Analysis of the social impact of 3D Printing and its future development

Yixuan Zhao*

Department of Mechanical, Aerospace, and Nuclear Engineering, Rensselaer Polytechnic Institute, Troy, 12180, United States

*Zhaoy19@rpi.edu

Abstract. This paper introduces basic process and social impact of 3D printing, which is also named as additive manufacturing (AM), and prospects for future development of AM technology. This paper starts with the historical background of AM technology, as it creates a new era of mechanical manufacturing. The AM can be summed up in five major steps: create 3d CAD model, convert file format to STL, divide model into layers using software, print the model from bottom in AM system, and finally, some end-part finishing process will be applied. The advantages of AM technology are outstanding, but its limitation also restraint the further development of the technology. I have discussed in details about types and impacts of current application and what are the key problems. Overall, even though there are still many unpredictable factors of development in AM technology, it is still progressing in a positive way and hopefully will move to its next step in next decade.

Keywords: 3D printing, Additive manufacturing, AM technology.

1. Introduction

3D printing technology has an important role and value as a new processing method emerging in the new era [1]. 3D printing technology is also known as additive manufacturing. As the name suggests, it is different from traditional processing methods. 3D printing technology accumulates materials layer by layer to form the final part model and the required structure, which can greatly solve the problem of material waste [2] question. Based on geography and photo sculpting, research into addictive manufacturing began in the 19th century. In the 1970s, the first successful effort was made [3]. Charles Hull devised the first AM method, stereolithography (SLA), in 1983. The introduction of SLA technology allowed 3D models to be printed from CAD data. Hull developed the first business to market AM technology products in 1986. The application of AM technology shifted from prototyping to manufacture of final products [4]. At this period, acrylate resins were the most often utilized substance. In 1990, selective laser sintering (SLS) technology was widely used for the first time in the field of engineering, enabling commercialization from the laboratory to the shop floor. And it greatly decreased system costs; new resins were also developed and commercialized for usage in a wide variety of 3D printers [5-7]. These advancements in the 1990s led to a rise in industrial, medicinal, and consumer applications. Since the beginning of the 21st century, additive manufacturing (AM) technologies have rapidly advanced and begun to be utilized in areas such as aerospace and medicine.

2. Background

The AM process can be summed up in five fundamental steps. The first step is to use computer software to draw a 3D model of the part according to the actual size of the part to complete the creation of the model. Secondly, it is necessary to convert the 3D model file format drawn in the CAD software into an STL file to prepare for the next 3D printing process [8]. In the software's internal system, the file format is automatically recognized. After that, the 3D model will be divided into multiple layers by the software, which are used as different instructions in the printing process to facilitate the execution of subsequent operations. In the AM system, the device follows the instructions as they are received and builds the physical item from the bottom up [9]. Depending on

the nature of the object's material or the intricacy of its form, various end-part finishing processes are necessary once the thing has been entirely fabricated (Examples of common machining operations: sanding, filing, polishing, curing, material filling or painting). Figure 1 is a schematic diagram of the 3D printing process.

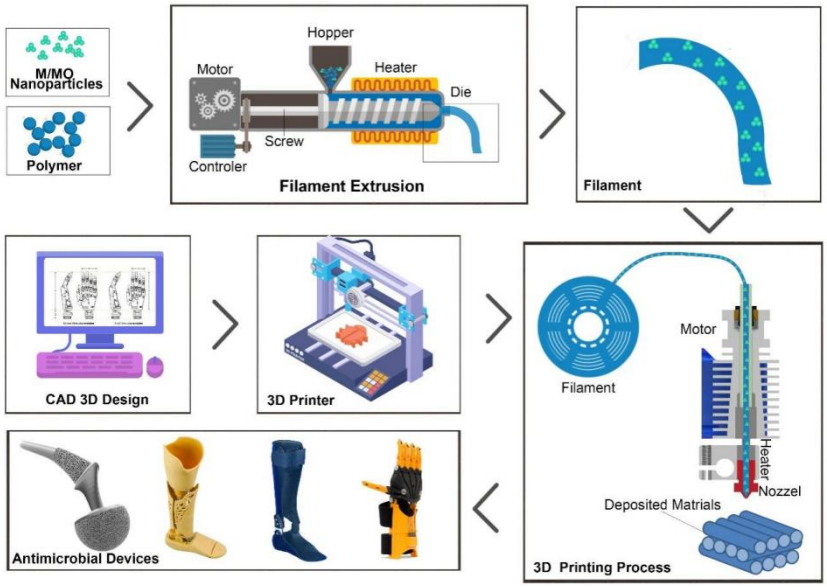


Fig. 1. Process of 3D printing.

In comparison to conventional manufacturing, the benefits of additive manufacturing are remarkable. As a result of the properties of the AM process, AM can generate complicated designs more efficiently and precisely [10]. AM enables the production of some designs that are unattainable with conventional manufacturing. AM's precision shortens review periods and provides greater design freedom. Additionally, because the only physical tool required for the AM process is the AM device, AM not only saves manufacturers time in product design and development during product processing, but also ensures flexibility in on-demand manufacturing. Last but not least, the AM device essentially prints out the physical model exactly as it appears in CAD, hence reducing the quantity of raw materials wasted. Despite its many benefits, AM has numerous disadvantages. It is only able to make things of a given size. If the product is very large, AM is inapplicable; a single AM device can only generate a single unit at a time and cannot complete production of products including an excessive number of units. As a result of the incomplete development of AM technology, the selection of raw materials is currently restricted.

3. Current Application

3.1 Types and Their Characteristics

Multiple AM technologies have been developed in the present day. All of these composites are the result of the following fundamental processes: The normal working procedure of 3D printing technology is first through vat photopolymerization, then start the material jetting process, then start the material extrusion, powder bed fusion step, then start the adhesive jetting, sheet lamination operation and direct energy Deposition, of which binder jetting is the most critical operation in 3D printing [11]. Among all the operating procedures of 3D printing, the vat photopolymerization step, also known as the photopolymerization procedure. This step is done by placing liquid photopolymers (such as the most common plastics) into a specially closed processing container. When the 3D printing starts, the polymer will be continuously layered into the model, continuously superimposed and stacked. During the printing process, the polymer material will be continuously sprayed, and the

print head of the device will work according to the path planned in the system, and finally build a predetermined model structure. The majority of these drops are composed of photopolymer. When UV radiation is used to solidify photopolymer to create a cured part, a secondary substance such as wax is required. It is used to support structures during construction and is removed after construction. The extrusion process of material is not only related to the process of high temperature heating of the nozzle to melt the material, but also related to the movement path of the nozzle [3]. This procedure will continue till the final product is complete. There are various heat source methods for heating heat sources in 3D printing, the most common being lasers and solid heat source materials. Laser is the most common processing heat source, and material particles (such as plastic or metal) can be selectively fused together in dynamic bed fusion by heating source processing. Once a layer has been established, a new one is made by applying powder to the item and repeating the procedure. In the process of work, in order to reduce the demand for support systems, 3D printing technology often requires pre-processing of printing materials in advance. In the continuous outward spray of the adhesive from the nozzle, the material particles of the model will continue to accumulate and then combine together, and finally achieve fusion [7]. This process may also involve the deposition of ink to generate the desired hue of the product. The working principle of this process is the same as that of powder bed fusion. When the powder of the first layer is generated, a second layer will be generated immediately, so that the layers are superimposed, and finally a whole can be formed. The thing being manufactured is supported by unbound material [8]. In sheet lamination, the materials are already in the shape of thin sheets. Each sheet is placed on top of the previous one, and they are adhered to one another in various ways. After all layers have been bonded together, a knife (often a laser) is used to cut away the excess material until the desired product shape has been achieved. In the directional deposition of energy, the source of heat is a very important working factor. Directed energy deposition system, as the most important part of 3D printing technology, can use wire-based or powder-based deposition materials for specific work. The following article is a detailed introduction and research on 3D printing technology.

3.2 Preferred methods for different materials

Polymers are the most commonly used material in AM systems, as seen by the chart above, and are compatible with the majority of the technologies besides Electron beam melting. Composites are utilized nearly as frequently as polymers, and they can be employed in addition to Digital light processing, Fused deposition modeling, Electron beam melting, Selective heat sintering, Direct metal laser sintering, and Ultrasonic consolidation; Metals can be utilized in a variety of methods, including electron beam melting, selective laser sintering, direct metal laser sintering, powder bed and inkjet head printing, laminated object manufacture ultrasonic consolidation, and laser metal deposition; In methods such as Selective laser sintering, Powder bed and inkjet head printing, Plaster-based 3D printing, and Laminated item manufacture, ceramics have a limited application.

4. Limitation and Social Impact

4.1 Limitation

Despite the fact that high-tech industrial printing can print on plastics, certain metals, and ceramics, the materials that cannot be printed are relatively expensive and scarce. Furthermore, printers have not yet matured to support the wide range of materials encountered in daily life.

Researchers have made some progress in multi-material printing, but until these advances become mature and effective, materials will continue to be a major barrier to 3D printing.

4.2 Social Impact

The technology of 3D printing is capable of recreating object geometry and function to a certain extent, and almost any static shape can be printed; however, it is difficult to print moving objects and

their sharpness. Manufacturers may be able to resolve this issue, but if 3D printing technology is to enter the home and allow anyone to print at any time, the machine's limitations must be addressed.

In recent decades, the music, film, and television industries have become increasingly concerned with intellectual property. Because many things will be more widely dispersed in the real world, 3D printing technology will also be a factor in this issue. There is no limit on the number of copies that can be made of any given item. One of the current challenges is to determine how to develop laws and regulations for 3D printing to protect intellectual property; otherwise, the market will be flooded.

5. Conclusion

I believe that the market prospect for AM is unpredictable in a positive way. In this decade, applications of additive manufacturing have expanded into a variety of areas, including commercial aerospace and defense, space, automotive, healthcare, and consumer goods. In the future, additive manufacturing will alter the ways of manufacturing and its procedures will become more streamlined and accurate. AM also offers design flexibility, which will aid in the development of structural design in a variety of disciplines, as well as the opportunity for customized manufacturing. Because the AM method lowers material waste, it will enhance the sustainability of the process. As AM technologies advance, however, there are also certain problems. Initially, the full capabilities of the technology must be established before addressing the limitations of the material. In addition, selecting the appropriate method requires a focus on the trade-offs between system size, cost, speed, and quality, among other factors. After technology has been fully developed, a number of ethical concerns arise. Printing of regulated objects, such as firearms, and printing of biomaterials, such as human cells, must be governed. In the majority of fields, international regulation should be uniform.

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