International Journal For Technological Research In Engineering
Volume 6, Issue 8, April-2019 *ISSN (Online): 2347 - 4718*

ADVANCES IN 3D PRINTING

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ABSTRACT: The term 3D printing covers a host of processes and technologies that offer a full spectrum of capabilities for the production of parts and products in different materials. Essentially, what all of the processes and technologies have in common is the manner in which production is carried out layer by layer in an additive process which is in contrast to traditional methods of production involving subtractive methods or moulding/casting processes. Applications of 3D printing are emerging almost by the day, and, as this technology continues to penetrate more widely and deeply across industrial, maker and consumer sectors, this is only set to increase. Most reputable commentators on this technology sector agree that, as of today, we are only just beginning to see the true potential of 3D printing. 3DPI, a reliable media source for 3D printing, brings you all of the latest news, views, process developments and applications as they emerge in this exciting field. This overview article aims to provide the 3DPI audience with a reliable backgrounder on 3D printing in terms of what it is (technologies, processes and materials), its history, application areas and benefits
Keywords: 3DP 3D Printing
ABS Acrylonitrile Butadiene Styrene
AM Additive Manufacturing
CAD / CAM Computer-aided design / Computer-aided manufacturing
CAE Computer-aided engineering
DLP Digital Light Processing
DMD Direct Metal Deposition
DMLS Direct Metal Laser Sintering
EBM Electron Beam Melting
EVA Ethylene Vinyl Acetate
FDM Fused Deposition Modelling (Trademark of Stratasys)
FFF Freeform Fabrication
LENS Laser Engineering Net-Shaping (Trademark of SNL, licensed to Optomec)
LS Laser Sintering
PLA Polylactic Acid
RE Reverse Engineering
RM Rapid Manufacturing
RP Rapid Prototyping
RT Rapid Tooling
SL Stereolithography
SLA Stereolithography Apparatus (Registered Trademark of 3D Systems)
SLM Selective Laser Melting
SLS Selective Laser Sintering (Registered Trademark of 3D Systems)

I. INTRODUCTION

3D Printing is a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material. It brings a digital object (its CAD representation) into its physical form by adding layer by layer of materials.

There are several different techniques to 3D Print an object. We will go in further details later in the Guide. 3D Printing brings two fundamental innovations: the manipulation of objects in their digital format and the manufacturing of new shapes by addition of material.

Digital
+
Additive Manufacturing

Technology has affected recent human history probably more than any other field. Think of a light bulb, steam engine or, more latterly, cars and aeroplanes, not to mention the rise and rise of the world wide web. These technologies have made our lives better in many ways, opened up new avenues and possibilities, but usually it takes time, sometimes even decades, before the truly disruptive nature of the technology becomes apparent.

It is widely believed that 3D printing or additive manufacturing (AM) has the vast potential to become one of these technologies. 3D printing has now been covered across many television channels, in mainstream newspapers and across online resources. What really is this 3D printing that some have claimed will put an end to traditional manufacturing as we know it, revolutionize design and impose geopolitical, economic, social, demographic, environmental and security implications to our every day lives?

What is 3D Printing ?

The starting point for any 3D printing process is a 3D digital model, which can be created using a variety of 3D software programmes — in industry this is 3D CAD, for Makers and Consumers there are simpler, more accessible programmes available — or scanned with a 3D scanner. The model is then 'sliced' into layers, thereby converting the design into a file readable by the 3D printer. The material processed by the 3D printer is then layered according to the design and the process. As stated, there are a number of different types of 3D printing technologies, which process different materials in different ways to create the final object. Functional plastics, metals, ceramics and sand are, now, all routinely used for industrial prototyping and production applications. Research is also being conducted for 3D printing bio materials and different types of food. Generally speaking though, at the entry level of the market, materials are much more limited. Plastic is currently the only widely used material — usually ABS or PLA, but there are a growing number of alternatives, including Nylon. There is also a growing number of entry level machines that have been adapted for foodstuffs, such as sugar and chocolate.

II. WORKING OF 3D PRINTING

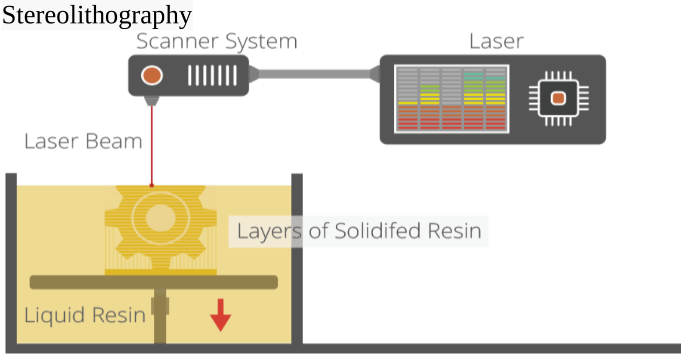
The different types of 3D printers each employ a different technology that processes different materials in different ways. It is important to understand that one of the most basic limitations of 3D printing — in terms of materials and applications — is that there is no 'one solution fits all'. For example some 3D printers process powdered materials (nylon, plastic, ceramic, metal), which utilize a light/heat source to sinter/melt/fuse layers of the powder together in the defined shape. Others process polymer resin materials and again utilize a light/laser to solidify the resin in ultra thin layers. Jetting of fine droplets is another 3D printing process, reminiscent of 2D inkjet printing, but with superior materials to ink and a binder to fix the layers. Perhaps the most common and easily recognized process is deposition, and this is the process employed by the majority of entry-level 3D printers. This process extrudes plastics, commonly PLA or ABS, in filament form through a heated extruder to form layers and create the predetermined shape.

Because parts can be printed directly, it is possible to produce very detailed and intricate objects, often with functionality built in and negating the need for assembly.

However, another important point to stress is that none of the 3D printing processes come as plug and play options as of today. There are many steps prior to pressing print and more once the part comes off the printer — these are often overlooked. Apart from the realities of designing for 3D printing, which can be demanding, file preparation and conversion can also prove time-consuming and complicated, particularly for parts that demand intricate supports during the build process. However there are continual updates and upgrades of software for these functions and the situation is improving. Furthermore, once off the printer, many parts will need to undergo finishing operations. Support removal is an obvious one for processes that demand support, but others include sanding, lacquer, paint or other types of traditional finishing touches, which all typically need to be done by hand and require skill and/or time and patience.

III. PROCESSES IN 3D PRINTING

Stereolithography



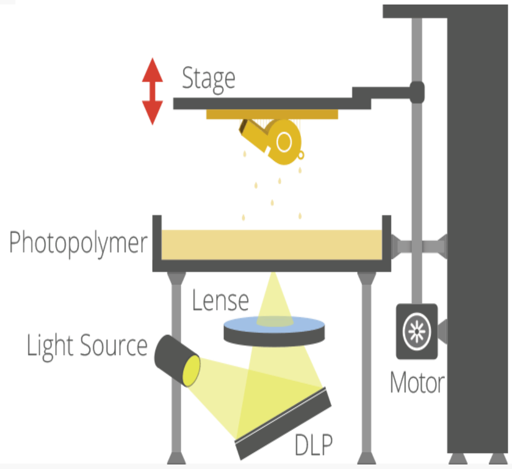
Stereolithography (SL) is widely recognized as the first 3D printing process; it was certainly the first to be commercialised. SL is a laser-based process that works with photopolymer resins, that react with the laser and cure to form a solid in a very precise way to produce very accurate parts. It is a complex process, but simply put, the photopolymer resin is held in a vat with a movable platform inside. A laser beam is directed in the X-Y axes across the surface of the resin according to the 3D data supplied to the machine (the .stl file), whereby the resin hardens precisely where the laser hits the surface. Once the layer is completed, the platform within the vat drops down by a fraction (in the Z axis) and the subsequent layer is traced out by the laser. This continues until the entire object is completed and the platform can be raised out of the vat for removal.

Because of the nature of the SL process, it requires support structures for some parts, specifically those with overhangs or undercuts. These structures need to be manually removed.

In terms of other post processing steps, many objects 3D printed using SL need to be cleaned and cured. Curing involves subjecting the part to intense light in an oven-like machine to fully harden the resin.

Stereolithography is generally accepted as being one of the most accurate 3D printing processes with excellent surface finish. However limiting factors include the post-processing steps required and the stability of the materials over time, which can become more brittle.

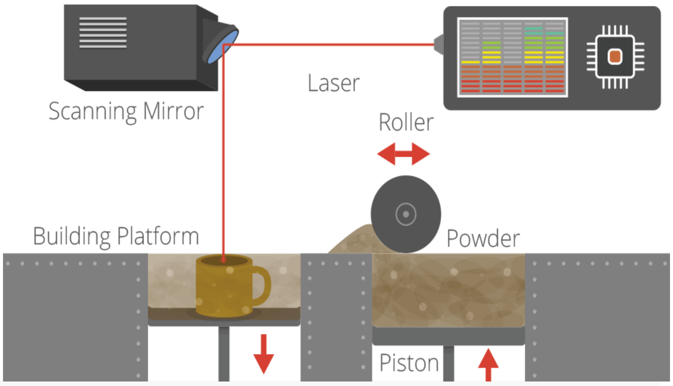
DLP



DLP — or digital light processing — is a similar process to stereolithography in that it is a 3D printing process that works with photopolymers. The major difference is the light source. DLP uses a more conventional light source, such as an arc lamp, with a liquid crystal display panel or a deformable mirror device (DMD), which is applied to the entire surface of the vat of photopolymer resin in a single pass, generally making it faster than SL.

Also like SL, DLP produces highly accurate parts with excellent resolution, but its similarities also include the same requirements for support structures and post-curing. However, one advantage of DLP over SL is that only a shallow vat of resin is required to facilitate the process, which generally results in less waste and lower running costs.

Laser Sintering / Laser Melting



Laser sintering and laser melting are interchangeable terms that refer to a laser based 3D printing process that works with powdered materials. The laser is traced across a powder bed of tightly compacted powdered material, according to the 3D data fed to the machine, in the X-Y axes. As the laser interacts with the surface of the powdered material it sinters, or fuses, the particles to each other forming a solid. As each layer is completed the powder bed drops incrementally and a roller smoothes the powder over the surface of the bed prior to the next pass of the laser for the subsequent layer to be formed and fused with the previous layer.

The build chamber is completely sealed as it is necessary to maintain a precise temperature during the process specific to the melting point of the powdered material of choice. Once finished, the entire powder bed is removed from the machine and the excess powder can be removed to leave the 'printed' parts. One of the key advantages of this process is that the powder bed serves as an in-process support structure for overhangs and undercuts, and therefore complex shapes that could not be manufactured in any other way are possible with this process.

IV. RESULT

For industrial manufacturing, one of the most cost-, time- and labour-intensive stages of the product development process is the production of the tools. For low to medium volume applications, industrial 3D printing — or additive manufacturing — can eliminate the need for tool production and, therefore, the costs, lead times and labour associated with it. This is an extremely attractive proposition, that an increasing number or manufacturers are taking advantage of. Furthermore, because of the complexity advantages stated above, products and components can be designed specifically to avoid assembly requirements with intricate geometry and complex features further eliminating the labour and costs associated with assembly processes.

