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Additive Manufacturing: A Comprehensive Review

[1] Pradeep Jain*, [2] Tarun Bhardwaj
[1] [2] Department of Mechanical Engineering, Ajay Kumar Garg Engineering College, Ghaziabad, Uttar Pradesh, India.
Corresponding Author Email: [1] *jainpradeep@akgec.ac.in

Abstract— ***Additive manufacturing (AM) is the prominent technology that is used to manufacture the 3D components of complex geometry and customized shapes. Owing to the requirement of the complex shape structure in various industries including aerospace, medical, automobile etc., the demand of AM has been increasing every year in manufacturing field. This paper explores the development, application and basic knowledge of AM, and current challenges and future trends. The basic properties of AM and its evolution in manufacturing industry helps in design flexibility, processing, multi-material selection etc. This paper provides the basic knowledge and paving the way to overcome the current barriers and motivate to do research on future trends.***

Keywords: Additive Manufacturing, Rapid Prototyping, 3D printing, freeform fabrication, layered manufacturing.

I. INTRODUCTION

Additive manufacturing (AM) so called 3D printing is defined as an eminent technique that creates 3D components directly from stl (standard tessellation language) file [1]. In this process, stl file is required by machine to manufacture the 3D components. Additive manufacturing (AM) brings a revolution in manufacturing field. It has gained an interest in research and industry owing to its capability to manufacture the complex shapes and customized material properties. Moreover, except some advantages including less material wastage, rapid prototyping, customized products etc., there are few limitations of this technology are high build time, less accuracy and surface finish etc.

The demand of additive manufacturing (AM) in manufacturing has been increasing every year. The layer-by layer system of fabricating parts is in high demand for serial production. Nowadays, AM is being utilized to fabricate metallic parts using steel, aluminum and titanium which is being utilized to its fullest.

In early 1980's, the models and prototypes are created using layer based approach from CAD file. The technology used for this process is called as rapid prototyping. This technology helped the engineers to manufacture the shape that they desire. Firstly, this technology is only used for prototyping but after that parts are also being created and used as end products. Moreover, the advancements in development of complex structure products is less human interaction with machine and reduction in time and cost. Now-a-days, various industry professional, engineers, doctors, scientists, artists are using this technology for various application including prototyping, medical instruments, architectural structure, automobile sector etc. [2–4].

Figure 1 presents the product development cycle. Here, it can be analyzed that the product will develop faster than any conventional manufacturing methods [5].

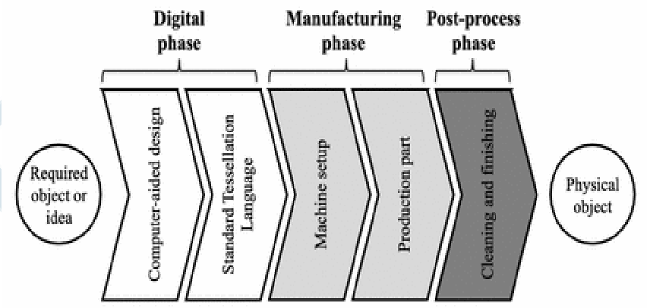

Figure 1. Product development Cycle [6]

II. PROCEDURE INVOLVED IN FOLLOWING MAJORLY USED AM PROCESSES:

Stereolithography

Stereolithography (SL) was the foremost developed AM system. This process uses the liquid resin as raw material for creating 3D components. Schematic of the process involved is shown in Figure 2. This process uses UV light to cure the liquid resin and the basic principle is the photopolymerization. Ceramic powder can also be processed by suspension of powder in liquid resin [7].

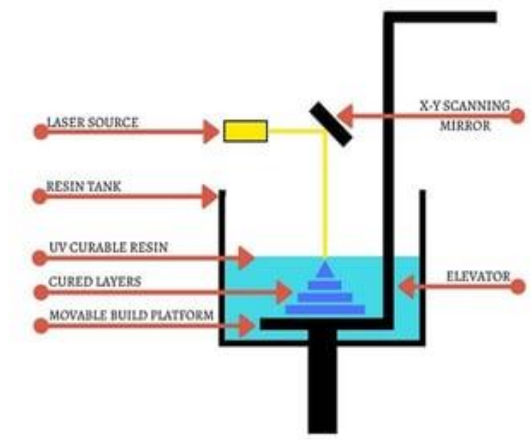

Figure 2. Vat Photopolymerization

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Fused Deposition Modeling

Fused deposition modeling (FDM) is an extrusion AM process that is used to extrude materials including PLA, ABS, ASA, PC, PEEK, PC-ABS blends etc. [8]. The advantage of FDM over Vat photopolymerization is that it does not require any post curing. However the limitations are that it takes lot of manufacturing time for creating the parts.

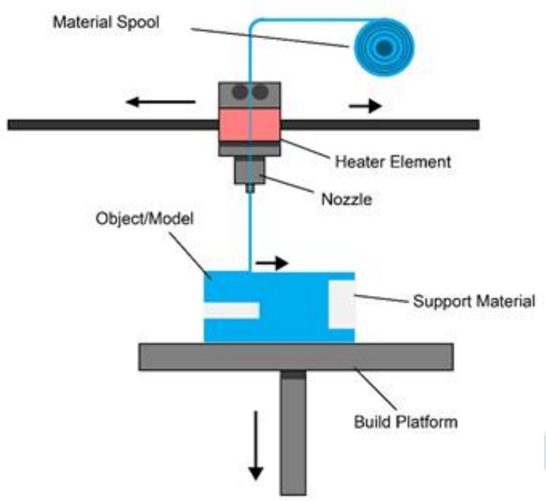

Figure 3. Fused Deposition Modeling [9]

Selective Laser Melting

Direct selective melting process uses the laser or electron beam as an energy source to fuse the powder particle. This particle size of powder is 5-45 Microns. Schematic of SLM is shown in Figure 4.

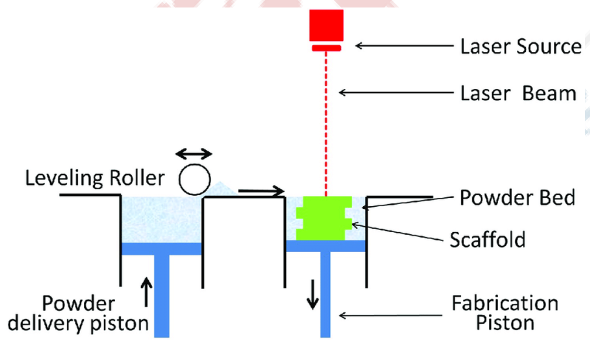

Figure 4. Selective Laser Melting Process [10]

Direct laser energy deposition

Direct energy deposition process uses laser or electron as a direct source to melt the powder particle and then deposit the molten metal directly on the base plate. The powder is carried using argon gas to flow through the nozzle. The process occurs in a closed chamber with an argon atmosphere specifically for few materials including titanium, magnesium etc. Schematic of DLED is shown in Figure 5.

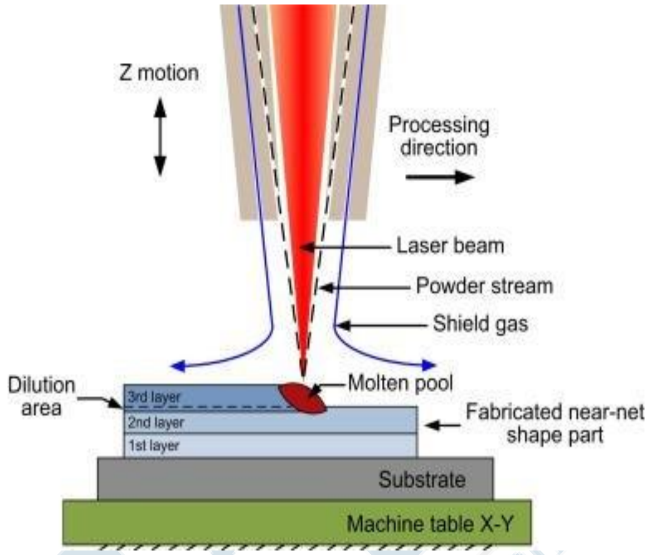

Figure 5. Direct laser energy deposition process [11]

Current Barriers and Future trends:

There are following current barriers in AM processes including mechanical anisotropy, surface finish, mass production and large part generation. Anisotropy is basically due to varying thermal gradients during the formation of each layer.

Future trends are following:

1. Additive software innovation will play catch-up
2. Increased focus on machine connectivity
3. The continued convergence of AM and AI
4. AM will drive distributed manufacturing
5. The next wave of growth in additive MES

Summary

This article summarized the majorly used processes of AM. The procedure of various AM processes is discussed in brief. This review article helps the researcher to understand the basic knowledge, current barriers and future trend of AM processes.

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