# Compare Material Properties of 3D Printer Using FDM Technology

Dhruv Maheshkumar Patel, Hasmukhi Amrutbhai Patel
Research Assistant, Software Engineer
D – 3, Darshan Complex, Nr. C.P Nagar, Ghatlodiya, Ahmedabad – 380061, INDIA

***ABSTRACT*** **- Additive Manufacturing refers to a process by which 3D design data is used to build up a component in layers by depositing material. The term "3D printing" is increasingly used as a synonym for Additive Manufacturing. There are different 3D printing methods that were developed to build 3D structures and objects, few of them are Stereo Lithography (SLA), Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS) and Electronic Beam Melting (EBM). FDM works on an "additive" principle by laying down material in layers; a plastic filament is unwound from a coil and supplies material to produce a part. Thus, FDM is also known as a solid-based AM technology. Two common types of filament used in FDM printing are Poly Lactic Acid (PLA) and Acrylonitrile Butadiene Styrene (ABS). We compared both materials using some characteristics and find suitable material according to the different applications. As the result shows, ABS is used for applications such as automobile and electronic housing parts, on the other hand PLS is used for applications ranging from plastic toys to medical implant. In simple terms, PLA is for hobbyist printers while ABS caters to those looking to produce commercial-grade parts. (**Abstract)

***Keywords*** **– 3D Printer, Additive manufacturing, Printer Filament, Poly Lactic Acid (PLA), Acrylonitrile Butadiene (ABS)**

## I. INTRODUCTION

### FUSED DEPOSITION MODELLING (FDM)

FDM technology was created in 1988 by Scott and Lisa Crump, the founders of Stratasys. Crump created the technology to build his daughter a toy frog using a glue gun and a mixture of polyethylene and candle wax. In 1989, Crump patented FDM technology and founded Stratasys. Stratasys created the software process that converts stereo lithography (STL) files into another format to slice sections of the 3D model and determines how the layers will be printed. [1]

There are several 3D printing technologies are available but most frequently used technology is known as fused deposition modelling (FDM). These types of 3D printers are extremely useful for rapid prototyping. Fused deposition modelling printer melts the printing material and extrudes it through a nozzle. In FDM successive layers of materials are laid down in different shapes and size according to 3D design data.FDM is popular with companies in a variety of industries, from automotive to consumer goods manufacturing. These companies use FDM throughout their product development, prototyping and manufacturing processes. The most common printing materials for FDM are acrylonitrile butadiene styrene (ABS) and Poly Lactic Acid (PLA). Figure 1 shows Fused Deposition Modelling (FDM) type 3D printer named “Ultimaker 2 Extended Plus”.

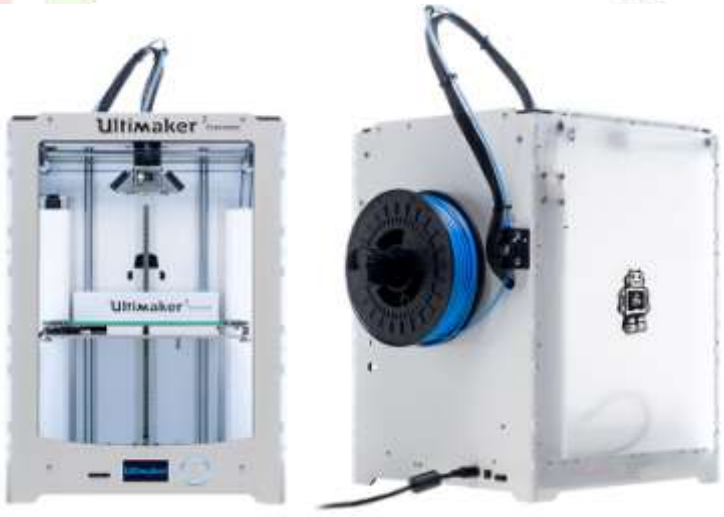


**Figure 1: Fused Deposition Modelling**

**POLY LACTIC ACID (PLA)**

Poly Lactic Acid (PLA) is a thermoplastic derived from renewable resources such as corn starch or sugarcane. Under correct conditions PLA is act as biodegradable material. Hence, PLA is considered a more eco-friendly plastic compared to ABS which is petroleum (OIL) based. This makes the material both easier and safer to use. PLA printed objects normally have a glossier look, which gives pleasant ecstatic look for object. Melting point of PLA is far lower than ABS which makes PLA to unsuitable for some applications. At the time of printing, when material is heating, PLA gives pleasant smell as the sugar base filament smells slightly sweet. On the other hand, PLA has more tensile strength with the range of 50 MPa to 60 MPa according to change in properties (Contain) of PLA filament. Figure 2 shows printed object using PLA material.

**ACRYLONITRILE BUTADIENE STYRENE (ABS)**

Acylonitrile Butadiene Styrene (ABS) is an oil-based plastic. Acrylonitrile Butadiene Styrene (ABS) as a thermoplastic can take numerous forms and can be modified to achievement multiple properties. It is a strong plastic with some flexibility. ABS has a high melting point and experience wrapping if temperature gets cool while printing. Hence, heated printing bed is required while using ABS as a filament for object print. ABS is soluble in Acetone, which allows welding of parts together with a few drops, and creates high gloss by brushing or dipping full pieces in Acetone. Its strength, flexibility, machinebility, and higher temperature resistance makes it most preferred plastic in the 3D industry. [2] ABS is not biodegradable, however it is recyclable. Figure 3 shows printed object using ABS material.

**Figure 2: OBJECT USING PLA**

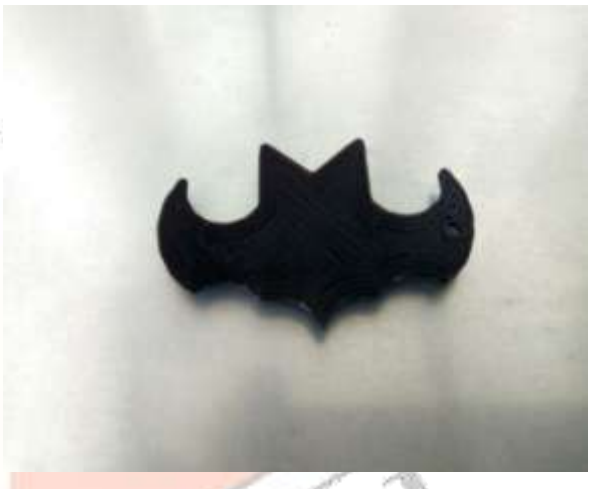

**Figure 3: OBJECT USING ABS**

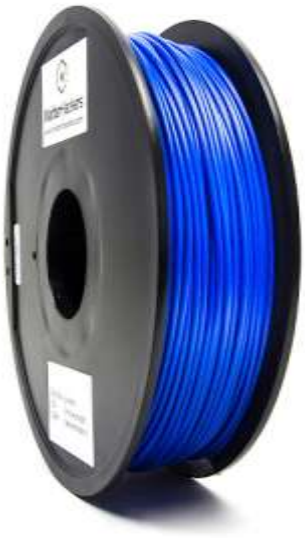

**Figure 4: WOUNDED ROLL FILAMENT**

## II. CATEGORY COMPERISION OF PLA AND ABS

**Table 1**

| SR. No | CATEGORY | PLA | ABS |
|---|---|---|---|
| 1 | **Tensile Yield Strength** | **60 MPa** | 45 MPa |
| 2 | **Printing Smell** | **Pleasant** | Nasty |
| 3 | **Warping** | **Low** | High |
| 4 | **Heated Bed Required** | **No** | Yes |
| 5 | **Environmentally Friendly** | **Yes** | No |
| 6 | **Non-Toxic** | **Yes** | No |
| 7 | **Glossy Finish** | **Better** | Good |
| 8 | **Shock Absorbance** | Good | **Better** |
| 9 | **High Temperature Uses** | Not intended for conditions above 55°C | **Not intended for conditions above 95°C** |
| 10 | **Bonding** | Not as easy bonding | **Easy bonding** |
| 11 | **Density** | 1.0 - 1.4 g/cm$^3$ | 1.3 g/cm$^3$ |
| 12 | **Biodegradable** | Yes, under the correct conditions | No |
| 13 | **Cost** | 2000 INR | 2000 INR |

## III. CONCLUSION

In this work, comparison of the two 3D printed material using FDM technologies has been studied. The results in the 3D material analyze process show that,

- Both material required dry place for store. PLA require air resist close container to prevent the effect of environment. Each is susceptible to moisture.
- Both material smells at the time of print, ABS smells like hot plastic so it needs ventilation during print. On the other hand, PLA smells like sweet sugar depending on printer.
- ABS giver batter structure Integrity as compare to PLA, hence ABS is most suitable for mechanical applications. While, PLA is use for general applications vary from toys to hobbies printing. PLA is also biodegradable material hence; PLA is most suitable for food related items.
- If considering temperature conditions, PLA does not require heated bed during printing but in case of ABS require heated bed for proper object printing. ABS requires special conditions and printers.

## IV. ACKNOWLEDGMENT

The author wish to acknowledge the support of Prof Kevin Naik for overall guidance in this works, and thanks IGNITE – The Silver Oak Incubation Centre for providing the hardware and material resources for performing this study.

## V. REFERENCES

[1] White Clouds: 'History of FDM technology'
https://www.whiteclouds.com/3dpedia-index/fused-deposition-modeling-fdm

[2] Bowling Green State University Scholar Works @BGSU: 'Measuring Accuracy of Two 3D Printing Materials'
http://scholarworks.bgsu.edu/cgi/viewcontent.cgi?article=1019&context=ms_tech_mngmt