ADDITIVE MANUFACTURING - RAPID PROTOTYPING & TITANIUM CONTRIBUTION

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ABSTRACT

Additive manufacturing technologies facilitate layer-sensible fabrication of complex parts directly from CAD files without part-oriented tooling. Illustration of additive manufacturing technologies include stereo lithography, fused deposition modeling, 3D printing, selective laser melting, laser engineered net shape processes, ultrasonic consolidation, and selective laser sintering. Additive manufacturing offers many strategic advantages, including increased design freedom for building intricate interior and exterior element geometries that cannot be made in any other way, the ability to rapidly Iterate during plan permutations, the capability to assemble purposeful parts in small batch sizes for end-user customization or bridge manufacturing, and the capability to restore exclusive parts for aerospace and other industries. From additive manufacturing processes and their brunt on industrial practice and intellectual study we can understand the basic principles of additive manufacturing, the limits of our capabilities for fabricating functional parts, and the impact that additive manufacturing is having on design and manufacturing.

The aerospace industry employs them because of the possibility of manufacturing light assembly to trim down heaviness. Additive manufacturing is transforming the practice of medicine and making work simpler for designers. In 2004, the Society of Manufacturing Engineers did a classification of the diverse technologies and there are at least four supplementary noteworthy technologies in 2012. Studies are reviewed which were about the potency of products prepared in additive manufacturing processes. However, there is still a lot of work and research to be proficient before additive manufacturing technologies become standard in the manufacturing industry because not each usually used manufacturing objects can be handled. The accuracy needs improvement to eliminate the necessity of a finishing process. The incessant and escalating development experienced since the early days and the successful results up to the present moment permit for buoyancy that additive manufacturing has a significant place in the future of manufacturing. The main advantage is it is a NO-SCRAP process.

Keywords: Accuracy, Additive, CAD, Future, Layer-Sensible, Lithography, NO-SCRAP

I. INTRODUCTION

Additive Manufacturing (AM) or Rapid Manufacturing is one of numerous names used for a group of processes that are based on sheet subjected manufacturing procedure to produce physical products directly from 3D computer data. The process starts by scheming a 3D model of a creation. The 3D replica is exported to the preprocessing software of the rapid manufacturing machine. The first footstep of preprocessing is a programmed process that divides the complex 3D model in a stack of 2D disks that together accurately resembles the 3D model. Using more layers means that the original 3D geometry will be approximated additional precisely. In an automated second process step each disk is divided in a series of lines or dots (depending on the type of RM process) that exactly explain the disk. The desired location of these lines or dots (per layer) can then be drive to a Rapid Manufacturing machine. A rapid manufacturing machine is basically a much uncomplicated machine. For example Fused Deposition Modeling (FDM) is a RM process that feeds plastic wire through an extrusion cranium thus creating a constant streak of molten plastic. Depositing a line of plastic basically means telling the machine to move the extrusion cranium from site A to site B while extruding. Repeating this many times will create a layer. Moving one coat thickness in z-direction means you are able to start creating the second layer. In the illustration represented above each coat is smaller than the coat it is constructed on. When trying to print more complex shapes this does not have to be the case. While overhanging geometry is to be printed, it cannot be suspended in mid-air. It should be supported by materials, not fraction of the last product. For FDM machines a second material is used to support overhanging features, the holdup materials. This matter can be broken away from the creation or for example can be dissolved in water.

II. GENERAL STEPS IN ADDITIVE MANUFACTURING[1]

Eight key steps in the process sequence:

- Conceptualization and CAD
- Conversion to STL/AMF
- Transfer and manipulation of STL/AMF file on AM machine
- Machine setup
- Build
- Part removal and cleanup
- Post-processing of part
- Application

2.1 Conceptualization and Cad

The first step in any product development process is to come up with an idea for how the product will look and function. Innovation can take numerous forms, from textual and narrative metaphors to sketches and representative models. If AM is to be utilized, the creation description must be in a digital form that allows a substantial replica to be made. It may be that AM technology will be used to prototype and not build the final product, but in either case, there are many stages in a product development process where digital models are required.

2.2 Conversion to Stl/Amf

The different 3D-CAD packages use diverse algorithms to show solid objects, so in order to achieve uniformity and standardization the 3D model for rapid prototyping, CAD file format is converted into STL file format (.STL) i.e. Standard Tessellation Language or Stereo Lithography file.

This format has been selected for standard file format by rapid prototyping industry. Nearly every AM technology uses the STL file format. The term STL was derived from Stereo Lithography, which was the first commercial AM technology from 3D observer to be enclosed but in fact was not mathematically closed. Such models could result in unpredictable output from AM machines, with different AM technologies treating gaps in different ways.

2.3 Transfer and Manipulation of Stl/Amf File on Am Machine

Once the STL file has been formed and repaired, it can be sent directly to the target AM machine. Ideally, we can press a “print” button and the machine should build the part straight away. This is not usually the case however and there may be a number of actions required prior to building the part. AM system software normally has a visualization tool that allows the user to view and manipulate the part. The user may wish to reposition the part or even change the orientation to allow it to be built at a specific location within the machine. In general the .STL file has been transferred to Am machine by means of direct connect or by manually through and transferring device such as pen drive.

2.4 Machine Setup

All AM machines will have at least some setup parameters that are specific to that machine or process. Some machines are only designed to run a few specific materials and give the user few options to vary layer thickness or other build parameters. Other machines are designed to run with a variety of materials and may also have some parameters that require optimization to suit the type of part that is to be built, or permit parts to be built quicker but with poorer resolution. Such machines can have numerous setup options available. It is common in the more complex cases to have default settings or save files from previously defined setups to help speed up the machine setup process and to prevent mistakes being made. Normally, an incorrect setup procedure will still result in a part being built. The final quality of that part may, however, be unacceptable.

2.5 Build

Once the machine setup steps were completed, the process switches to the computer-controlled building phase. This is where the previously mentioned layer-based manufacturing takes place. All AM machines will have a similar sequence of layering, including a height adjustable platform or deposition head, material deposition/spreading mechanisms, and layer cross-section formation. Some machines will combine the material deposition and layer formation simultaneously while others will separate them. As long as no errors are detected during the build, AM machines will repeat the layering process until the build is complete.

2.6 Part Removal and Cleanup

Ideally, the output from the AM machine should be ready for use with minimal manual intervention. While sometimes this may be the case, more often than not, parts will require a significant amount of post-processing before they are ready for use. In all cases, the part must be either separated from a build platform on which the part was produced or removed from excess build material surrounding the part. Some AM processes use additional material other than that used to make the part itself (secondary support materials).

2.7 Post-Processing of Part

Post-processing refers to the (usually manual) stages of finishing the parts for application purposes. This may involve abrasive finishing, like polishing and sandpapering, or application of coatings. This stage in the process is very application specific. Some applications may only require a minimum of post-processing. Other applications may require very careful handling of the parts to maintain good precision and finish. Some post-processing may involve chemical or thermal treatment of the part to achieve final part properties. Different AM processes have different results in terms of accuracy, and thus machining to final dimensions may be required. Some processes produce relatively fragile components that may require the use of infiltration and/or surface coatings to strengthen the final part. As already stated, this is often a manually intensive task due to the complexity of most AM parts. However, some of the tasks can benefit from the use of power tools, CNC milling, and additional equipment, like polishing tubs or drying and baking ovens.

III. RECENT METHODS

- VAT Photo Polymerization
- Material Jetting
- Material Extrusion
- Powder Bed Fusion
- Sheet Lamination
- Direct Energy Deposition

3.1 Vat Photo Polymerization [2]

Photo polymerization processes make use of liquid, radiation-curable resins, or photopolymers, as their primary materials. Most photopolymers react to radiation in the ultraviolet (UV) range of wavelengths, but some visible light systems are used as well. Upon irradiation, these materials undergo a chemical reaction to become solid. This reaction is called photo polymerization, and is typically complex, involving many chemical participants.

3.2 Material Jetting [3]

Printing technology has been extensively investigated, with the majority of that investigation historically based upon applications to the two-dimensional printing industry. Recently, however, it has spread to numerous new application areas, including electronics packaging, optics, and additive manufacturing. Some of these applications, in fact, have literally taken the technology into a new dimension. The employment of printing technologies in the creation of three-dimensional products has quickly become an extremely promising manufacturing practice, both widely studied and increasingly widely used. This chapter will summarize the printing achievements made in the additive manufacturing industry and in academia. The development of printing as a process to fabricate 3D parts is summarized, followed by a survey of commercial polymer printing machines. The focus of this chapter is on material jetting (MJ) in which all of the part material is dispensed from a print head. This is in contrast to binder jetting, where binder or other additive is printed onto a powder bed which forms the bulk of the part. Binder jetting is the subject of some of the technical challenges of printing are introduced; material development for printing polymers, metals, and ceramics is investigated in some detail. Models of the material jetting process are introduced that relate pressure required to fluid properties. Additionally, a printing indicator expression is derived and used to analyze printing conditions.

3.3 Material Extrusion [4]

Material extrusion technologies can be visualized as similar to cake icing, in that material contained in a reservoir is forced out through a nozzle when pressure is applied. If the pressure remains constant, then the resulting extruded material (commonly referred to as "roads") will flow at a constant rate and will remain a constant cross-sectional diameter. This diameter will remain constant if the travel of the nozzle across a depositing surface is also kept at a constant speed that corresponds to the flow rate. The material that is being extruded must be in a semisolid state when it comes out of the nozzle. This material must fully solidify while remaining in that shape. Furthermore, the material must bond to material that has already been extruded so that a solid structure can result. Since material is extruded, the AM machine must be capable of scanning in a horizontal plane as well as starting and stopping the flow of material while scanning. Once a layer is completed, the machine must index upwards, or move the part downwards, so that a further layer can be produced.

3.4 Powder Bed Fusion [5]

Powder bed fusion (PBF) processes were among the first commercialized AM processes. Developed at the University of Texas at Austin, USA, selective laser sintering (SLS) was the first commercialized PBF process. Its basic method of operation is schematically shown in Fig. 5.1, and all other PBF processes modify this basic approach in one or more ways to enhance machine productivity, enable different materials to be processed, and/or to avoid specific patented features.

3.5 Sheet Lamination [6]

One of the first commercialized (1991) additive manufacturing techniques was Laminated Object Manufacturing (LOM). LOM involved layer-by-layer lamination of paper material sheets, cut using a CO2 laser, each sheet representing one cross-sectional layer of the CAD model of the part. In LOM, the portion of the paper sheet which is not contained within the final part is sliced into cubes of material using a crosshatch cutting operation. A number of other processes have been developed based on sheet lamination involving other build materials and cutting strategies. Because of the construction principle, only the outer contours of the parts are cut, and the sheets can be either cut and then stacked or stacked and then cut. These processes can be further categorized based on the mechanism employed to achieve bonding between layers:

- Gluing or adhesive bonding
- Thermal bonding
- Clamping
- Ultrasonic welding

3.6 Direct Energy Deposition [7]

Directed energy deposition (DED) processes enable the creation of parts by melting material as it is being deposited. Although this basic approach can work for polymers, ceramics, and metal matrix composites, it is predominantly used for metal powders. Thus, this technology is often referred to as "metal deposition" technology.DED processes direct energy into a narrow, focused region to heat a substrate, melting the substrate and simultaneously melting material that is being deposited into the substrate's melt pool. Unlike powder bed fusion techniques DED processes are NOT used to melt a material that is pre-laid in a powder bed but are used to melt materials as they are being deposited. DED processes use a focused heat source (typically a laser or electron beam) to melt the feedstock material and build up three-dimensional objects in a manner similar to the extrusion-based processes from Chap. 6. Each pass of the DED head creates a track of solidified material, and adjacent lines of material make up layers. Complex three-dimensional geometry requires either support material or a multiaxis deposition head.

IV. THE BENEFITS OF AM

- Complexity is free
- No assembly required
- Little lead time
- Few constraints
- Less or no wastage
- Infinite shades of material

V. LIMITATIONS OF AM

- Slow build rate
- High production cost
- Considerable effort in application design and setting process parameters
- Requires post processing
- Discontinuous production process
- Limited component sixe
- Poor mechanical properties

VI. APPLICATION

- Aerospace Industry
- Armament Industry
- Automotive Industry
- Dental Industry
- Electronics Industry
- Furniture Industry
- Implants and Prosthetic Industry
- Jwellery Industry
- Special Food Industry
- Sport Industry
- Surgical Devices and Aids Industry

- Textile Industry
- Tool and Mold Making Industry
- Toys and Collectibles Industry

VII. FUTURE [8]

- Printing models in some polymer materials at CERN
- Subcontracting parts in polymer
- Subcontracting parts in metal
- Exploring ceramic materials
- Exploring the installation of an 3D metal printer
- Several collaboration agreements in 3D printing
- R&D to print pure Copper and Niobium
- Further R&D of materials
- Contact to universities and other organisations

VIII. RECENT TRENDS IN ADDITIVE MANUFACTURING TECHNOLOGY [9]

NORK Titanium has developed an innovative additive manufacturing technology based on wire feedstock as raw material and utilizing plasma arc as a heat source. The process has been developed for deposition of titanium and titanium alloys, hereunder the most common used alloy for the aerospace application, Ti6Al4V. The process leads itself to production o parts with geometries and properties of industrial interest such as structural aerospace components. Production of aerospace parts by conventional technology requires about 5 times the material amount in the final part, and individual part may have "buy to fly" value of 10 or more. Additive manufacturing can reduce the "buy to fly" ratio significantly, typically to 1.5 or better. It reduces lead time and flexibility in design as an additional benefit.

Conventional part manufacturing processes	Additive Manufacturing/ 3D Printing processes

Milled plate
• Mill annealed
• Beta annealed
	Powder based
	• Laser
	  • Powder melting
	  • Powder sintering (SLS)
	  • Powder blowing
	• Electron beam
	  • Powder melting
	  • Powder sintering (EBS)

Forgings • Forged block • Die forgings	

Extrusions	**Wire based**
	• Electron beam
	  • Electron beam free form fabric. (EBFFF)
	• Laser
	• Arc
	  • Plasma arc direct metal deposition (DMD)

Castings • Precision castings ++ • Hot Isostatic Pressing (HIP) castings	
Conventional forming	**Sheet metal based** • Sheet metal ultrasonic consolidation

IX. CONCLUSION

In this paper article the overview of Additive Manufacturing is explained with its basic introduction. The paper also focus on various methods of the Additive Manufacturing processes were explained in short which gives a prior idea about what Additive Manufacturing is. From this paper we were able to understand the need of the Additive Manufacturing and its importance for the growth of modern technology in the welfare of industrial revolution. Except the cons the pros were much more effective which gives a imparting effect for the revolution and further research in this technology. Also we were able to understand the contribution of AM in medical fields such as human implants like knee joints, bones, ball joints, skull structure. Also Am contributed in human tissue culture.

The most revolutionary aspect is the Titanium contribution in AM industry. As many researches going for using Titanium material as a raw material for Additive Manufacturing Process which gives much more effective properties of products being manufactures. Additive Manufacturing gives more scope to Research and Development in every field of manufacturing with rise of new concepts and ease methodologies with economical considerations.

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