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3D printing methods used in engineering

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Abstract: 3D printing as a functional Rapid Prototyping tool has been used for years, and along with the advancement of engineering technology, 3D printing technology is also developing and improving. This technology has not found representation only in the engineering industry, but across industries such as healthcare, construction, etc. In the end, I also present specific cases of the use of 3D in practice. From the most basic 3D printing with simple technology, several kinds of printing methods have evolved. From the point of view of simplicity for the novice user, the technology is FDM (Fused Deposition Modeling). With this 3D printing technology, the process of applying a thin layer of molten filament to the printing surface is used until a complete model is finally created. FDM is also characterized by the use of a wide range of materials, such as ABS, PLA, HIPS, PET-G but also wood or copper. Other methods I will describe are SLA, SLS, DOD-PolyJet. These are less available for use and acquisition by the average user, but are increasingly sought after, due to the expanded printing options. In the end, there is also an example that we processed for a company in the field of assembly.

1 Introduction

The basic principle of 3D printing is "additive manufacturing", which in practice means that we do not have a large block of material at the beginning, but printing begins on a clean substrate by gradually applying the material layer by layer as precisely as possible, according to the requirements for strength, stiffness and thermal properties, or resistance to influences such as chemicals, water, sunlight, alcohol, etc. According to these requirements, the material (filament) and the method of creating the model are subsequently chosen. The way the printer applies the material is layer by layer in 3D space. It is then moved horizontally by the next layer until a complete 3D model is created. Even though individual printing methods differ from each other, they all have one thing in common: applying material layer by layer. Therefore, it is necessary to modify the 3D model (most often in STL format) in the software before printing, dividing it into several thin layers forming the entire object. The thickness of the layers best corresponds to the quality of the model. The thinner the individual layers, the more accurate the print quality, and the transition between layers is minimal. So printing in the smallest possible layers appears to be the most optimal quality, but it has its limitations. The hardware itself has limits on how thin a layer it can create. If the software allows even extremely thin layers, we waste a lot of time in the area of dividing the model into layers, because the software has to cut the model into many layers. The printing time itself is also significantly extended because it takes longer to create one layer and at the same time a larger number of layers must be created. These shortcomings and limitations in terms of quality and time are minimal against the advantages of 3D printing. It is necessary to find the most suitable type of technology, determine the required properties of the print, choose the material accordingly and ultimately find a compromise between speed and precision of printing [1-4].

2 Fused Deposition Modeling - FDM

The principle of this method consists in melting the material. The material entering the process is the filament, which reaches the print head, where it is heated to the required melting temperature. Subsequently, it is printed with the help of a nozzle, which slowly applies the individual layers to the printing pad (Figure 1).

The main advantage of this technology is the use of a very large number of types of materials for this type of printing. Another of the advantages and positives of this type of printing is the creation of a minimal amount of waste. The disadvantage is the lower quality of the final surface of the material, which is indicated by the minimum height of the layer during printing, which is around 0.25 mm [1-4].

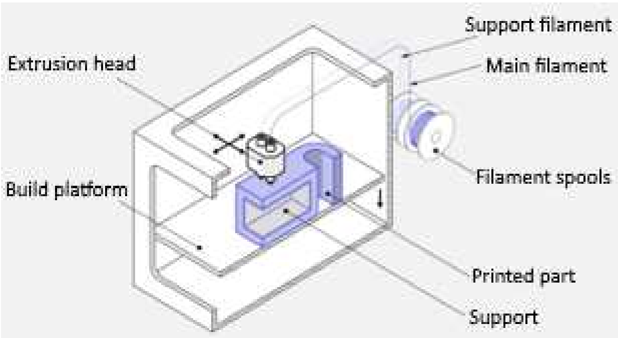

Figure 1 Fused Deposition Modeling

3 Stereolithography - SLA

SLA 3D printing works by first placing a build platform in a tank of liquid photopolymer at a distance of one layer height from the surface of the liquid. The UV laser creates another layer by selectively curing and solidifying the photopolymer resin. During solidification, part of the photopolymerization process, the monomeric carbon chains that make up the liquid resin are activated by UV laser light and become solid, forming strong, unbreakable bonds between them. The laser beam is focused in a predetermined path using a set of mirrors, called galvos (Figure 2).

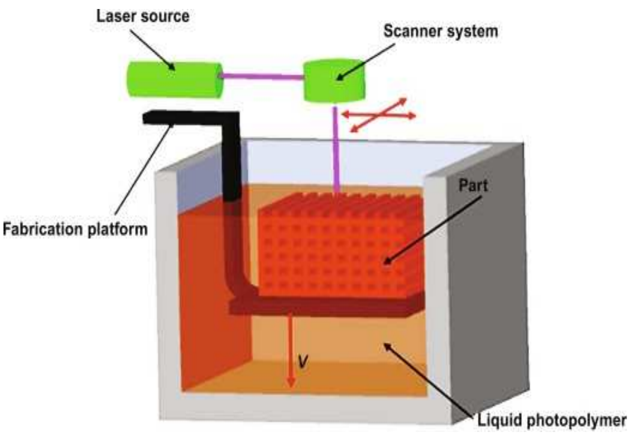

Figure 2 Method of stereolithography

The main advantage of this method is good printing accuracy. This method is more time-consuming to prepare and complete, as it is necessary to remove supports as mentioned above, which we call postprocessing [1-4].

4 Selective Laser Sintering - SLS

The SLS method uses a combination of laser and powder for printing, which is dispersed in a thin layer on top of the platform inside the build chamber. The printer preheats the powder to a temperature slightly below the melting point of the raw material, making it easier for the laser to raise the temperature of specific areas of the powder bed as it follows the model to solidify. The laser scans a cross-section of the 3D model and heats the powder just below or directly to the melting point of the material. This mechanically joins the particles together to form one solid part. The unfused powder supports the part during printing and eliminates the need for special support structures. The platform is then lowered one layer into the assembly chamber, typically between 50 and 200 microns, and the process is repeated for each layer until the parts are finished (Figure 3).

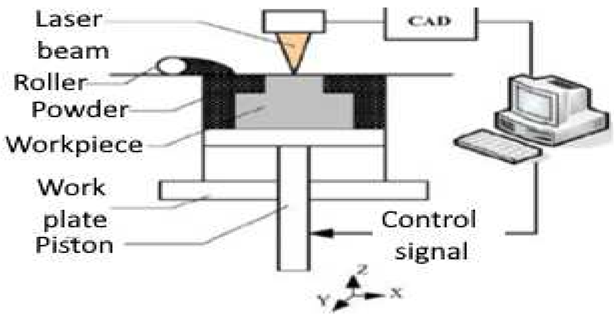

Figure 3 Selective Laser Sintering

With the help of this method, it is possible to print a fully functional model, and thanks to the diverse selection of materials, it is possible to choose from a wide range, such as - ceramics, polycarbonate, metal, nylon, etc. This one is not compact for home users, as its dimensions are a bit larger due to the built-in trays ready to feed different types of material directly from the printer part [1-4].

5 DOD - PolyJet, MaterialJetting

PolyJet 3D printing technology is quite similar to a regular inkjet printer that prints on paper. In this method, 2 types of material are used: construction material, which forms the basis, and support material, which ensures stability during the printing process. For the help of the print head is the material applied to the printing substrate. Thanks to the large number of nozzles that the nozzle head has, it is possible to apply a larger width of material at once without problems. These nozzles apply a small amount of material in the form of drops, which, after being applied to the material, are immediately cured with the help of a UV lamp located in the printer near the print head (Figure 4). The main material is photopolymer, and the supporting material can be removed with the help of water, as well as with SLS technology, or it can also be removed mechanically. This PolyJet technology gives us high-quality printed and subsequently cleaned parts. Where with FDM technology the minimum layer is 0.1, this is the smallest possible height at an incredible 0.014 mm. Since it can print a wider layer of material, it is therefore much faster than SLA technology. The width of the printed layer can be adjusted using the print head, which can be changed to the desired size. Last but not least, there is a wide range of materials and colour options to choose from [1-4].

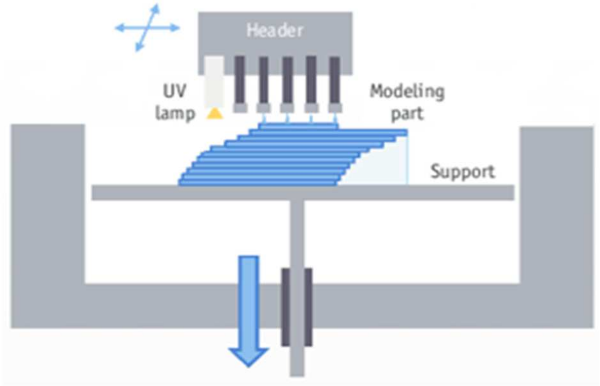

Figure 4 PolyJet

6 Colour Jet Printing, Binder Jetting

Colour Jet Printing (CJP) is an additive manufacturing technology with two main components: a core material and a binder. The core material is applied with a roller in thin layers to the construction platform. After each layer is applied, a coloured binder is selectively ejected from the inkjet print heads and this causes the core to solidify. The build platform is lowered to allow each successive layer to be laid out and printed, resulting in a full-colour three-dimensional model (Figure 5).

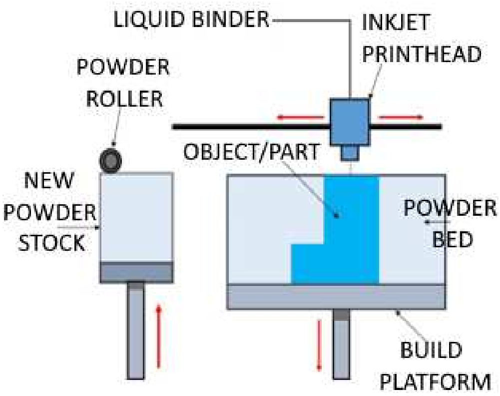

Figure 5 Colour Jet Printing (Binder Jetting)

As with the DOD method, one of the advantages is fast printing with the help of a wide print head that can apply a wide layer of the binder. The printed models using this method do not have high strength and therefore it is necessary to modify them quite often, that is, to use the so-called postprocessing [1-4].

7 Conclusions

This article describes 3D printing technologies. 3D printing is becoming an integral part of both small-scale production and large enterprises. A big benefit is their purchase price, of course, it depends on the size of printers, 3D printing technologies, and the use of different types of materials and software for converting to gcode format file. another benefit is the simplicity of model creation, as the software converts the model in .stl format to .gcode and calculates the extruder path itself, if necessary, it is possible to configure the properties of the printer as well as the model in the software. The disadvantage of 3D printing is occasional imperfections, as, for example, an FDM printer works at the micrometer level.

3D printing has also found its place in the field of aviation. Maintainers from the 60th Maintenance Squadron and 349th Aircraft Maintenance Squadron, along with engineers in Georgia, are using 3D printing in maintenance as a rapid means of creating faulty or damaged components.

Improving properties and their degradable footprint is a challenge for industrial companies. The KIMYA company disclosed an analysis of the material used in FDM printing, more precisely 3D PETG filaments. The report shows that the use of recycled PETG filaments helps reduce CO2 emissions by 35% compared to standard PETG filaments.

Art and design are pushing the boundaries with 3D printing. In the last good, 3D printing is used more and more often by fashion designers or artists. An example is the Texas project Sunday Homes, where reconstruction is planned using 3D printing.

In addition to improving patient outcomes, the medical device industry could potentially use 3D heart replicas for testing.

Engineers at the Massachusetts Institute of Technology (MIT) have devised a way to 3D print a replica of a human heart, which could have a significant impact on personalized treatment for people with heart problems. The engineers behind the discovery hope it will help doctors tailor treatments to the specific shape and function of a patient's heart. 3D printed hearts are soft and flexible, and researchers can manipulate them to mimic a patient's ability to pump blood. The process of making one of these 3D copies of the heart begins by converting medical images of the patient's heart into a three-dimensional computer model [5-9].

Mr. Tay Yi Wei Daniel at the Journal of materials processing technology states that 3D printing of concrete can be used to build many complex structures. However, due to its material properties in the fresh state, it is difficult to build overhanging structures without support. To unleash the true potential of concrete 3D printing, a support structure is needed to support any protruding fresh material that is usually removed during post-processing. This study demonstrates the feasibility of adjusting print parameters to print the main structure and the supporting structure using a single type of building material [8].

Ramezani, Hamed in the study used multiphysics simulation to determine the potential printability of chitosan hydrogel as a desirable biomaterial used in tissue engineering. In the simulations, the flow was assumed to be laminar and two-phase. Furthermore, the influence of different speeds and viscosities in extrusion-based chitosan 3D printing was investigated [7].

Our result of using 3D printing specifically with FDM technology is the design and realization of a pusher model, for a company that had high losses when gluing cardboard boxes and the production of a new pusher from the company would have a long payback period. That is why the company chose 3D printing technology. The pusher is in the form of a prototype and is being tested directly in the company.

Another use is the processing of a request from a company that needed a grid for a filter device with flexible properties, where the 3D print is already directly introduced in production and meets the predetermined requirements.

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