framework, Polylactic corrosive was utilized, while carbon strands or spun fibers of regular jute filaments were utilized as fortifications.

MOSTAFA YAKOUTA et al. [2018] compiled a list of essential innovations for producing metal-added substances. It focuses on the effect of significant cycle boundaries on the microstructure and mechanical properties of the following component. Several materials are taken into account, including aviation compounds such as titanium (TiAl6V4 "UNS R56400"), aluminum (AlSi10Mg "UNS A03600"), and iron-and-nickel-based combinations (treated steel 316L "UNS S31603", Inconel 718 "UNS N07718", and Invar 36 FeNi36 "UNS K93600").

DALJEET SINGH et al. [2019] study demonstrates that PLA samples are manufactured utilising an added substance producing strategy and then evaluated for mechanical representation and decomposition behavior with varying boundaries. The change in weight of platforms was calculated using a computerized weight scale, and the pH value was calculated using a pH meter. SEM and EDS independently characterized the morphology and essential composition of PLA platforms, whereas common testing equipment estimated their compressive strength.

6. CONCLUSIONS

The purpose of this analysis was to determine the status of 3D printing yesterday, today, and tomorrow. The purpose of the literature review is to update the data set and ensure that it contains the most up-to-date writing possible. Also arrange the journals in a manner that facilitates simple and rapid search. The arrangement of publications is dependent on research methodology, content, calendar, and year. Examination of the result of the research papers and identifying gaps & providing hints for future research is main purpose of literature review.

The review of the relevant literature suggests that there are still a number of unexplored research avenues. Not every production method is foolproof. On the premise of investigation, there is always a need for improvement. Also included is 3D manufacturing. On the basis of literature review on 3D printing, to enhance the mechanical properties in 3D printing products is the recent area in which improvement is required. A specimen is subjected to tensile testing in order to collect pertinent data and information.

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