

ADDITIVE MANUFACTURING TECHNOLOGY FOR COMPONENTS PRODUCTION IN NIGERIA: BENEFITS, CHALLENGES, AND WAY FORWARD

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ABSTRACT

The recent advancement of modern manufacturing technologies is gradually disrupting scale and distribution in the manufacturing and production industry. Additive manufacturing (AM), also referred to as 3D printing, is one such advanced manufacturing technology with the potentials of contributing significantly to both environmental and industrial sustainability. As global perspectives shift towards manufacturing and production processes that help to promote environmental sustainability, 3D printing comes in handy for manufacturers as a useful tool that can be utilized in promoting sustainability both at the environmental and industrial scale. This paper discusses the general status of AM as a novel technology in manufacturing industries, and the rate of adoption of this technology in the manufacturing and production industries in Nigeria. It contends that AM is a beneficial tool that can be leveraged upon by manufacturers to promote environmental sustainability as well as to modify manufacturing processes for enhanced production of components. The paper further highlighted certain challenges that might hinder manufacturers in the country from adopting AM as a manufacturing tool, as well as a variety of measures that can be taken to overcome these challenges.

Keywords: *3D printing, Environment, Manufacturing, Sustainability, Nigeria*

1. INTRODUCTION

Recently, many disruptive changes are happening in the manufacturing and production industries. One of the key drivers of this change is the advent of advanced manufacturing processes that allows for a more sustainable, cost-effective production. Among these sets of emerging manufacturing technology processes, Additive Manufacturing (AM) stands out as one with great potential of contributing significantly to both environmental and industrial sustainability.

The adoption of additive manufacturing as a manufacturing tool across the manufacturing and production industries has the capability of solving many problems faced by manufacturers and consumers in Nigeria. This includes time and resource-efficient production; reduced carbon emission, suppressed supply chain; and other sustainable benefits that can significantly trigger economic development across the country. Along with discussing these various aspects in detail, this paper aims to give an insight into the various opportunities that come with adopting AM technologies as a manufacturing tool for industries in Nigeria. The paper began by providing an overview of the AM technologies, followed by analyzing the awareness and rate of adoption of this technology in Nigeria. The paper then highlighted significant benefits of adopting AM technologies in Nigeria, the challenges to adopting AM technologies in the country, and possible solutions to overcoming these challenges, with a final consideration and conclusion given at the end.

2. OVERVIEW OF ADDITIVE MANUFACTURING TECHNOLOGY

The term "Additive Manufacturing" is used to describe a broad range of technologies in the manufacturing industries, which enables objects to be fabricated layer by layer. Typically, AM begins with the designer making a Computer-Aided Design (CAD) file of the required geometry to be produced, which is then converted

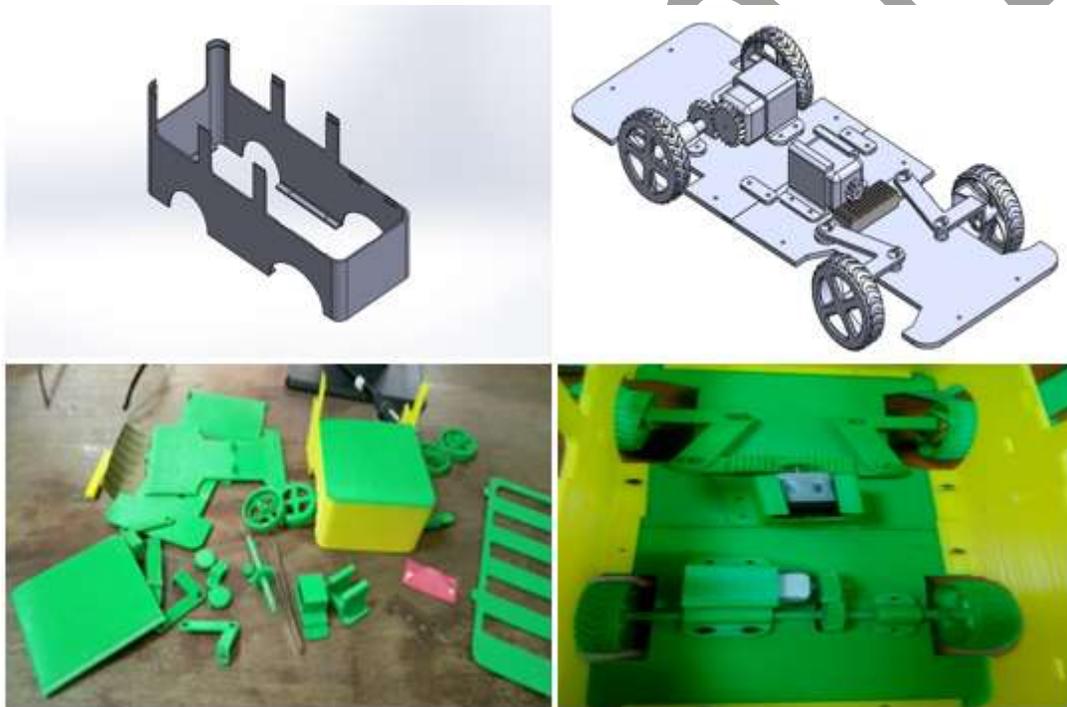
to a Surface Tessellation (STL) file. This file is feed into the computerized system where the computer program divides the object into suitable layers. The computer software then transmits these divided data set to the machine in the form of production instruction, which enables the manufacturing system to build the required geometry layer upon layer until the part is completed. Some of the most commonly used AM techniques are Fused Deposition Modelling (FDM), Stereolithography (SLA), Selective Laser Melting (SLM), Selective Laser Sintering (SLS), Electronic Beam Melting (EBM), and Binder Jetting. Materials for 3D printing range from metals, polymers, ceramics, to composite materials.

One of the earliest applications of AM was for rapid prototyping and tooling, which was largely employed to reduce lead time and cost of developing prototypes for new parts and devices. However, the emergence of advanced technologies in the field of AM has made it possible for AM to be utilized for direct manufacturing in today's world. Nowadays, AM technologies are gradually gaining popularity in the automobile, aviation, medical, and even fashion industries were they had been deployed in fabricating various intricate parts that might not have been possible using conventional manufacturing processes such as formative and subtractive manufacturing.

3. ADDITIVE MANUFACTURING TECHNOLOGY IN NIGERIA

As AM technologies continue to find useful applications in various sectors and industries across the world, many countries, organizations, and businesses are increasingly making use of this technology to achieve a more effective and efficient production, especially in the developed world. However, AM technologies seem to be in its very early stages of adoption in Nigeria. A research carried out by Farayibi and Abioye (2017) to investigate the awareness of AM technologies in south-western Nigeria observed that a larger percentage of individuals are still not aware of AM technologies, while a greater response from the research responses shows that many have

not heard of the technology before. Nonetheless, AM technologies have been implemented by some industries in Nigeria in recent years; this includes the Nigerian foundry limited and the National Space Research and Development Agency (NASRDA). In 2017, the Nigerian foundry limited partnered with a US-based 3D printer manufacturing company to install 3D printing machines to facilitate the efficient production of casting accessories. The National Space Research and Development Agency has also utilized AM technologies for prototyping and manufacturing of components. Figure 1 below shows a 3D designed and assembled



autonomous vehicle prototype manufactured using additive techniques at the National Space Research and Development Agency, Abuja.

*Figure 1: Design and manufacturing of autonomous vehicle prototype using AM at NASRDA
Photo Credit: Adesanmi, 2018*

4. BENEFITS OF ADDITIVE MANUFACTURING TECHNOLOGIES

There are so many benefits that can be derived in applying AM technologies in manufacturing and production in Nigeria, which makes it increasingly important to raise awareness for the adoption of this technology in Nigeria. Some of these benefits are discussed below.

4.1 Resource Efficiency

One of the chief benefits of AM technologies is that they serve as a tool to reduce both energy and material consumption during production. For instance, conventional manufacturing processes such as milling and forming lead to material waste, and most of the time, require large energy input. However, AM technologies make use of a near-exact amount of the material needed for production, thus provides no room for material waste. This indicates that manufacturers stand to gain more by implementing this technology for components production.

4.2 AM Compresses Traditional Supply Chain.

Another beneficial aspect of AM technologies is that it compresses the gap between production and consumption. Since 3D printers are highly localized, customizable, and accessible, production and consumption can be merged together through on-demand manufacturing, where components are only printed on-demand, hence reducing the need for logistics and transportation, which is a major feature of the conventional supply chain process. A graphical illustration of how AM is able to compress supply is shown in figure 2 below

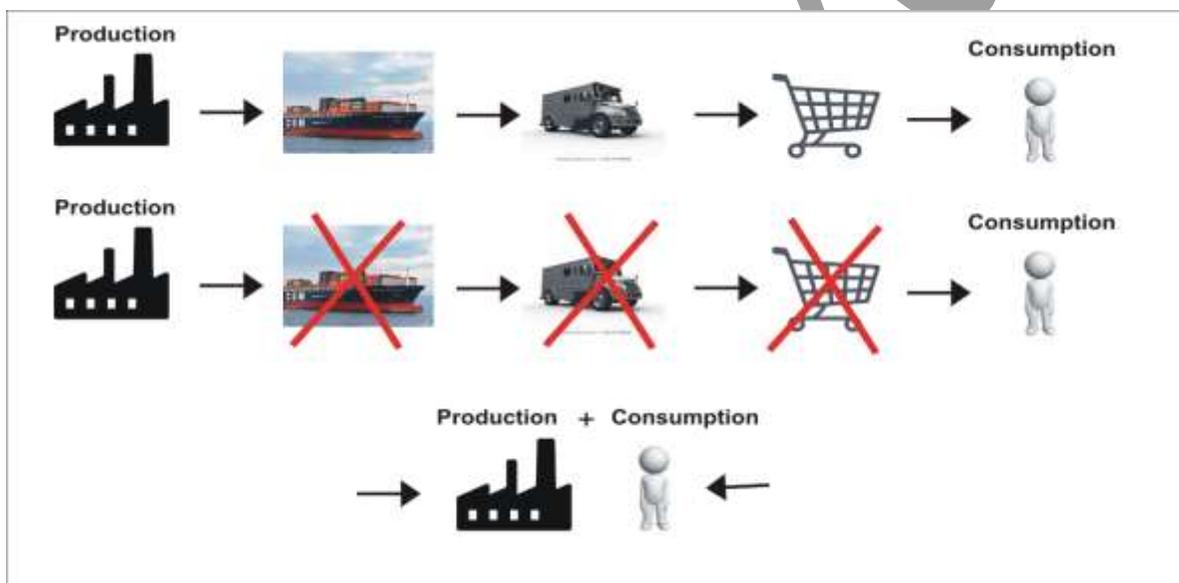


Figure 2: AM enables more localized supply chains

The compressed supply chain that is made possible by AM technologies implies that manufacturers and producers in Nigeria can leverage on this technology to appreciably reduce the time spent on ordering tooling equipment and other components which are used for facilitating further productions from overseas, and this will increasingly save cost, since production time has an inverse linear relationship with cost.

4.3 AM Reduces Emission

AM has the capability of reducing the carbon footprint if adopted by manufacturers in Nigeria and beyond. Since 3D printed commodities can be created on-demand in just one single process, this means that a huge number of flight journeys and weights that that is incurred in importing products and components from abroad will reduce significantly. In a 2014 study carried out by Gebler et al., 3D printing was estimated to play a huge role in reducing cost globally by up to \$539bn, slash primary energy supply by 2.54 – 9.30 exajoules, and reduce CO2 emission by up to 525.5 megatonnes by 2025. Going by these figures, one can argue that AM technologies have a huge potential in increasing profits for businesses, and at the same time, improve environmental sustainability through reduced emission.

4.4 AM Enables Enhanced Manufacturing

AM no doubt enhances manufacturing in a good number of ways. Using AM techniques, various aspects of manufacturing can be accomplished in a better, flexible, and time-efficient manner. Some of the areas in which AM enhances manufacturing include; rapid prototyping, multi-material printing, production of complex and intricate parts, as well as breaking the barrier between the knowledge of design and production. For instance, in the area of multi-material printing, 3D printing makes it possible to fabricate components with a heterogeneous and complex arrangement of materials. This development has been predicted to find useful implementation in the pharmaceutical and plastic industry. In the case of plastic industries, for example, injection molds for plastics are mainly constructed of tool steel to provide wear and durability owing to repetitive use. Nonetheless, with multi-material printing provided by AM techniques, it is possible to make the mold surface out of tool steel and the rest on copper, and since copper has greater thermal conductivity than tool steel, this means that the machine can be cooled faster and with lesser energy, thus reducing cost and time (Toyserkani, 2017).

Furthermore, AM makes it possible to customize objects as desired, as nearly any kind of shape can be produced with the technology. Unlike conventional manufacturing, parts such as; cavities, channels, walls of varying thickness, and undercuts can be easily achieved using AM techniques. This flexibility in shape production is greatly making AM important in the medical field as the technology has been applied to produce complex prostheses for the physically challenged.

4.5 Improved Agricultural Practice

AM also provides an opportunity for the agricultural sector in Nigeria to manufacture agricultural tools on demand for farmers. With smallholder farmers contributing significantly to food and agricultural products produced in the country, AM can serve as a tool to manufacture less intensive farming implements for farmers such as harvesting, planting, processing, and wedding tools. This will certainly help improve agricultural production while making the farming process less labor-intensive for farmers.

5. CHALLENGES TO THE ADOPTION OF AM TECHNOLOGIES IN NIGERIA

As we have seen, there are a lot of advantages and benefits that arise from adopting AM technologies in the production and manufacturing industries in Nigeria. However, it is important to highlight certain challenges that are hindering the adoption of this technology in Nigeria.

5.1 Low Awareness of Technology Among Stakeholders

One of the major challenges facing the full deployment of 3D printing technologies in Nigeria is the low awareness of the technology among stakeholders in the country. The poor awareness of this technology has affected the rate at which manufacturing and production industries in the country are able to adopt and implement AM in their manufacturing processes since there is a limited number of available experts who can model, manufacture, and operate 3D printing technologies.

5.2 Fabrication of Weapons for Illegal Purposes

It is pertinent to note that AM technologies operate on a design based economy as the process drastically reduces the barrier between the knowledge of a product and the knowledge of its manufacturing processes. This entails that anyone with access to a 3D CAD file and access to a 3D printing machine can easily 3D print their desired components. This development has increasingly lead to the fear of individual illegal 3D printing weapons with AM technologies. As a result of this, many countries are putting strict policies towards the domestic use of AM technologies. Although there are no concise and clear cut policies on this aspect of 3D printing in Nigeria presently, however, this can be part of the reason why the adoption of these technologies is not yet huge in the country.

5.3 Low Maturity of Technology for Large Scale Structures

Another major challenge facing the adoption of AM technologies in Nigeria is the low maturity of the technology for large scale structures. Presently, available 3D printers cannot be used for printing very large scale structures such as huge storage tanks; hence, this limitation is also limiting its adoption in certain industries across the country. Although extensive research is ongoing to improve the technology in order to use it for manufacturing large objects in the near future.

5.4 Limited Availability of Approved Raw Materials

One other major setback to the adoption of AM technology is the limited availability of raw materials for AM processes. While there are many available materials for conventional manufacturing processes such as casting, forming, and extrusion molding, AM has only a few approved materials that can be used for printing, especially in the area of metal alloys powders. According to Toyserkani (2017) there are a lot of commercially available steel alloys for conventional casting, but just seven that have been verified and approved for AM production by

original equipment manufacturers (OEMs), and this ratio is only a little bit higher in the case of Aluminum. This limited availability of materials makes it severely difficult for some manufacturers to benefit from the technology.

6. FOSTERING THE ADOPTION OF AM TECHNOLOGIES IN NIGERIA

Given the benefits and challenges that have been discussed above on the adoption of AM techniques, it is clear that there is a need to foster the adoption of this technology so that AM does not become a missed opportunity for improving economic growth in Nigeria. Some of the measures that can be taken in order to overcome these challenges and foster the adoption of AM in Nigeria are discussed hereinafter.

6.1 Public-Private Partnership for Promoting AM Technologies

First, for AM technologies to fully come alive in Nigeria, the government will need to play a significant role. This will include providing an enabling environment to partner with businesses in the production and manufacturing sectors in the country to ensure that they provide the needed support in helping these businesses acquire AM technologies where necessary. More so, through partnership to effect technology transfer from countries where AM technologies have been fully matured and applied for industrial and commercial use, the government can significantly improve the awareness and adoption of this technology in the country.

6.2 Supporting Skill Development of AM technologies Among Engineers and Designers.

Another strategy through which the adoption of AM technologies can be improved in Nigeria is through skill development of AM technologies among engineers and designers in the country. As stated earlier, one of the key limitations to the adoption of this technology by industries in the country is the limited number of experts who are specialized in 3D techniques; hence for this problem to be overcome, there is a need to support the skill development of AM among our engineers and designers. For this to happen, institutions, engineering

organizations, agencies, as well as the government must put hands on deck to ensure that our engineers are trained on the potential uses and benefits of AM technologies through regular workshops and seminars.

6.3 Supporting the Research and Development of AM Technologies

Finally, it is imperative for the government and research – funding organizations to support the research and development of AM technologies in Nigeria as this will encourage more researchers to go into this area so as to solve some of the problems facing the improvement of the technology. Building research centers that will focus on AM technology research in the country will be a good way to foster the interest of scholars, academics, and prosumers on AM technologies.

7. CONCLUSION

In conclusion, AM technology has shown promising potentials in alleviating some of the challenges faced by societies as the technology makes it possible for communities to innovate, design, and manufacture products that are essential for their everyday life. More so, manufacturing industries stand to gain from both the economic and environmental perspectives by adopting this technology as a manufacturing tool. However, just like every new technology, AM technologies have their own challenges, but these challenges will certainly be solved with the advancement in technology. Hence, it is essential for major industrial players in Nigeria to make efforts towards adopting this technology so as to benefit from its many advantages.

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