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Additive Manufacturing

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ABSTRACT
The paper proposes a domain statement for Additive manufacturing as a field of study which is based on layer based manufacturing from a 3D model. AM differs fundamentally from forming and subtractive techniques. Additive manufacturing process have made a global impact on technology with its complexion and light weight fabricated design. However, this design freedom is countered by build envelope (size) and production rate (speed) constraints characteristic of most commercially available AM equipment. It has been a topic of intense study and review by many researchers. The evolution of AM have been a great boon to industries and technologies. This review will help to understand AM Generic process and application of metal additive manufacturing in various industries.
KEYWORDS: 3D Printing, Additive Manufacturing,Rapid Manufacturing, Aerospace Industry, Pharmaceutical Industry, Healthcare Industry,Automotive Industry, Nano manufacturing, Biotechnology.

I. INTRODUCTION

[1]. The term additive manufacturing (AM) refers to a very wide range of technologies: in 2010, it was defined by the American standardization organization ASTM as “a process of joining materials to make objects from three-dimensional (3D) model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.” 3D printing uses a computer aided (CAD) design to translate the design into a three-dimensional object. The AM refers to a technology of deposition of successive thin layers of material upon each other to create a final product (3D product). In contrast, AM needs only some basic dimensional details and a small amount of understanding as how the AM machine works and the materials that are used to build the part. The term rapid prototyping (RP) is used in a variety of industries to describe a process for rapidly creating a system or part representation before final release. [2] Each layer is approximately 0.001 to 0.1 inches in thickness. [3] A wide variety of materials can be utilized; namely, plastics, resins, rubbers, ceramics, glass, concretes and metals. Additive manufacturing provides the important opportunity to advance manufacturing industry which have a great impact on research and development (R& D) expenditure for manufacturing.

II. EVOLUTION

The AM first emerged in 1987 with stereo lithography (SL) from 3D systems, a process that solidifies thin layers of ultraviolet (UV) light-sensitive liquid polymer using a laser. The SLA-1, the first commercially available AM system in the world, was the precursor of the once popular SLA 250 machine.

1988-1994	Rapid Prototyping
1994	Rapid Casting
1995	Rapid Tooling
2001	AM for Automotive
2004	Aerospace(Polymers)
2005	Medical (Polymer Jigs and Guides)
2009	Medical Implants (Metals)
2011	Aerospace (Metals)
2013-2016	Nano-manufacturing
2013-2017	Architecture
2013-2018	Biomedical Implants
2013-2022	In situ Bio-manufacturing

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2013-2032	Full Body Organs

III. THE GENERIC AM PROCESS

AM involves a number of steps that moves from CAD design to the final 3D- product. Different products will involve AM in different ways and to different degrees. In the process of AM, early stages of the product development process may only require rough parts, with AM being used because of the speed at which they can be fabricated. At later stages, part may require precise cleaning and post-processing (including sanding, surface preparation, and painting) before they are used. AM is a perfect process of creating complex and lightweight materials.

The steps for Generic AM processes are:-

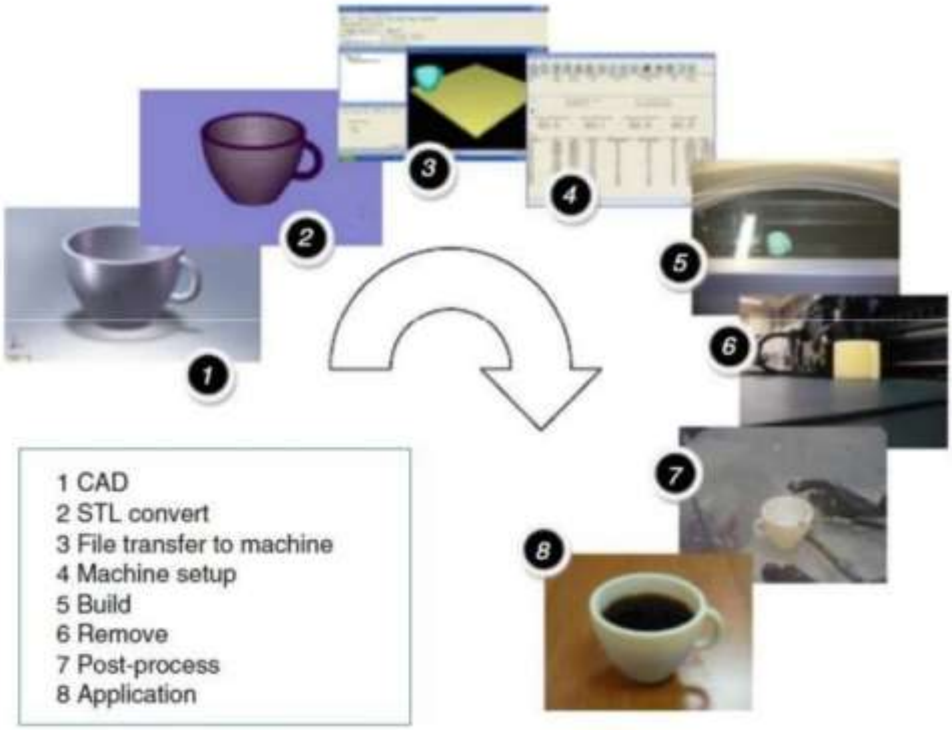

Fig III.1:- [7] Generic AM Process

i) **Computer Aided Designing Software (CAD):** Every products to be manufactured should be first inserted in CAD software which requires dimension of to be fabricated product.
ii) **Conversion to STL:** Nearly, almost every AM machine accepts the STL (Stereo lithography) file format and every CAD system can output such a file format. STL files describe only the surface geometry of a three-dimensional object without any representation of colour, texture or other common CAD model attributes.
iii) **Transfer to AM Machine and STL File Manipulation:** The STL file defining the part should be transferred to the AM Machine. There may be some changes to be done in order to check whether it is in correct size, position, angle and orientation for final product.
iv) **Machine Setup:** The AM process must have a proper setup earlier to the build process. Such settings are related to the build parameters like material constraints, energy source, layer thickness, timings, etc.
v) **Build:** Building a part is an automated process where the final product is made. It is an automated process and machine can process this without any supervision but few steps like: running of material, power or software glitches, etc. should be noticed.
vi) **Removal:** After the completion of part, it should be removed from AM Machine. This may require interaction with the machine, which may have safety interlocks to ensure safety.

vii) Post-processing: After removal from the AM machine, parts may require an additional amount of cleaning. Parts may be weak at this stage or they may have supporting features that must be removed.

viii) Application: After Post-processing, parts built may require priming and painting to give an acceptable surface texture and finish. Many AM machines requires careful maintenance and handling. The raw materials used in some AM processes have limited shelf-life and may also be required to keep in conditions that prevent them from unwanted chemical reactions. Exposure to excessive light, moisture and other contaminants should also be avoided.

IV. APPLICATION OF METAL ADDITIVE MANUFACTURING

i) Aerospace Industry: The main requirement for the aerospace industry is to produce light weight, complex geometries, and good mechanical properties in small quantities. [4] These techniques are used to fabricate low-volume complex aerospace parts, aircraft wings and replacement parts in the aerospace industry along with fabricating specialized parts, lightweight structures, parts with minimal waste, on-demand parts, and replacement parts to support long term space exploration.AM technologies have developed a new materials and design in Aerospace Industry. The main challenges includes residual stress, inhomogeneity, dimensional accuracy, and surface finish. AM is continuously upgrading and transforming segments in aerospace industry including commercial and military aircraft, space applications, as well as missiles systems. The newly production of titanium have started which can have a great saving in aerospace industry.

ii) **Pharmaceutical Industry:** Additive manufacturing have really a great advancement in Pharmaceutical Industry. With the use of printing materials, it is possible to 3D- print drugs. AM makes it much more cost-effective to produce items in small batches, such as custom plastic or metal tools, toys or replacement parts. The capabilities of additive manufacturing in pharmaceutical production allows a high level of control over when a drug is released within the body and how the pharmacodynamics of the drug can be altered by changing its composition and shape. AM helps to combine multiple drugs into a single dose. It can be a customisation dosage for patients. In addition to oral dosage forms, researchers have used additive manufacturing to create transdermal and topical drug delivery systems. Additive manufacturing can be used to print splints, prosthetics, implants and other medical devices. AM in future days have a great potential to transform Pharmaceutical Industry. The use of AM can enable more personalised medicine, more complex drug-release profiles and reduced costs.

iii) **Healthcare Industry:** The use of metal AM processes in the healthcare industry is briefly reviewed. In the dental industry, AM process can be used for creating precise dental crowns, bridges, and implants. [5] The capability of SLM process to manufacture custom, complex and accurate consists of scanning the dental impression of the patient's teeth, digital modelling of the part and then SLM production. This technology is very useful for fabricating custom- made medical implants as well as surgical tools and fixtures for use in operation rooms. The main advantage of AM in the medical industry is its capability to produce complex components with low production cost as well as customized components.

iv) **Automotive Industry:** Metal AM has significant implications on part design. Fabricating complex light structure through AM have being advantageous in Automotive Industry. [6] A significant advantage is in-house and on demand production, which reduced inventory needs, shipping costs, and material procurement costs. Additive manufacturing allows automotive companies to customize car assembly tools by improving its functionality and reducing its weight at a lower cost than traditional manufactured tools. There are even cases where completely new tools are developed for specific, customized designs.

v) Nano manufacturing: AM have been integrated with nanotechnology to fabricate parts from new Nano composites. The benefits of using nanomaterial in AM processes is enhancing the material properties of the fabricated parts. Using AM, parts with better optical, thermal, electrochemical, and mechanical properties have been obtained. Applying 3D printing concepts to nanotechnology could bring similar advantages to nanofabrication- speed, less waste, economic viability- than it is expected to bring to manufacturing technologies.

vi) **Biotechnology Industry**: AM have been a great advantage to Biotechnology Industry.Bio fabrication compasses the automated generation of tissue constructs by means of bio printing, bio assembly, and subsequent maturation. The most widely applied AM techniques for bio printing with bio inks are based on laser- induced forward transfer, inkjet printing, and robotic dispensing. The recapitulation of tissue models achieved through three-dimensionality are aided by 3D printing, which provides an environment to sustains cell proliferation and differentiation. 3D-printed cell culture systems often substitutes for existing commercial culture platforms, providing a more cost-effective, well-tailored solution for specific interests, and causing customizable for optimized specific tissue applications. Cells are seeded onto solid and biodegradable scaffolds, and tissue formation is often induced by bio molecules, such as growth factors. Various tissue engineering approaches have been employed to build tissues and organs that could be used in patients, including myocardial tissue, vessel, heart valve and trachea.. With the help of AM artificial organs like bladder, cartilages, kidney, and liver can be manufactured.

CONCLUSION

This paper is aimed to review various additive manufacturing processes and applications. The world is forever changing with the help of 3D printing. Additive manufacturing industry is definitely booming and rapidly becoming a very large industries in many sectors. Manufacturers could create moulds much faster and more precise than before. The advancement and technological aspects in research and development have a great impact in industries.3D printing is a limitless process. As a result, the technology is seeing an increased adoption beyond prototyping and tooling into an end and spare part production. AM can significantly reduce energy usage as compared to traditional manufacturing process. In this way, additive manufacturing can reduce material costs and waste by as much as 90 percent.

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