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A review on 3D printing: An additive manufacturing technology

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ABSTRACT

Additive manufacturing, often known as 3D printing, is a type of digital fabrication technique that builds physical items from a geometrical model through the addition of materials. The field of 3D printing is one that is rapidly expanding. 3D printing has been a common practice around the world in recent years. Mass customization and manufacture of open-source designs are becoming increasingly common uses of 3D printing in the agricultural, healthcare, automotive, and locomotive industries. Using a CAD model as a starting point, 3D printing technology can build a three-dimensional object layer by layer. This paper provides an overview of the different types of 3D printing techniques, Classification, Materials used, & their applications in various sectors.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Design, Manufacturing and Materials Engineering.

1. Introduction

Many different kinds of products and services use 3D printers to create actual replicas of computer-generated designs, including everything from toys to medical implants to detailed maps and historical artefacts. Many other materials can be used to create templates, such as plastic and plaster and metal and fruit. Each of these materials has its own set of advantages and disadvantages. There's also the matter of paper to consider. Using ordinary paper as a construction material to generate additively manufactured pieces is a letdown. It's possible that a 3D-printed item might not be able to handle the wear and tear that you might put it through. Using the correct binding and sealing methods, you may practically return paper to its original wood type, with all the strength, durability, and ruggedness of wood-based objects. With the help of a variety of programming tools, this paper explores and describes the additive manufacturing process from all angles. Applications and growth materials must be considered while selecting printing procedures [1–3]. This study examines and presents the benefits and drawbacks of this technology in the context of large application development. There is a wide range of available technology and materials for making metal items. With a wide selection of materials already available, including titanium and nickel alloys, as well as stainless steel, the range is only growing. Regarding non-manufacturing, area-selective atomic layer deposition (ALD) has emerged as a viable alternative. ALD restricts the amount of material deposited at a restricted location. Patterning and chemical mechanical polishing can be reduced, allowing for self-aligned production and reducing the number of manufacturing stages [4–6]. Due to the competitive process and usage of certain tools, especially in high-quality manufacturing, 3D printing technology is tested for its compatibility with porous clay materials. New technical approaches for producing porous attractiveness are reviewed here.

Parts of blue-green clay are 3D printed and then fused in order to complete the process. Different powders are created depending on the 3D printing quality of the pottery and the materials being examined. The physical features of the particles, such as particle size, flow, and water, are also explored in relation to the 3D printing process. Looks examines the relationship between the final print outcome and various 3D printing parameters. Low extent additives made to order3-D printing variations are growing surprisingly in prototyping manufacturing [7–10]. 3D printing and its many materials and their qualities are the focus of this study, which covers a wide range of technologically interesting ground. They take a look at the history of 3-D printing and examine what materials have been utilized to produce 3-D printed gadgets and choose the best materials for our 3-D printing equipment from them. Metal foil laminated object manufacturing and sheet metal laminated object manufacturing principles are also discussed in this paper. The experimental results for qualifying and optimizing

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each sub-process of metal foil laminated manufacturing methods are revealed for each sub-process of the method [11–13]. Fig. 1 shows a general process flow for Additive manufacturing.

1.1. Classification of Additive manufacturing

Additive manufacturing, often known as 3D printing or layered manufacturing, is fabricating things by layering materials in a 3D printer. ASTM defines additive manufacturing as "the process of combining materials to build products from 3D model data, usually in a layer-by-layer way, as opposed to subtractive manufacturing approaches." Charles W. Hull brought additive manufacturing to the world in 1984, and it has been thoroughly investigated in the previous two decades. A stereolithography file is often built from a computer-aided design (CAD) file. A 3D printer can decode the STL file format. To render 3D printing, a variety of polymers, metals, ceramics, and composites are used. Material extrusion, binder jetting, material jetting, powder bed fusion directed energy deposition, sheet lamination, and vat photopolymerization are among the seven additive manufacturing techniques classified by ASTM/F2921 (Fig. 2). Additive manufacturing is built to process smart and adaptive materials [36,37].

1.2. 3D printing materials

The quantity of 3D-printable materials utilized globally is a small percentage of all polymers, composites, alloys, and metals. 3D printers, on the other hand, use a diverse and ever-expanding spectrum of ordinary, precious, and exotic materials. Polymers, composites, carbon fibre, and other materials can all help grow any business. Even if any organization doesn't have a market for 3D printed products, you'll always need to replace broken parts, even if it's just a temporary fix while you wait for an OEM part. You may have assembly procedures that necessitate the usage of specialized jigs and fixtures by your finishing staff. You may have innovative operations and maintenance people who can adapt commercial-off-the-shelf equipment to manufacture new and better inkjet-printed items using 3D printed parts. Table 1 shows different-different technologies with their input materials [35–37].

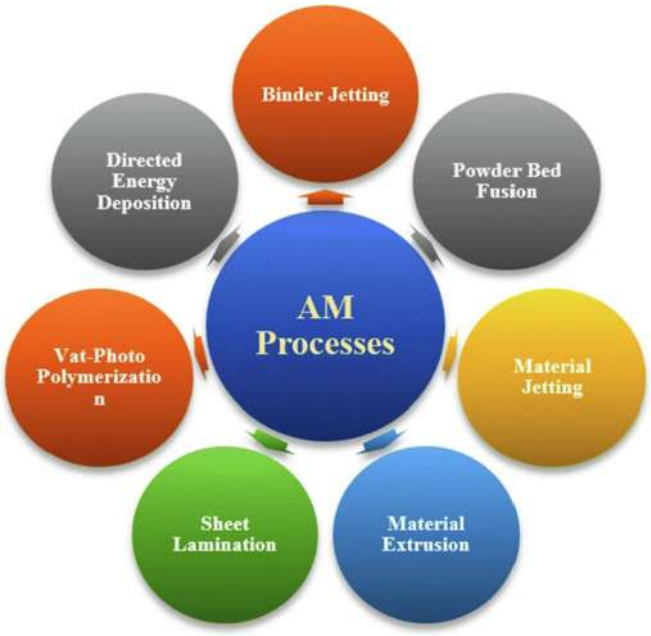

Fig. 2. Classification of Additive manufacturing.

Table 1
Technologies with their input materials.

Technology	Sample Materials
Material Jetting	Photopolymers, silver, wax
Powder Bed Fusion	Aluminum, ceramic, cobalt, gold, Inconel, nickel, polymer, silicate, steel, titanium
Binder Jetting	Aluminum, bronze, ceramics, foundry sand, gypsum, Inconel, stainless steel
Stereolithography (vat photopolymerization)	Polymers, composites
Sheet Lamination	Carbon fiber, copper, fiberglass, Kevlar, stainless steel, titanium
Material Extrusion	Polymers, composites, fiberglass, Kevlar, metal, nylon, biomaterials
Directed Energy Deposition	Aluminum, copper, Inconel, magnesium, nickel, steel, titanium, zirconium

2. Types of Additive Manufacturing/3D Printing

2.1. FDM-Fused Deposition Modelling

Basically, FDM stands for Fused Deposition Modelling. In this technology, a thermoplastic filament coil is used as input material. The most commonly used material in FDM is ABS (Acrylonitrile Butadiene Styrene). In this process, a particular thermoplastic filament is heated up to its melting point on the inside of an extruder, and then it is extruded layer by layer, and that particular layer by layer arrangement is done to form a 3D solid object as shown in Fig. 3. Mr. Scott Crump first introduced this kind of 3D printing technology in 1986 [14–17].

2.2. SLS- Selective Laser Sintering

Basically, Sintering is a process in which powder is used as a raw material and this powder is heated up just below the It's melting point was reached, and then this particular powder melted together to form a solid object.

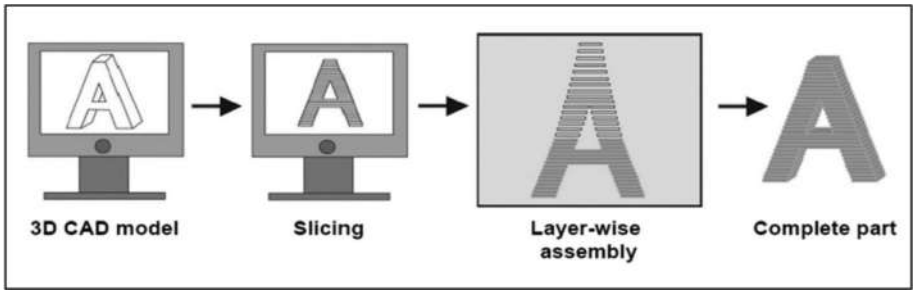

Fig. 1. Additive Manufacturing Process (Source: www.javelin-tech.com).

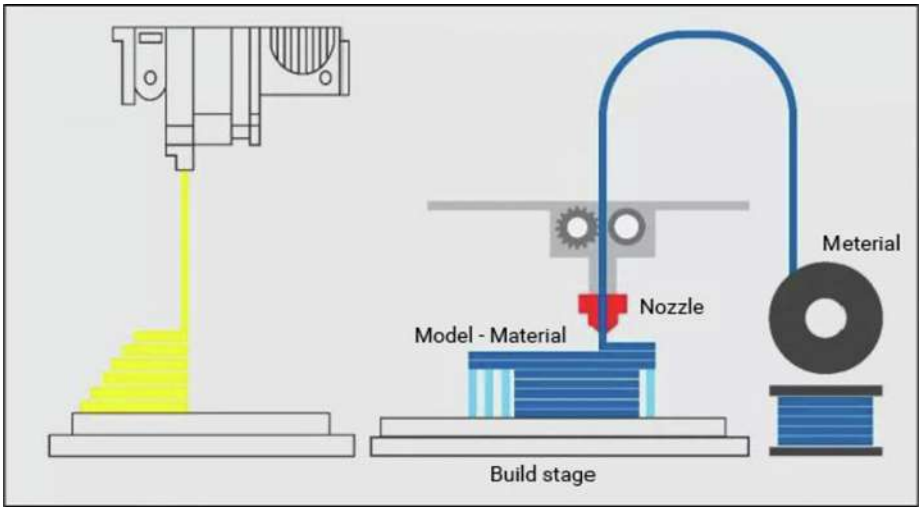

Fig. 3. Fused Deposition Modelling (Source: www.pcbway.com).

Selective Laser Sintering is an additive manufacturing (AM) technology. In this, polymeric powder is used to create a 3D object. There are different materials that are available that are used as raw materials in the Selective Laser Sintering Process, like Thermoplastic, Ceramic, Glass, Metal, etc. But the majority of the material used is plastic, and in plastic material, Nylon 11 and Nylon 12 are used. In SLS, a CO2 laser is used, and this laser is connected to the user's computer. After the laser tracts the accurate geometries, inside the chambers, powder is heated just below its melting point, and then this particular powder is fused together to form a solid object as shown in Fig. 4 [18].

2.3. SLA- Stereo-lithography

Stereolithography is the first ever process of 3D printing that was introduced to the market. This particular process can manufacture the 3D printed parts from liquid resin polymer into solid objects. There are four important components present in this process. The first one is UV Curable Photopolymer Liquid, which is present in the tank. The second one is the perforated table. The third one is the laser source, and the last one is the computer, which controls the movement of the laser source and perforated table. After the CAD file is prepared, that CAD file is converted into an STL file, which is the input file of a 3D printer, and according to that STL file, the 3D printer prints 3D objects accurately. In the SLA process, a laser heats the photopolymer liquid's upper surface, and then the photopolymer liquid gets hardened up instantly. This particular laser has the provision to move in any shape to form the design of that particular object as shown in Fig. 5 [19,20].

2.4. LOM- Laminated Object Manufacturing

Laminated Object Manufacturing (LOM) is an additive manufacturing process that is used to create 3D objects using paper, plastic, and metals. In this process, paper or plastic laminates are successively glued together and the desired shape of the object is cut using a laser cutter. In this laminated object manufacturing process, initially a sheet is joined to a substrate with a heated roller, then a laser is used to trace the desired dimensions of the model or the prototype. Actually, the laser removes the area which is not part of the object, then the platform with the completed layers moves down. After that, a fresh sheet of metal is rolled into the position, and the platform goes back to its original position to receive the next layer again as shown in Fig. 6. The process is repeated until the model or prototype is completed [21–23].

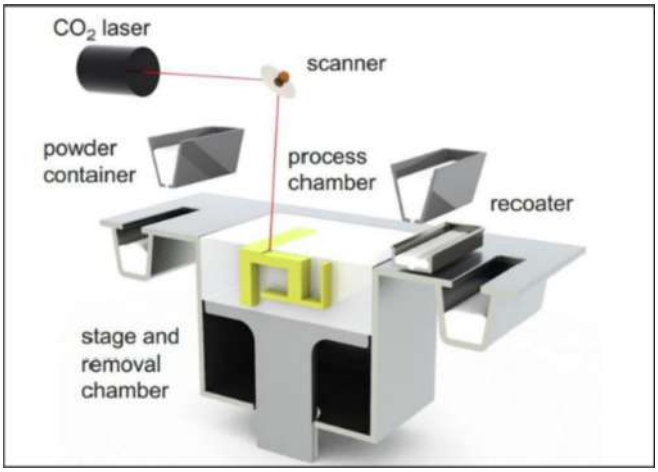

Fig. 4. SLS- Selective Laser Sintering process (Source: 3dprint.com).

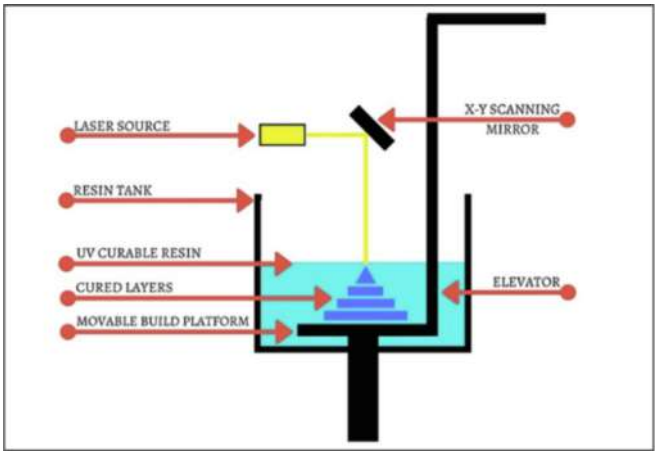

Fig. 5. SLA- Stereo-lithography Process (Source: manufactur3dmag.com).

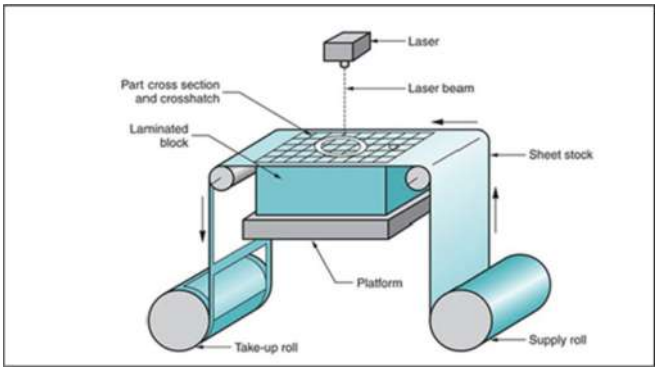

Fig. 6. LOM- Laminated Object Manufacturing process (Source: www.starrapid.com).

2.5. SDL-Selective Deposition Lamination

A sheet of paper is laid out on the platform at the beginning of the process. To ensure that the support can be easily removed, glue is selectively sprayed to the paper, with a larger concentration in the working region and a lower concentration in the support area, respectively. A paper feeding mechanism places a fresh sheet over the recently adhered one in the next stage. The built plate is now pushed closer to the heated plate and applied to ensure a uniform bond. Build height is reached, and then a sharp edge tool cuts one sheet of paper in accordance with design data and produces the part's edge as shown in Fig. 7. As the initial sheet is finished, the next sheet is immediately deposited until the part is finished [24,25].

To analyze SDL more thoroughly, a survey is performed on levels that justify the term "selective deposition lamination."

- Selective: Aid elimination is made easier due to the machine's ability to provide better glueing at the working region while decreasing the amount at the aid position. As a result of the LOM procedure, glue is applied to the entire piece of paper, making it difficult to remove.
- Deposition: Applying glue as in SLS, with the aid of a paper cutter is an art that requires perfection. LOM gluing is done more consistently, where glue is applied to the entire sheet.
- Lamination: Laminates are sheets stacked on top of each other in a layered fashion. Paper is used to construct these components, so they will last a long time [26].

3. Applications

3D printers have been used for centuries, regularly transforming 3D computer plans into complex physical artefacts for product creation, educational, artistic, medical, surveying, ancient preservation and other applications, few of them are explained below as shown in Fig. 8 [27].

3.1. Medical Application

In the healthcare profession, AM can be utilised to create prosthetic parts of the body that are personalized to the user's needs. Printing out a hearing aid shell can also be done with this printer. Preparation for surgery can benefit from the ability of AM to build complicated models. 3D printed representations of a patient's anatomy can be used instead of MRI and CT scans by surgeons to better understand the patient's anatomy prior to surgery. Additionally, these models can be utilised for surgical training and simulation purposes [27,28].

3.2. Education

Every forward-thinking academic institution and every innovative educator strive to maximise student-teacher collaboration in the pursuit of ever-improving methods for improving the educational experience. Because of this, educational institutions have been forced to keep pace with rapid changes in technology. Students are increasingly exposed to new and innovative ways of learning, including online virtual classrooms, online learning. Nowadays lots of people are talking about AM in the educational community. AM also emerged as the ground-breaking technology and is being recognized as a new motivator for education. Clearly, this technology has made its way into many schools, institutes, and even curriculums, as educational institutions have come to realise its relevance and how it aids in the achievement of successful educational experiences [29–32].

3.3. Architecture

AM is very useful for architects because when architects design a building, they usually do so with a blueprint or a plan. Due to their complex nature, a layman cannot understand these blueprints. Quite often, architects cannot express their ideas clearly and have to make renderings that are time-consuming.AM now changes all of that, models are direct scaled versions of the draw-

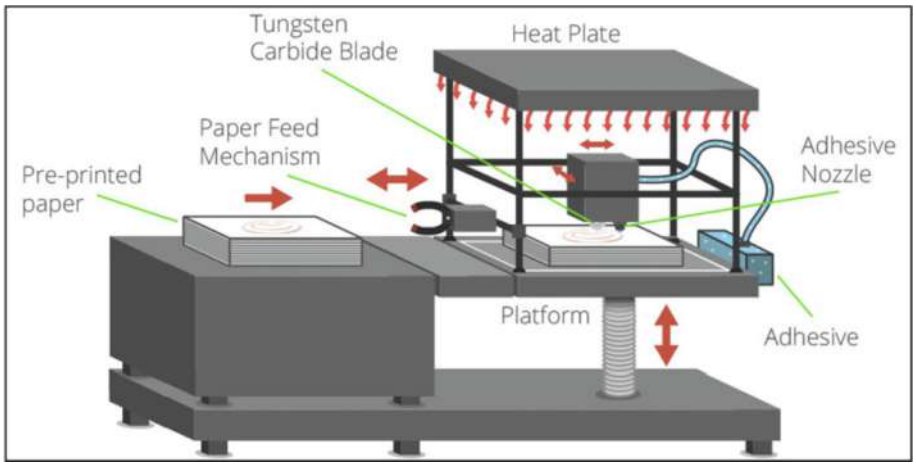

Fig. 7. Working of selective deposition lamination process (Source: www.makepartsfast.com).

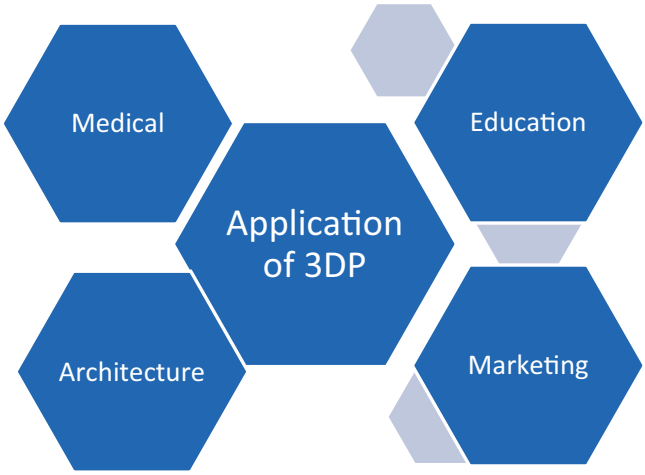

Fig. 8. Applications of 3DP.

ings and brings beautiful designs to life. It may be a value addition for a project or make your pitch a success [33].

3.4. Marketing

Additively manufactured parts are significantly more potent than flyers for salesmen and advertisers who need to demonstrate new products to consumers and prospects before they go on sale. Having the ability to handle a new product in one's hands helps customers better understand and remember it [34,35].

4. Conclusion

This review covers a wide range of topics related to the use of 3D printing in manufacturing. As 3D printing technology enters the production sector, it has numerous advantages for the people, businesses, and the government alike. As a result, more research into effective strategies for increasing the uptake of 3D printing technology is required. Having more knowledge about 3D printing technology would assist companies and the govt to develop the infrastructure of 3d printing sector. As a result, the purpose of this article is to provide an overview of the various 3D printing processes, materials utilized in production, and applications. Researchers will be able to conduct future research on the many types of Rapid prototyping machines and the best materials to utilize with each one.

CRediT authorship contribution statement

Aniket Jadhav: Data curation, Visualization, Methodology, Writing – original draft. **Vijay S. Jadhav:** Conceptualization, Writing – review & editing, Supervision, Investigation, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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