3D Printing in Advanced Fabrication Technique - A Review

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Abstract: *3-D printing or Additive Manufacturing (AM) is an advanced fabrication technique that uses computerized three-dimensional design information to construct components by accumulating textures chronologically. Due to their achievement in constructing complex and difficult design concepts, rapid prototype testing, and reduced-volume or one-of-a-kind manufacturing throughout many industry sectors, AM methodologies are becoming much more popular comparison to traditional initiatives. This paper provides the overview of 3D or 3-Dimensional Printing in depth.*

Keywords:*3D Printing, stereolithography, DLP, FDM,*

I.INTRODUCTION

3D printing, also known as additive manufacturing, is a method of creating a three dimensional object layer-by-layer using a computer created design. 3D printing is an additive process whereby layers of material are built up to create a 3D part. This is the opposite of subtractive manufacturing processes, where a final design is cut from a larger block of material. As a result, 3D printing creates less material wastage.This is also perfectly suited to the creation of complex, bespoke items, making it ideal for rapid prototyping.

Although patient-specific three-dimensional (3D) visualization already provides good insight into the complex anatomy of a patient, in some cases, this is not sufficient, and more advanced techniques are required, such as the use of virtual and augmented reality but also 3D printing [1]. On the one side, 3D printing allows the surgeon to hold and examine the structures printed in a tactile way, sometimes providing a better insight into the 3D anatomy. On the other side, a real-life-size 3D printed anatomy allows to test procedures by introducing the actual implants, wires, and instruments into the printed anatomy.

The basis for 3D printing was laid in the 1980s. Medical applications arose from this new technology early on in the development, mainly in maxillofacial surgery. Although one paper already reported on the use of stereolithography (STL) printing of mitral valves basedon ultrasound (US) imaging in patients as early as 2000, the real interest for 3D printing in cardiovascular applications started some years later.Manufacturers, engineers, designers, educators, medics, and hobbyists alike use the technology for a huge range of applications.

Figure 1 3D Printing

The 3D printing process involves building up layer upon layer of molten plastic to create an object. As each layer sets, the next layer is printed on top and the object is built up. To make a 3D print, a digital file is needed that tells the 3D printer where to print the material. The most common file format for this is the G-code files. This file essentially contains ‘coordinates’ to guide the printer’s movements, both horizontally and vertically – also known as the X, Y, and Z axes. 3D printers can print these layers at different thicknesses, known as layer height. A bit like pixels on a screen, more layers in a print will give a higher ‘resolution’. This will give a better-looking result, but take longer to print.

This adding up of layers gives 3D printing its alternative name – 'additive manufacturing'.Additive manufacturing is the opposite of 'subtractive' processes where material is removed (or subtracted) from a larger block to create the final object, for example CNC machining.Plastics are a versatile type of material, and as a result there are many ways of manufacturing with it. 3D printing is no exception.The most widely used technologies are FFF (fused filament fabrication) 3D printing, SLA (stereolithography), and SLS (selective laser sintering).

Figure 2 Additive Manufacturing

Plastic polymers are the most common material used in 3D printing. Using other materials is possible. For example, there are dedicated metal 3D printers, but these are niche compared to polymer printers. And super-sized machines based on 3D printing technology are starting to be developed for construction materials like concrete. Mainstream 3D printer types such as FFF and SLS can print blends of polymers and other materials (such as metal, glass, or wood). These are known as composites and offer some of the properties of the blended material. In the context of FFF 3D printing, you may see the terms '3D printing material' and '3D printing filament' used interchangeably. This is because the raw material comes on spools of thin filament.

A.3-Dimensional Printers

Adoption of 3D printing has reached critical mass as those who have yet to integrate additive manufacturing somewhere in their supply chain are now part of an ever-shrinking minority. Where 3D printing was only suitable for prototyping and one-off manufacturing in the early stages, it is now rapidly transforming into a production technology. Most of the current demand for 3D printing is industrial in nature. 3D printing encompasses many forms of technologies and materials as 3D printing is being used in almost all industries we could think of. It's important to see it as a cluster of diverse industries with a myriad of different applications.

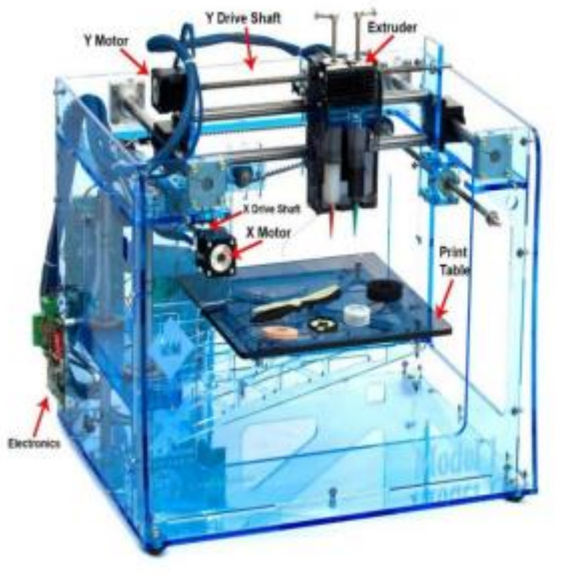

Figure 3 Three-dimensional printer

Companies have used 3D printers in their design process to create prototypes since the late seventies. Using 3D printers for these purposes is called rapid prototyping.In short: it's fast and relatively cheap. From idea, to 3D model to holding a prototype in your hands is a matter of days instead of weeks. Iterations are easier and cheaper to make and we don't need expensive molds or tools. Besides rapid prototyping, 3D printing is also used for rapid manufacturing. Rapid

manufacturing is a new method of manufacturing where businesses use 3D printers for short run / small batch custom manufacturing.
Car manufacturers have been utilizing 3D printing for a long time. Automotive companies are printing spare parts, tools, jigs and fixtures but also end-use parts. 3D printing has enabled on-demand manufacturing which has lead to lower stock levels and has shortened design and production cycles.
Automotive enthusiasts all over the world are using 3D printed parts to restore old cars. One such example is when Australian engineers printed parts to bring a Delage Type-C back to life. In doing so, they had to print parts that were out of production for decades.

II.LITERATURE REVIEW

(Tuncay & Ooijen, 2019) [1]Novel techniques such as 3D printing are investigated by different research groups for specific clinical questions, and they all explore the technical requirements and shortcomings of the technique. While the topic is current, the actual clinical benefit of 3D printing yet re- mains to be proven. However, technical developments are ongoing and the implementation of 3D printing for cardiac valve treatment is one of the more promising clinical application areas. However, the application of 3D printing in cardiac valve replacement introduces additional requirements on the used printing material and the nature of the printed structure. This review shows that, with the advent of new flexible and transparent materials and higher accuracy of 3D printers, an accurate representation of the cardiac anatomy can be obtained. This 3D printed representation of the anatomy can already be used in a variety of applications, especially for training purposes.

(Ruschi et al., 2019) [2] The performed review allowed for a joint perception of how AM's environmental performance has been measured, how it varies between different industries and within same sectors, and what role LCA plays in assuring environmental attractiveness of what is increasingly perceived as a disruptive technology (Kothman and Faber, 2016). In fact, perhaps the most important insight from this investigation is how LCA seemed necessary as an additional lens to select an optimized manufacturing approach from the environmental point of view, before applying AM in a large scale within any industry. To the best of the authors' knowledge, there has been no documented review of AM's life cycle impact yet.

(Stramiello et al., 2020) [3] 3D printing has emerged as a viable adjunct for surgical planning and implantable interventions in pediatric tracheal obstruction. With continued innovation of printable materials available and increased access to this technology, there is great potential for 3D printing to have an increasingly prominent role in the management of this disease. 3D printing provides the novelty of creating patient-centric specifications not only through space, but possibly also through time with bioresorbable materials, making its application to an ever-growing pediatric population intuitive.

(Cacciamani et al., 2019) [4] The present systematic review methodically analyzed for the first time the impact of 3D-printing technology in theurological field. Patient counseling, and surgical training and planning seem to take advantage of these new technological opportunities. Three-dimensional–printed anatomical models for surgical planning have a wide array of applications in the hospital inpatient setting. Coupled with the benefits, they have fuelled growing clinical interest in surgical applications, as indicated by the number of published papers addressing the use of 3D printing in preparation of surgical cases. The benefits of 3D-printing result from the clarity provided by patient-specific anatomical models that illustrate structure and pathology, which may be vague, obscure, or hidden in X-ray, CT, magnetic resonance imaging (MRI), or ultrasound images.

(Jiang et al., 2019) [5]The current literature regarding the use of 3D printed models for the purpose of enhancing preoperative planning in orthopaedicsurgery suggests that there is a tangible benefit to its implementation. Surgeons and patients alike reported great benefit in its use as an educational tool. The technology also offers objective improvements to the surgical procedure itself. While these reported benefits may be sufficient for centres to trial the technology, further investigation into the development of a validated protocol is required before the technology becomes a routine part of planning complex orthopaedic procedures.

(Buswell et al., 2018) [6]Through a reflective critique of the literature combined with new insights from ongoing work in the UK, France, Denmark and the USA, this paper attempts to draw together the technological issues that effect extrusion-based 3DCP and disentangles the critical interdependencies between the materials, manufacturing and design processes. Solutions to some of these issues have been presented and research areas have been identified to establish the current state-of-the-art. The commercial success of 3DCP lies in the robustness of the design and manufacturing process, the ability for architects and engineers to design certifiable components and building elements and in the value of the manufactured components.

(Ford & Minshall, 2018) [7]The emergence of additive manufacturing and 3D printing technologies is introducing industrial skills deficits and opportunities for new teaching practices in a range of subjects and educational settings. In response, research investigating these practices is emerging across a wide range of education disciplines, but often without reference to studies in other disciplines. Responding to this problem, this article synthesizes these dispersed bodies of research to provide a state-of-the-art literature review of where and how 3D printing is being used in the education system. Through investigating the application of 3D printing in schools, universities, libraries and special education settings, six use categories are identified and described: (1) to teach students about 3D printing; (2) to teach educators about 3D printing; (3) as a support technology during teaching; (4) to produce artefacts that aid learning; (5) to create assistive technologies; and (6) to support outreach activities. Although evidence can be found of 3D printing-based teaching practices in each of these six categories, implementation remains immature, and recommendations are made for future research and education policy.

(Kumar & Kumar, 2020) [8] 3D printing is also known as additive manufacturing is one of the most accurate fabrication techniques which covers potential applications in almost all industrial/commercial/households fields. A wide variety of materials are reported in last 2–3 decades for fabrication of functional/non-functional structures, but scope is limited to few studies in the field of food printing. This paper is a state of art review for different 3D printing process, processing techniques and materials available for food printing. In addition, review has been made about nourishment/food materials that can be 3D printed with redid flavour, shape and altered substance and constituents can be printed. This paper also concludes future aspects of 3D food printing.

(Pranzo, 2018) [9] One of the most widespread additive manufacturing (AM) technologies is fused deposition modelling (FDM), also known as fused filament fabrication (FFF) or extrusion-based AM. The main reasons for its success are low costs, very simple machine structure, and a wide variety of available materials. However, one of the main limitations of the process is its accuracy and finishing. In spite of this, FDM is finding more and more applications, including in the world of micro-components. In this world, one of the most interesting topics is represented by microfluidic reactors for chemical and biomedical applications. The present review focusses on this research topic from a process point of view, describing at first the platforms and materials and then deepening the most relevant applications

III.TECHNOLOGIES USED IN 3D PRINTING

Stereolithography – This makes use of a liquid plastic as the source material and this liquid plastic is transformed into a 3D object layer by layer1. Liquid resin is placed in a vat that has a transparent bottom. A UV (UltraViolet) laser traces a pattern on the liquid resin from the bottom of the vat to cure and solidify a layer of the resin. The solidified structure is progressively dragged up by a lifting platform while the laser forms a different pattern for each layer to create the desired shape of the 3D object.

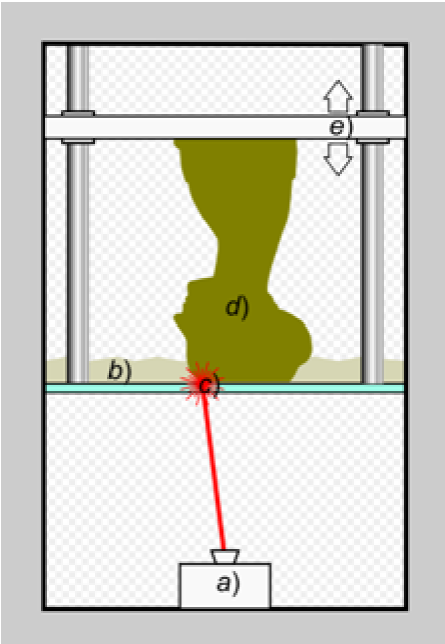

Figure 3Stereolithography Technique for 3D Printing

Digital Light Processing (DLP) **-** 3D printing DLP technology is very similar to Stereolithography but differs in that it uses a different light source and makes use of a liquid crystal display panel. This technology makes use of more conventional light sources and the light is controlled using micro mirrors to control the light incident on the surface of the object being printed. The liquid crystal display panel works as a photomask. This mechanism allows for a large amount of light to be projected onto the surface to be cured, thereby allowing the resin to harden quickly.

Fused Deposition Modeling (FDM) - With this technology, objects can be built with production-grade thermoplastics. Objects are built by heating a thermoplastic filament to its melting point and extruding the thermoplastic layer by layer. Special techniques can be used to create complex structures. For example, the printer can extrude a second material that will serve as support material for the object being formed during the printing process. This support material can later be removed or dissolved.

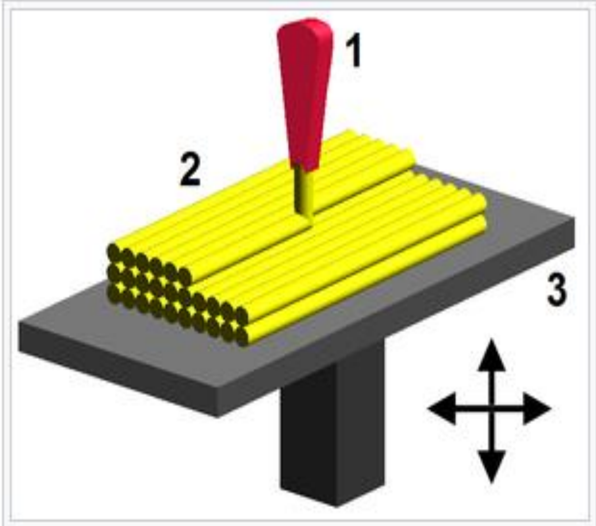

Figure 4 Fused Deposit Modelling

Selective Laser Sintering (SLS) - SLS has some similarities with Stereolithography. However, SLS makes use of powdered material that is placed in a vat. For each layer, a layer of powdered material is placed on top of the previous layer using a roller and then the powdered material is laser sintered according to a certain pattern for building up the object to be created. Interestingly, the portion of the powdered material that is not sintered can be used to provide the support structure and this material can be removed after the object is formed for re-use.

IV.PROCEDURE OF 3D PRINTING

3D printing has become synonymous with manufacturing. Research, in fact, indicates it's the most popular prototyping method used by manufacturing companies. Using a 3D printer, manufacturing companies can quickly build prototypes for testing and quality assurance purposes. While there are many different types of 3D printing processes, though, nearly all of them consist of three basic steps.

Step 1) Modeling

Before a manufacturing company can build an object with a 3D printer, it must design the model using computer software. Modeling is the first step of 3D printing. Manufacturing companies typically design object models using a special type of computer software known as a computer-aided design (CAD) package. Once complete, the object model is saved as a stereolithography (STL) or an additive manufacturing file (AMF) format.

During the modeling step, manufacturing companies will check the model file for errors. Most CAD packages are able to detect errors that, if ignored, could cause defects in the printed object. Common errors found in model files include holes, self-intersections, manifold errors and faces.

Step 2) Printing

The second step of 3D printing involves printing, or building, the object. Assuming there are no errors in the STL or AMF file, the manufacturing company can upload it to the 3D printer. The 3D printer will use the instructions in the respective file to dictate where and how the material is deposited. Most 3D printers build objects by depositing layers of material onto a bed. The 3D printer will build the bottom layer first, after which it will build the next-highest layer. 3D printers may use different materials to build objects, though thermoplastic is the most common material used for this process. Thermoplastic pellets or beads are extruded out of the printer head, at which point they fall onto the bed where they form the printed object.

Step 3) Finishing

The third and final step of 3D printing is finishing. As the name suggests, finishing involves making the final touches on the printed object. Solvents, for example, may be added to the printed object to eliminate any superficial imperfections while also creating a smoother surface finish. Alternatively, if supports were used to hold the object during printing, they'll have to be removed during this third and final step.

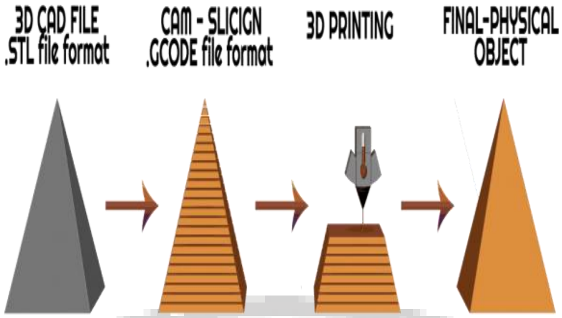

Figure 5 Procedure of 3D Printing

The printing time depends on a number of factors, including the size of the part and the settings used for printing. The quality of the finished part is also important when determining printing time as higher quality items take longer to produce. 3D printing can take anything from a few minutes to several hours or days - speed, resolution and the volume of material are all important factors here.

V.CONCLUSION

As 3D printing technology continues to improve it could democratise the manufacture of goods. With printers becoming faster, they will be able to work on larger scale production projects, while lowering the cost of 3D printing will help its use spread outside of industrial uses and into homes, schools and other settings. This paper covered the overview of 3D printing, the techniques used in this printing, the procedure of 3D Printing. The role of investigators in determining the importance of 3D Printing in different sectors like in health sector, manufacturing, automotive industry and many more.

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