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3D Printing Technology, Types and the Applications

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ABSTRACT- Presently we are developing each day and consistently. We embrace innovation with new development and make new creations. There are heaps of new advances we embraced in our everyday existence. In this innovation one of them is 3D Printer. This is an Exploration Paper on 3D Printing in which reader is presented the Historical backdrop of 3D Printing, different types of 3D Printing, different materials utilized in 3D Printing and their Upsides, Drawbacks and Applications

Key words- 3D printer, binder, polymers, metal casting, extrusion, polycarbonate,

1.INTRODUCTION [1]

3D printing or additive manufacturing is a process of making a three-dimensional solid object of virtually any shape from a digital model. Successive layers of material are laid down in different shapes. Traditional machining techniques rely on the removal of material by methods such as cutting or drilling whereas 3D printing layers are added successively. Thus, it uses a layering technique where an object is constructed layer by layer until the complete object is manufactured. In this way 3D printing moves us away from the mass production line to a one-off customizable production. You can literally make any object from a house to a bar of chocolate, so to say.

The initial 3D printers were used in the 1980s where a pattern submerged in a liquid polymer would be traced by a computer. The traced pattern hardened into a layer, thanks to the laser, and that was how you built an object out of plastic. Since then tremendous progress has been made in additive manufacturing such that material extrusion is now used. By this method, an object is built out of matter that is pushed from a mechanical head like the way an Ink jet printer extrudes ink onto paper.

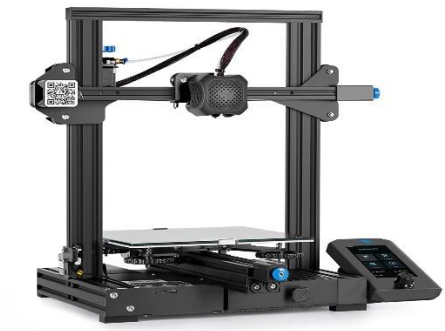

Fig. 1. 3D-Printer

Interestingly, the cost of acquiring 3D printers has been decreasing with the advancement of technology. Domestic usage of 3D printers has been on the rise with the average cost ranging from a few hundreds of dollars going up. However, one major drawback is that it requires expertise to print 3D objects. In fact, it requires a competent person to make both the digital file and the final printing. Commercial usage of 3D printers has been on the increase too in sectors such as the automotive industry and aerospace engineering. Spare parts, for example, are being made in the automotive and aero-space industry leading to improved economies of scale. 3D printing is changing how the production line in industries works which made some analysts to dub the

emergence of 3D printers as the second Industrial revolution.

3D printing has also had a tremendous usage in the field of medicine; from the field of Bionics, to Prosthetics to Digital Dentistry. Inevitably, this is positively affecting and changing every aspect of medicine. Most of the work is still in its exploratory phase but pundits predict medicine of tomorrow is going to be revolutionized by the integration of 3D printing as a tool.

2. TYPES of 3D PRINTING [2]

Varieties of 3D printing technologies have been developed with the different function. According to ASTM Standard F2792, ASTM catalogued 3D printing technologies into seven groups, including the binding jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photopolymerization. There are no debates about which machine or technology function better because each of them has its targeted applications. Nowadays, 3D printing technologies are no longer limited to prototyping usage but are increasingly also being used for making variety of products.

2.1. Binder jetting

Binder jetting is a rapid prototyping and 3D printing process in which a liquid binding agent is selectively deposited to join powder particles. The binder jetting technology uses jet chemical binder onto the spread powder to form the layer. The application of the binder jetting is would be producing the casting patterns, raw sintered products or similar large-volume products from sand. Binder jetting can print a variety of materials including metals, sands, polymers, hybrid and ceramics. Some materials like sand not required additional processing. Moreover, the process of binder jetting is simple, fast and cheap as powder particles are glued together. Lastly, binder jetting also has the ability to print very large products.

2.2. Directed energy deposition

Directed energy deposition is a more complex printing process commonly used to repair or add additional material to existing components. Directed energy deposition has the high degree control of grain structure and can produce the good quality of the object. The process of directed energy deposition is similar in principle to material extrusion, but the nozzle not fixed to a specific axis and can move in multiple directions. Furthermore, the process can be used with ceramics, polymers but is typically used with metals and metal-based hybrids, in the form of either wire or powder. The example of this technology is laser deposition and laser engineered net shaping (LENS). Laser deposition is the emerging technology and can be used to produce or repair parts measured in milli meter to meters. Laser deposition technology is gaining attraction in the tooling, transportation, aerospace, and oil and gas sectors because it can provide scalability and the diverse capabilities in the single system. Meanwhile, laser LENS can exploit thermal energy for melting during the casting and parts are accomplished subsequently.

2.3. Materials extrusion

Material extrusion-based 3D printing technology can be used to print multi-materials and multi-colour printing of plastics, food or living cells. This process has been widely used and the costs are very low. Moreover, this process can build fully functional parts of product. Fused deposition modelling (FDM) is the first example of a material extrusion system. FDM was developed in early 1990 and this method uses polymer as the main material. FDM builds parts layer-by-layer from the bottom to the top by heating and extruding thermoplastic filament.

The operations of FDM are as follows:

I. Thermoplastic heated to a semi-liquid state and deposits it in ultra-fine beads along the extrusion path.

II. Where support or buffering needed, the 3D printer deposits a removable material that acts as scaffolding. For example, FDM uses hard plastic material during the process to produce 3D bone model.

2.4. Materials jetting

According to ASTM Standards, material jetting is a 3D printing process in which drop by drop of build material are selectively deposited. In material jetting, a printhead dispenses droplets of a photosensitive material that solidifies, building a part layer-by-layer under ultraviolet (UV) light. At the same time, material jetting creates parts with a very smooth surface finish and high dimensional accuracy. Multi-material printing and a wide range of materials such as polymers, ceramics, composite, biologicals and hybrid are available in material jetting.

2.5. Powder bed fusion

The powder bed fusion process includes the electron beam melting (EBM), selective laser sintering (SLS) and selective heat sintering (SHS) printing technique. This method uses either an electron beam or laser to melt or fuse the material powder together. The example of the materials used in this process are metals, ceramics, polymers, composite and hybrid. Selective laser sintering (SLS) are the main example of Powder based 3D printing technology. Carl Deckard developed SLS technology in 1987. SLS is 3D printing technology that's functionally in fast speed, has high accuracy, and varies surface finish. Selective laser sintering can used to create metal, plastic, and ceramic objects. SLS used a high Power laser to sinter polymer powders to generate a 3D product. Meanwhile, SHS technology is another part of 3D Printing technology uses a head thermal print in the process to melt the thermoplastic powder to create 3D printed object. Lastly electron beam melting enhances an energy source to heat up the material.

3. MATERIALS USED in 3D-PRINTING TECHNOLOGY [3]

In the 3D-printing needs high quality materials for making high quality devices. 3D-printers technology is capable to making high quality devices by using of many types of material like metals ceramics and their combination forms.

3.1 Plastic

This most common material used for 3D-printing. This is most diverse material for 3D Printed toys and household products. This available in transparent and also in colours like green red yellow etc. Plastic is light in weight also high durability its surface smoothness very well. The types of plastic used in this process are usually made from one of the following materials

1) Polyastic acid (PLA)

This is eco-friendly material. PLA made up of from sugar cone and corn starch therefore biodegradable. This is available in two forms soft and hard. Plastics are made from polyastic acid so it is used in industries hard polyastic acid are stronger and therefore they used for making ideal products.

2) Acrylo nitrille butadiene styrene (ABS)

ABS is best option of home based 3D-printiners. It is valued for strength and safety. ABS is available in various colors. This makes the material suitable for products like stickers and toys. ABS also used to make jewelry and vases.

3) Polyvinyl alcohol plastic (PVA)

It is used in low end home printers. It is low cost. This material used for temporary used items.

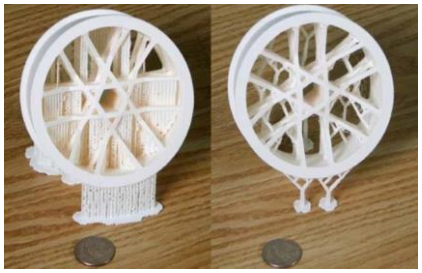

Fig. 2. PVA

4) Polycarbonate (PC)

PC is only used on this printer which feater nozzle is designed and operates on high temperature. This is less frequently used.

3.2 Powders

Today's 3D-printers use powdered materials to construct objects or products. This powder is melted inside the printer and distributed in layers unit the preferred thickness and pattern are made. There are many powders used in printers but most common are:

1) Polyamide (Nylon)

Nylon strength and flexibility is very therefore it is used for joining pieces and interlocking parts in 3D models.

2) Alumide

This powder makes the strongest products. This is mainly used for makes industrial models and prototypes.

3.3 Metals [2]

Metal 3D printing technology gain many attentions in aerospace, automobile, medical application and manufacturing industry because the advantages existing by this process. The materials of metal have the excellent physical properties and this material can be used to complex manufacturer from printing human organs to aerospace parts. The examples of this materials are aluminium alloys, cobalt-based alloys, nickel-based alloys, stainless steels, and titanium alloys. Cobalt-based alloy is suitable to use in the 3D printed dental application. This is because, it has high specific stiffness, resilience, high recovery capacity, elongation and heat-treated conditions. Furthermore, 3D printing technology has capability to produce aerospace parts by using nickel base alloys. 3D-printed object produces using nickel base alloys can be used in dangerous environments. This is because, it has high corrosion resistance and the heat temperature can resistant up to 1200 °C. Lastly, 3D printing technology also can print out the object by using titanium alloys. Titanium alloy with have very exclusive properties, such as ductility, good corrosion, oxidation resistance and low density. It is used in high stresses and high operating temperatures and high stresses, for example in aerospace components and biomedical industry.

3.4 Smart Materials [2]

Smart materials are defined as this material have the potential to alter the geometry and shape of object, influence by external condition such as heat and water. The example of 3D printed object produces by using smart materials are self-evolving structure and soft robotics system. Smart materials also can be classified as 4D printing materials. The examples of group smart materials are shape memory alloys and shape memory polymers. Some shape-memory alloys like nickel-titanium can be used in biomedical implants microelectromechanical devices application. In the production of 3D printed products by using nickel-titanium, transformation temperatures, reproducibility of microstructure and density is the important issue. Meanwhile, Shape memory polymer (SMP) is a kind of functional material that responds to a stimulus like light, electricity heat, some types of chemical and so on. By using 3D printing technology, the complicated shape of shape memory polymer could be easily and conveniently to produce. The quality evaluation of this material is performed based on the dimensional accuracy, surface roughness and part density.

4.ADVANTAGES [4]

1. Time-to-Market: 3D printing allows ideas to develop faster. Being able to print a concept on the same day it was designed shrinks a development process from what might have been months to a number of days, helping companies stay one step ahead of the other.

2. Save Money: Prototyping injection mould tools and production runs are expensive investments. The 3D printing process allows the creation of parts and/or tools through additive manufacturing at rates much lower than traditional machining.

3. Mitigate Risk: Being able to verify a design before investing in an expensive moulding tool is worth its weight in 3D printed plastic, and then some. It is far cheaper to 3D print a test prototype than to redesign or alter an existing mould.

4. Feedback: With a prototype, you can test the market by unveiling it at a tradeshow, showing it to buyers or raising capital by pre-selling on Indigo or Kick-starter. Getting buyer's response to the product before it actually goes into production is a valuable way to verify the product has market potential. 5. Get the Feel: One thing you can't get a picture or virtual prototype on the computer screen is the way something feels in your hand. If you want to ensure the ergonomics and fit of a product are just right, you must actually hold it, use it and test it.

5.DISADVANTAGES [4]

1. Intellectual property issues: The ease with which replicas can be created using 3D technology raises issues over intellectual property rights. The availability of blueprints online free of cost may change with for-profit organizations wanting to generate profits from this new technology.

2. Limitations of size: 3D printing technology is currently limited by size constraints. Very large objects are still not feasible when built using 3D printers.

3. Limitations of raw material: At present, 3D printers can work with approximately 100 different raw materials. This is insignificant when compared with the enormous range of raw materials used in traditional manufacturing. More research is required to devise methods to enable 3D printed products to be more durable and robust.

4. Cost of printers: The cost of buying a 3D printer still does not make its purchase by the average householder feasible. Also, different 3D printers are required in order to print different types of objects. Also, printers that can manufacture in colour are costlier than those that print monochrome objects.

5. Fewer Manufacturing Jobs: As with all new technologies, manufacturing jobs will decrease. This disadvantage can have a large impact to the economies of third world countries especially China, that depend on a large number of low skill jobs.

6. APPLICATIONS [4]

1. The Aeronautics and Aerospace industries push the limits of geometric design complexity; the evolution and consistent improvement of the vehicles demand that the parts become more efficient and accurate even as the size of the vessels become smaller. This is why design optimization is essential to the progression of the industry. Optimizing a design can be challenging when using traditional manufacturing processes, and that's why most engineers have turned to 3D Printing.

2. To support new product development for the medical and dental industries, the technologies are also utilized to make patterns for the downstream metal casting of dental crowns and in the manufacture of tools over which plastic is being vacuum formed to make dental aligners.

3. For the jewellery sector, 3D printing has proved to be particularly disruptive. There is a great deal of interest and uptake based on how 3D printing can, and will, contribute to the further development of this industry. From new design freedoms enabled by 3D CAD and 3D printing, through improving

traditional processes for jewellery production all the way to direct 3D printed production eliminating many of the traditional steps.

4. Architectural models have long been a staple application of 3D printing processes, for producing accurate demonstration models of an architect's vision. 3D printing offers a relatively fast, easy and economically viable method of producing detailed models directly from 3D CAD, BIM or other digital data that architects use.

5. As 3D printing processes have improved in terms of resolution and more flexible materials, one industry, renowned for experimentation and outrageous statements, has come to the fore. We are of course talking about fashion.3D printed accessories including shoes, headpieces, hats, and bags have all made their way on to global catwalks

CONCLUSION

Presentation part is about the concise history of 3D printing, in the following area we have portrayed the 3D-printing and the processes utilized in 3D-Printing, different 3D Printer materials and their properties. In the next section, we have featured the primary benefits and restrictions of 3D Printing innovation. Next section highlights the Applications of three-dimensional Printing Technology. One can presume that the 3D Printing innovation's significance and social impact has increased consistently and impacted the human's life, their economy and current culture. 3D Printing innovation could alter the world. AS displayed, 3D Printing can have an application in practically each of the each of the classifications of human necessities. 3D Printing have enormous scope modern region where we can develop new things. New 3D printing innovations set aside less effort for making products. These items making exceptionally exact item quicker than expected and less expense with next to no big equipment and machines, so is plays vital job in our modern areas. This research paper accommodating for studies on future extent of 3D printing and furthermore, new innovations and their applications. In worldwide, big market is accessible for this sort of innovation.

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