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# SELECTION CRITERIA OF MATERIALS USED IN 3D PRINTERS

***Abstract:*** The three-dimensional printer allows us to produce three-dimensional models designed on a computer using one or more materials. The drawings designed with three-dimensional design programs come to the printing stage after being converted to a suitable format for the printer. These time-saving devices are also an important part of our lives by removing the margin of error. In practice, the properties of the products produced by the spread of these devices began to be examined.Raw materials used in printers for 3D printing are called filaments. ABS and PLA filaments are generally preferred. Also filaments such as PETG, HIPS, PVA and Nylon are used. 30-40% mixed with PLA; There are also special materials such as wood, bark, bamboo, bronze, brass, copper, flexible PLA, temperature and light sensitive PLA, carbon fibers and antibacterial filaments. With these materials, it is possible to obtain unique models suitable for design. This paper describes the properties and comparisons of all these materials.

***Key worlds:*** 3D Printer ,Raw material , Materials comparison

## 1.Introduction

With the development of technology, production technologies are developing in an insignificant way. Among these, FDM, MJF, SLA, Colorjet and DMLS are the most popular technologies. We all know that 3D design is a very important step for the 3D printing process. There are dozens of different approaches and methods in 3D design, such as printing. And almost every designer and design team has different 3D design programs. But there are very basic issues that we need to pay attention to which program, which printing technology or even which 3D printer we use. In addition to the material you will use in 3D printing, the technology to be used in printing is also very important. Clamped parts can be the best example in this regard; ABS, Polyamide, Alumide materials such as a single printing process from the assembled parts can be produced, Gold, Silver, Bronze, Resin materials such as 3D prints are not possible with this. This is not because of materials, but with the use of these materials in 3D printing technology. We use ABS material for FDM (Filament based 3D printing technology), Polyamide, Alumiti for SLS (Powder based 3D printing technology) and Resin for SLA (Liquid polymer based 3D printing technology). In addition, the lost wax casting is used for precious metals

FDM Technology works in the form of a cylindrical form of thread-shaped plastic materials, which are melted and layered through an extrusion head. This method, which enables 3D printer technology to enter our homes, is the most known and most commonly used layered manufacturing

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technology. Production prices are very suitable in this method.

The giant printer brand HP's multijet technology has met the layered manufacturing process, and plastic 3D printing has reached the highest quality to date with a revolutionary change. MJF technology is based on the principle of melting, fusing and sintering the plastic material in powder form according to the shape of the models to be produced. The mechanical properties of the printed parts are at least as much as the plastic injection method and in most cases are much better than the conventional methods.

The SLA method is the first to explore the layered manufacturing technologies. It is based on the principle that the thermoset plastic resins in liquid form will be spotty solidified according to the shape of the model to be produced. This technology is the light energy that provides solidification. Because the light diameters used are quite small, even small details of 0.1 - 0.2 mm are possible with this method. Another feature of SLA technology is that the parts can be produced in a way that has a smooth surface.

Colorjet is a 3D printing method that enables us to make full color productions that have been created by adapting inkjet technology used in paper printers for many years. Gypsum used in this technology, plastic mixture;

The dusty material called sandstone has a hard and brittle structure similar to ceramic materials. The coloration is made by dyeing the model in yellow, blue, pink, black and white inks by spraying from the HP cartridges.

It is the most suitable method especially for small model models, concept models and figure production.

DMLS technology uses cylindrical powdered metal materials. The production is based on the principle of melting, fusing, sintering of the material. The energy required for sintering is provided by a laser or a similar source of radiation. Aluminum, steel, cobalt-chrome alloys, nickel alloys and titanium metals can be produced by this method. The mechanical strength of materials is often higher than that of machined parts. The most important advantage is that it is possible to print lightweight parts with reduced volume thanks to design flexibility. Therefore, it is widely used in aerospace applications.

## 2. Materials Used in 3D Printers

New materials Following rapid development in the 3D printing market, products are constantly being added to ensure the desired performance:

1. Increased print speed
2. Adherence between structure plate and layers
3. Improving precision and aesthetics
4. Low shrinkage and dimensional stability.

They appear in the form of features. High performance materials, high mechanical strengths and thermal properties as well as functional prototypes and small series production parts meet the demands of the demanded applications. Environmental responsibility is the main driver and many products have been designed in this respect, using low volatile organic compounds (VOC) emissions for low carbon footprint and renewable energy sources.

## 3. Selection of Materials Used in 3D Printers

In 3D printing, material selection is a very important issue. This material selection will be based mainly on the printing technology of the part to be obtained by 3D printing, the place of use, the duration of use and many other factors. Therefore, we think it is important to recognize these materials.

ABS, which is a very cheap material, exhibits very good surface properties in FDM technique as well as high strength and toughness properties. It is an amorphous polymer obtained from acrylonitrile and styrene in polybutadiene. The most important feature of this polymer is its high

impact resistance. With this material, the design we produce in the printer is more durable than other materials. The reason for this material to be stiff and resistant is the butadiene substance in the material. ABS material can be easily shaped and colored. Bad odors can be felt when working with this polymer. This is because ABS material is an oil derivative. Another matter is that recycling of this substance is easier than other materials, but the quality is not observed after recycling.

**Figure 1.** A piece made of ABS

**Advantages:**
It is more durable than PLA.
Long life.
Cheap is.
There are many different types of properties.
It is very suitable for the production of consumer products such as Lego, buttons, toys.
**Disadvantages:**
There may be a problem of bending inwards from material ends during production.
Not suitable for recycling.
It is a shrinking material when cooled, so the measurement accuracy is low.
The smell during production leaves an unpleasant smoke.
**Ideal Uses:**
Low-budget prototypes, mechanical parts, hobby products, simple geometry design products, assembly parts.
**Not Recommended Areas:**
It is not recommended for prototypes that require high accuracy, complex parts, large size and large quantities.

Particularly, the most common material in the desktop usage of 3D printer technologies is PLA. Polyyllactic acid is derived from renewable biological sources. Therefore, they do not harm the environment. It is produced by polymerization of lactic acid produced by fermentation of sugar obtained from plants. Like ABS material, this material is also tough and durable. PLA material, unlike ABS material, begins to melt at lower temperatures. Odor emerges during the process. The design made with PLA material gains a brilliant appearance. It is a more useful material for visual design. A standard PLA material is transparent and glossy. However, these materials have a wide range of colors with several processes.

**Figure 2.** A piece made of PLA

It allows easy production and the price is quite cheap. The material known as polylactic acid is used in production with FDM technology. Polylactic acid is a material that is completely organic based on corn starch. Thus, it is an advantageous material in terms of health and environment. However, it is not advisable to use it directly as a food container because of the additional additives added to the production process.

**Advantages:**
Odorless
It is a very hard material.
It is an organic material and suitable for recycling.
Cheap is.
There are many different types of properties.
Usage areas are quite wide.
**Disadvantages:**
Low temperature resistance.
Durability is not as high as ABS.
Because of its high hardness, its fragility is

also high.

**Ideal Uses:**

Low-budget prototypes, mechanical parts, hobby products, design products with simple geometry, mounting parts, models requiring measurement accuracy, large-scale prototypes.

**Not Recommended Areas:**

Prototypes that require very precise measurement accuracy, complex parts, more production, mechanical parts to work under constant load, parts that require impact resistance.

3D printer material that shows physical properties like silicone and rubber are flexible plastics. It usually allows production with FDM and SLS technologies. Produced products can easily be shaped by physical force; then it will return to its original shape. You can use it for all prototypes that should be elastic.

**Figure 3.** A piece of flexible plastic

**Advantages:**

Flexible

Resistant to abrasion.

**Disadvantages:**

High performance cannot be achieved with fine details.

For models requiring the use of support material, rough surfaces may be formed.

**Ideal Uses:**

Production of prototypes, hobby products, accessories for designs expected to show elastic properties.

**Not Recommended Areas:**

Prototypes that require very precise measurement accuracy, complex parts, overproduction, mechanical parts under continuous load.

Wood PLA containing 30% wood fibers and 70% PLA on average is another type of material used in 3D printers. This material, which has been developed for production with FDM technology, is used for the models which have the appearance of wood. Thanks to the real tree fibers contained in the smell and appearance is quite natural.

**Figure 4.** Parts made of Wood PLA

**Advantages:**

The only advantage is that it has wood appearance.

**Disadvantages:**

High performance cannot be achieved with fine details.

For models requiring the use of support material, rough surfaces may be formed.

Large models are more expensive than PLA and ABS.

**Ideal Uses:**

Prototype productions, hobby products, accessories production of the expected designs.

**Not Recommended Areas:**

Prototypes that require very precise measurement accuracy, complex parts, overproduction, mechanical parts under continuous load.

Full Color 3D printing material in which 3D printouts can be produced is sandstone. The 3D human figures that we constantly encounter are produced with this material. It is also widely used in modeling and prototype production. The material shows the behavior of the ceramic material as characteristic. It is very hard and brittle. It is a suitable material for more visual products. The biggest advantage is 4 million colors. On the material fed to the powdered system, the ink nozzles with the "Inkjet" technology are produced by the ink jet and the combining of these powders with pure water.

**Figure 5.** A model made of sandstone with a 3D printer

**Advantages:**
It is the only material that can be produced in real color.
It is suitable for secondary processes such as sanding, varnish and coating processes.
Hardness is very high.

**Disadvantages:**
It is expensive.
It carries a risk of degradation under moist conditions and under the sun.
It is fragile.

**Ideal Uses:**
Production of live figures and sculptures, reproduction of historical monuments, mechanical prototypes for visual purposes.
**Not Recommended Areas:**
Low budget prototypes, extremely fine detail designs, moving parts
Polyamide, also known as nylon, is a widely used industrial plastic which is rarely used in 3D printing technologies and is mostly used in FDM and mostly SLS methods. Thanks to its flexible structure and strength, it can work without breaking under heavy loads. Generally, it is produced based on the logic of combining the powdered material with sintering by laser. Thanks to the method, thin, grift, flexible and high strength parts can be produced without support material. Products can be easily painted, exposed to surface treatments.

**Figure 6.** A piece made of polyamide

**Advantages:**
It is the most durable plastic material.
It can be bent without breaking.
It does not react easily because of its resistance to chemical effects.
The measurement accuracy is very high.
The food is harmonious and harmless.
Melting temperature is higher than other plastics.
It can work at high temperature without losing its properties.
**Disadvantages:**
It is expensive.
Risk of degradation in humid environments.

**Ideal Uses:**
Durable mechanical parts, assembly parts, heavy industry products, automotive parts, special design products with grift structure, prototyping works requiring high precision, small quantity large quantities.
**Not Recommended Areas:**
Low budget prototypes, extremely fine detail designs.

From the group of resin-type materials, the materials developed by the 3D Systems brand for its printers are known as photopolymer resin materials. They are cured with UV light like all resins. Thanks to Multijet technology, the technical properties of the products are excellent. Although they are produced in a very large writing area, they provide maximum resolution.

**Figure 7.** A piece of photopolymer resin material

**Advantages:**
Ultra high resolution thanks to 16 micron layer thickness.
Material available in casting method
High hardness
Relatively high temperature resistance
Waterproof
Biocompatibility
**Disadvantages:**
Low measurement accuracy on large parts
High cost
**Ideal Uses:**
All jewelry products, dentistry applications, in-ear products, mechanical parts, assembly parts, small-size production.
**Not Recommended Areas:**
Large-sized parts, low-budget prototypes, models requiring very high precision.

Flexible Resins; UV light cured plastic materials. They are generally used as SLA or DLP technologies. With flexible resins, both highly detailed and elastic models can be produced.

**Figure. 8.** A piece made of flexible resin

**Advantages:**
Good surface quality thanks to 25 micron layer thickness
Flexible and durable products
Stylish image
**Disadvantages:**
Not suitable for large production
Expensive
**Ideal Uses**
Special design flexible products, elastic prototypes.
Not Recommended Areas:
**Large-sized parts, low-budget** prototypes, models requiring very high precision.

In 3D printing, non-metal printing materials are generally mentioned above. In addition, some 3D printer manufacturers have produced special 3D printing materials for their own printers for use in their own printers.

## 4. Conclusions and Recommendations

The material of every 3D print can be different. These materials are fragile / rigid, flexible / rigid, smooth / rough or heavy / light ratios can be varied. That is, the model to be designed should be designed in accordance with the material selected. Let's say that you will design a model to be produced with ceramics; you have to take into account the various requirements based on the design of this material; supporting drooping parts, strengthening protruding parts, rounding corners, etc. The selection of your print material will make a basic orientation in your 3D design, which you must follow as required by your material.

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