Agnieszka Łagoda
Department of Manufacturing and Materials Engineering, Faculty of Mechanical Engineering,
Opole University of Technology, ul. Mikołajczyka 5, 45-271 Opole, Poland;
a.lagoda@po.edu.pl

3D printing as an example of supporting sustainable production and reducing the negative impact on the environment

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ABSTRACT
3D printing is one of a promising method of obtaining almost any kind of component or necessary part. Additionally, additive manufacturing can support sustainable production and also be a way to help the environment and protect it from the negative impacts. Prototyping or even printing final products ready to work just from printer, has never been so easy, available for almost everyone and fast to make. In this article the advantages, merits and new possibilities of 3D printing are presented.

1. Introduction

3D printing is one of the fastest developing producing methods. Just several years ago, paper color printing was a great discover and 3D printing was an innovation. Nowadays, 3D printing has almost no limits and there is the possibility of printing in a wide range of materials from ABS to ceramics and metal.

3D printing can be treated as an easy way to support the sustainable production by helping in prototyping process. It reduces production time, prevents material waste. It also has main influence on producing the biomedical objects as individual replacements parts, eg. dental implants, bones [1]. Medical low-cost 3D printers allow hospitals to build 3D printing laboratories. Using 3D printers for models, can shorten the surgery time [2, 3].

2. 3D printing

3D printing history started in 1984. Charles Hull wrote the article about spatial printing and two years later, patented the idea. The first thing he printed was the mug for his wife. Nowadays, after almost 40 years many new techniques and methods are developed and so much more difficult models are printed [4]. The highest number of 3D printing publications are noticed in 2019 [5]. The 3D printing has almost no limitation. The only one is connected to hardware and imagination. It is possible to print almost everything, from new vehicles and engine components, automotive industry elements to even beak for a penguin in Warsaw zoo, skull bones, human heart for research, human and animal prosthesis or aerial parts [6–8]. Materials for 3D printing are very differ and very often, cheaper than other materials. There is a possibility to print in plastic, metal and different kinds of materials.

There are few methods of printing. The most common is Selective Laser Sintering (SLS) technique (Fig. 1A). It's a very precise, but kind of expensive method. The second one, Digital Light Processing (DLP) uses the resin and the UV screen curing layers in it (Fig. 1B). Fused Deposition Modeling (FDM) is the cheapest method, where the heated nozzle melts the thermoplastic (Fig. 1C) [5]. Except for this three methods, there are also Polymer jetting (Polyjet) method and Two-photon polymerization (2PP) [9] shown in Fig. 2.

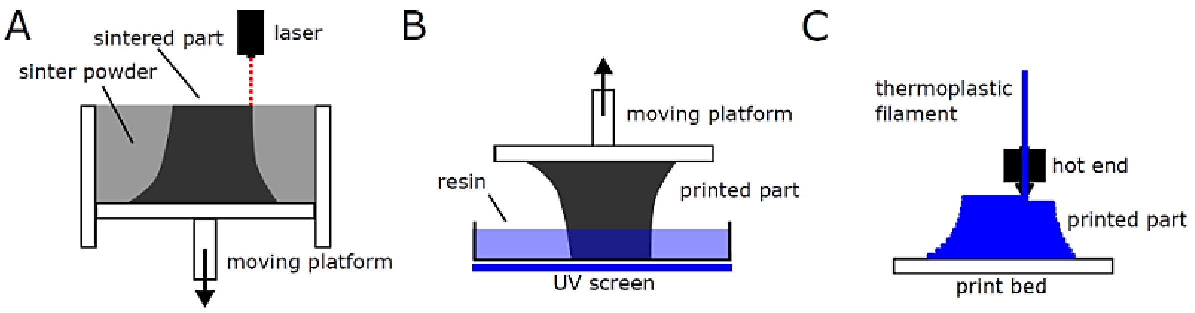

Figure1. 3D printing methods: A – Selective Laser Sintering, B – Digital Light Processing, C – Focused Deposition Modeling [5]

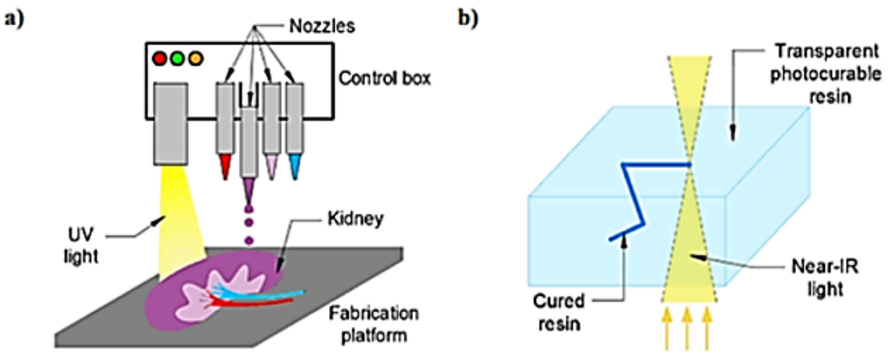

Figure 2. 3D printing technologies: a) Polyjet, b) 2PP [9]

3. Supporting the sustainable production

3D printing and widely known additive manufacturing (AM) revolutionizes the market. Making prototypes has never been so easy. Opening a new factory is no longer necessary, because everyone can own a business at home and produce wide range of objects in 3D printing technology [10]. Nowadays, there is a possibility even to manufacture the functional parts directly from the printer. Production can be moved to all new level [11,12]. For example, Co-Cr-Mo alloys are manufactured by casting and wrought methods. Currently, biomedical implants made from the same alloy can be rapid manufactured by 3D printing keeping parameters for every individual person, reducing production time, costs and environmental impact [13]. Actually, it is even possible to print an exemplary human airway and vascular and describe an effective routine workflow for patients [14]. The main difficulty problem connected with 3D printing is a large number of different parameters as the laser power or layer thickness, which had very high impact on finished product and it's fatigue [15]. Every 3D printing method has its own limits. FDM has trouble with unsticking the layers and, for example, SLS is very limited in closed object with empty space inside printing. It doesn't change the fact that there are still much more advantages using 3D printing. At the same time, SLS is also a method with very low material loss, which reduces production costs. Powder that has not been sintered in the printing process can be reused. In addition, unacceptable printed elements and parts can be atomized and the resulting powder can be used again. This method shows a lot of possibilities of saving material and reducing costs. The majority of printed objects can even replace some production line parts such as small gears or graspers. Their strength might be a little bit lower, but parts can be ready even in 20 minutes [16]. The biggest advantage of 3D printing is the ability to stop printing in every moment, change parameters and continue printing or start again easily. Thanks to this, there is a possibility to react to a changing design concept or unexpected errors occurring during process quickly.

4. 3D printing using biodegradable materials

3D printer materials are not only metals, ceramics or thermoplastic. There is a possibility to print even with biodegradable materials. The eco-friendly and biodegradable biomass materials can be used in 3D printing with success [17]. The examples of natural fiber composites and their applications in 3D printed shown in Fig. 3.

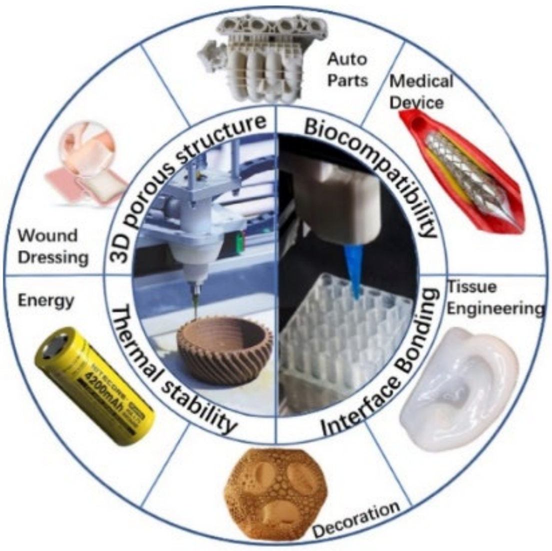

Figure 3. Natural fiber composites and application in 3D printing method [17]

Instead of traditional petroleum-based polymers as polyethylene, polystyrene and polypropylene, there are degradable polymer-based polymers using natural fibers and 3D printing method [18]. The application of 3D printing with degradable materials includes biomedical appliance with different shape [19]. Biodegradable materials have undeniable advantages: are non-cytotoxicness, are degradable and protect the environment, have quite good mechanical properties [20 – 22]. Biodegradable composites are the most popular. Biopolymers can offer environmental benefits, such as biodegradability, renewability and less greenhouse gas emissions. The most known, polylactic acid (PLA) is a renewable material with very good mechanical properties and is perfect for FDM printing method, because of low costs of printing device and material. The printing processes of carbon fiber PLA composite are shown in Fig. 4 [23].

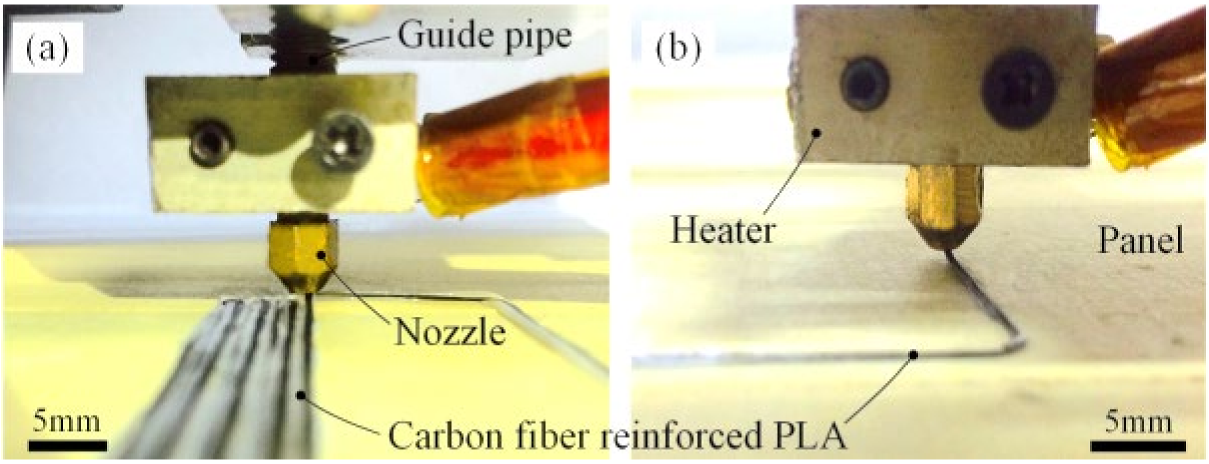

Figure 4. Carbon fiber PLA printing process, where a) straight path, b) curve path [23]

3D printing technology can even give new life to garbage and help to save our planet. As a material to printer filaments made of recycled ocean high-density polyethylene pellets, recycled ocean polypropylene or the waste soy hulls can be used [24].

Also 3D food printing (3DFP) applications keep growing and developed a large set of possibilities, such as the discovered and optimization of novel edible inks. This method may be used as an important prototyping tool. It can extend and accelerate the food products manufacturing and have huge benefits in economic, nutritional/toxicological, societal, and environmental areas [25].

5. Conclusions

3D printing is a very future-proof method of obtaining any object. Not only does it support sustainable production, but also helps the environment and protects it from the negative results. It can also help our nature in not-known way to this time. The great examples are the reefs built by 3D printing (Fig. 5) and attached in the ocean [26].

Figure 5. Sequence of manufacturing process using 3D printer [26]

3D printing is without a doubt a great way of sustainable production and a way to protect our environment. The development of 3D printing can bring a lot of new opportunities and a lot of new method to support every area of life of every single person in the world. The biggest development is very easy to be seen mainly in medical field of study. Implants personalization was never so fast and easy as now is. The only disadvantage is connected with the cost of devices, but without any doubt, 3D printing is a future technology with a lot of benefits.

6. Literature

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