3d Printing Technologies and Its Application in Engineering

Aliu, O. H. and Akingbade, L. O.

Department of Computer Engineering, The Federal Polytechnic, Ilaro. Ogun State

Olaniyi.aliu@federalpolyilaro.edu.ng and luisa.akingbade@federalpolyilaro.edu.ng

ABSTRACT

3D printing also called digital fabrication technology can create three dimensions of physical objects from a geometrical representation by successfully adding the needed materials. It is one of the fast unfolding technology that is generally used all around the globe and has brought awareness globally mostly in the engineering field. 3D printing technologies have various challenges such as low dimension accuracy, size of distribution, and little options of materials, build failure, customization of fit and design among others. This paper is aimed at spreading the awareness of 3D printing technologies in the area of engineering and the benefit of using it especially in prototyping of your design. 3D printing technologies have been of great benefit to the industries with its ability to lower costs, reduce waste with addictive manufacturing, improve lives and create tangible design and product testing with better quality.

Keywords: 3D printing, addictive manufacturing, 3D printing technologies, 3DP in Engineering.

1.0 Introduction

3D printing is capable of creating a physical object from geometrical representation by adding of required materials. It has evolved greatly in recent years. It was first brought into public in 1980 by Charles Hull (Hull, 1986).

In the area of engineering, 3d printing will focus on printing a prototype of your initial design utilizing generic materials, which saves money and time over producing an actual prototype. It entails the use of CAD modeling to generate 3D objects using a layer-by-layer process of combining materials. The use of 3D printing technology will help increase manufacturing speed while lowering costs. It permits production without the use of tools, assembly lines, or human labor. 3D printing allows you to create components, tools, and appliances in a range of materials from the comfort of your own home or business. You can make, change, or download a 3D digital model of an object using a computer. Utilize 3D printers to create cost-effective custom, better, and design parts that could not previously be made. This paper provides general knowledge of how 3D printing operates and why it should be mostly deployed for use in engineering field.

2.0 Literature Review

3D printing has emerged as one of the most transformative discoveries in human history, affecting every aspect of life. The influence of 3D printing technology on supply chains, as well as the fundamental challenges with 3D printing technology and the prospects for changing manufacturing and supply chains, were examined (Lukas, 2017). The usage of 3D printing technology, as well as the materials used in the manufacturing company and its applications, were highlighted. It may print an object directly from a computer-aided design (CAD) model, layer by layer deposition of material (Shahrubudin et al., 2019). The viability of 3D printed construction in remote environment was discussed. When compared to traditional construction, the use of 3D construction, which is an addictive, layer-by-layer construction process, has the ability to cut material consumption, optimize design, reduce cost, and reduce construction time. The viability of 3D printed construction was suggested in areas such as defining 3D printing standards, automating additional construction processes, performing both environmental impact and cost life cycle analyses, and printing full scale structures and components with locally sourced materials in an uncontrolled environment. (Steven et al., 2021).

3.0 3D Printing Methodology

3D Printing being a fast emerging technology with high potential to make a great change in the society by offering fast and reliable fabrication of products. The common methodology in play is discussed such as

- SLA (stereolithography)
- Fused deposition modeling (FDM)
- Material jetting and
- Selective laser sintering (SLS).

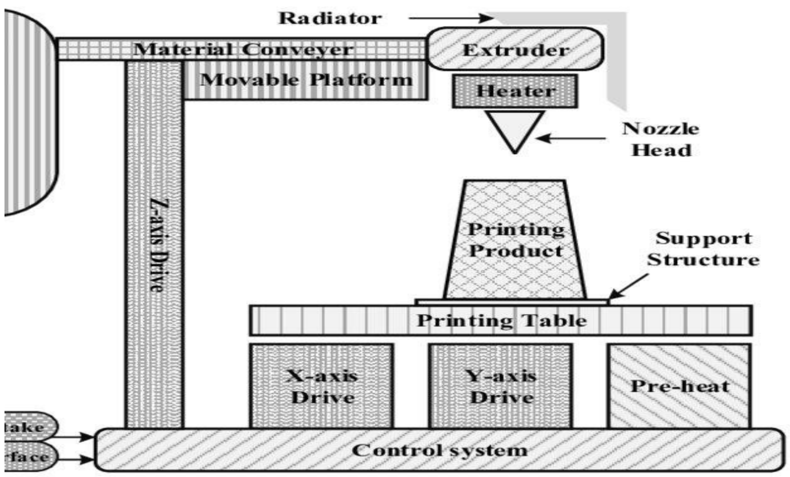

Figure 1 3D Printer Schematic Diagram

Source: (Peng, 2016)

3.1 Material Jetting

It is a 3DP process where the materials for the construction are carefully placed one by one. A print head pour out droplets of a photosensitive material that become solid, forming a part layer by layer under ultra violet (UV) light (Silbernagel, 2019).It also produces products with a smooth surface finish and a high degree of dimensional accuracy. Materials such as composite, polymers, ceramics, biological and hybrid are accessible in material jetting. It exhibit a necessary pressure to force droplets of liquid out of the nozzle (Liu et al, 2017).

3.2 Selective Laser Sintering (SLS)

Powder bed fusion is the most prevalent form. It makes use of laser light to super melt or fuse the powder materials and form a 3D objects in place of gluing the layers with a liquid binder (Singh & Raghav, 2018). The powder is dispersed in the first layer adequately on the plate with a roller design for it. After that, the powder is heated below meeting point using a laser beam, the powder particles are fused together to form a layer with the expertise of the controlling computer software. Post-processing is used to delete unused content.

3.3 Fused Deposition Modeling (FDM)

It was created in the early 1990s, The approach makes use of polymer as a primary component (Stansbury, & Idacavage, 2016). By heating and removing the thermoplastic filament, it is built layer by layer from the bottom to the top. It operation includes:

I. The thermoplastic drop ultra tiny beads through the extraction channel after heating to a semi-liquid state..
II. The 3D printer drops a scaffolding look alike removable material when carrying or buffering is needed.

FDM enable the creation of complex objects using a multi-nozzle printing technique with high precision and different ingredients (Goxanes et al, 2014).

3.4 Stereolithography (SLA)

SLA is a type of VAT photo polymerization, VAT photopolymerization in other to make its layer, it uses a VAT liquid photopolymer resin. SLA provides high level of accuracy and resolution, versatility and great efficiency. It's a superior type of 3D process technologies.It is widely used in tissue engineering, tissue scaffolding, and the production of implementable devices.

4.0 3D Process

It works by combining two-dimensional layers of material to create three-dimensional items from a digital 3D model that has been turned into G-code using a slicer tool. The step by step process is further discuss below using figure 2.

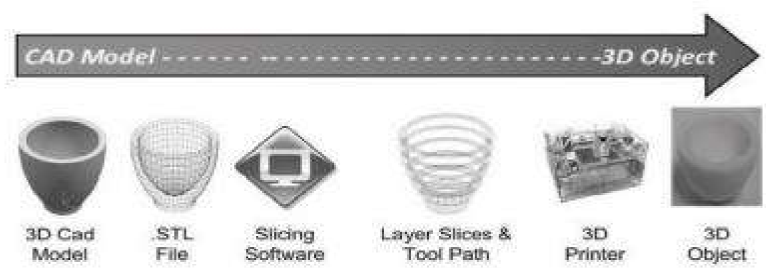

Figure 2 CAD Model source: (Campbell et al, 2011)

4.1 Computer Aided Design (CAD)

It's a digital model of 3D process. It's the first step in 3D process. There are several design consideration to look at when designing for 3DP and they generally focused on feature geometry restrictions and technology-specific support requirements. There are various professional CAD programs that work perfectly in 3DP.

4.2 STL files conversion and file manipulation

The CAD model is converted into an STL file at this step. STL describes an object's surfaces using triangles (polygons). Things to put into consideration include polygon count, physical size, and water tightness when converting a model to an STL file.

4.3 STL file, slicer program and G-code

Once a STL file is generated, It has been placed in a slicer program. The STL file is converted to G-code by the slicer application. G code is a programming language for numerical control. It is mostly used to drive automated machine tools in 3D printers. The designer can personalize the slicer program.

4.4 3D Printing

The printer is loaded with print material. The raw materials used in 3DP have a finite shelf life and must be handled with care. Once the printing has begun, most 3DP machines doesn't need monitoring. The only common issue is when the materials finish or an error in the software. The print is removed and sometime it requires a highly technical skill to extract when the print is still encased in build material or mounted to the build plate.

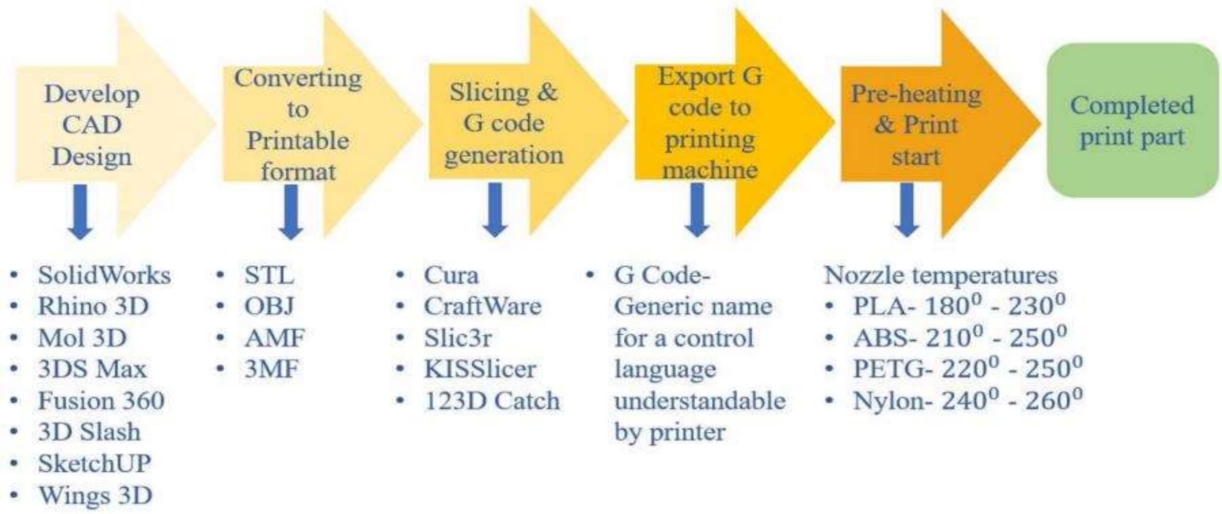

Fig. 3 3D Printing Flow chart

Source: (Wickramasinghe et al, 2020)

4.5 Material Used

There are different materials that can be used. 3D printing requires materials of remarkable performance which meets the requirement to build a quality devices. Here are some of the commonly used materials in 3d printing.

4.5.1 Metals

Metal materials offer the best physical qualities and can be used for aircraft components. Mostly Aluminum alloys and stainless steel are examples of materials. 3D printing produce using metals can be used in dangerous environment due to its high operating temperature and high stress e.g. aerospace components and production industry.

4.5.2 Polymers and Ceramics

3D printing is mostly used in production of polymers components for prototyping and functional structures with difficult geometric. 3D printing may be done with ceramics and concrete without large pores or blisters. Ceramics is strong, fire resistant and durable. Most common examples are aluminium and bio active glass.

4.5.3 Composite

They are low weight and have high performance in industries. Example of composite materials are glass fibers, re-informed polymer composite and carbon fibers RPC .

4.5.4 Smart Materials

Soft robotics system are printed by 3D printing technology. They fall into the category of 4D printing materials. instances are nickel-titanium and alloys. They can also be used in electromechanical devices.

4.6 Application of 3D printing Technology in Engineering

3D printing technologies are implemented in every aspect of the society. Its application in engineering will give a diverse problem solving approach to design implementations.

4.6.1 Automotive

In automotive industry, 3DP technology is used for Prototypes and engine parts creation. The 3DP technique can assist reduce material waste and usage, cost and time and allows testing of new design in a very fast time (Maghnani, 2015).

4.6.2 Construction

It may be used to generate construction components or to print entire buildings. With 3DP technology, industries may design and produce visuals of buildings in a timely and cost-effective manner, avoiding delays and assisting in the detection of problems.

4.6.3 Electronics

They are utilized in structural electronics devices such as active electronic materials, electrodes, and devices, as well as adaptive design by embedding conductors in 3D printing devices. Most common examples include transistors, amplifier and diode .

5.0 Conclusion and Recommendation

3D printing opens up new possibilities and is gradually establishing itself as a valuable tool for improving a wide variety of technical output. It has the ability to lower costs while raising earnings. Experts anticipate that this technology will continue to advance at a rapid pace and will play a significant role in future engineering productions.

The most frequent perception of 3D printing is that it is mostly used to create final things out of plastic, rubber, and soft materials. 3DP works with a wide range of materials, including metals and smart materials, to increase engineering output. Nowadays, 3DP technologies are utilized for more than just prototyping; they are increasingly being employed to create a wide range of products.

To get widespread acceptance, 3D printing in the engineering profession requires greater investment, training, and process maturity. People's perceptions about 3D printing and the technology's availability in engineering must be bridged.

References

Campbell, T., Williams, C., Ivanova, O. and Garrett, B. "3D Printing Technologies, Potential, and Implications of Additive Manufacturing*"* Washington, DC: Atlantic Council of United States, 2011

Hull, C.W., (1986). Apparatus for production of three-dimensional objects by stereolithography. In.: Google Patents

Maghnani, R. (2015). "An Exploratory Study: The impact of Additive Manufacturing on the Automobile Industry," International Journal of Current Engineering and Technology, Vol. 5, No.5, pp. 1-4.

Peng, Tao. (2016). Analysis of Energy Utilization in 3D Printing Processes. Procedia CIRP. 40. 62-67. 10.1016/j.procir.2016.01.055.

Silbernagel, C. (2018) "Additive Manufacturing 101-4: What is material jetting?," Canada Makers. [Online]. Available: http://canadamakes.ca/what-is-material-jetting/. [Accessed 2021].

Singh, P., & Raghav, P. (2018). "3D Food Printing: A Revolution in Food Technology," Acta Scientific Nutritional Health, Vol. 2, No.2, pp. 1-2.

Stansbury, J. W., & Idacavage, M. J. (2016). "3D Printing with polymers: Challenges among expanding options and opportunities," Dental Materials, Volume 32, pp. 54-64.

Wickramasinghe, S., Do, T., & Tran, P. (2020). FDM-Based 3D Printing of Polymer and Associated Composite: A Review on Mechanical Properties, Defects and T