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Comparison of mechanical properties between PLA and ABS for FDM products

Fouzi Alhadar
dept. Mechanical Engineering
The Higher Institute for Technical Siences Tarhuna
Tarhuna, Libya
alhadar7533@gmail.com

Amir Kessentini
dept. Mechanical Engineering
National Engineering School of Sfax
Sfax, Tunisia
amirkessentini2020@gmail.com

Abraheem Hadeeyah
dept. Mechanical Engineering
The Higher Institute for Technical Siences Tarhuna
Tarhuna, Libya
ibrahem27777@gmail.com

Ibrahim Ali Farj Emhemed
dept. dept. physics
Azzaytuna University
Tarhuna, Libya
I.emhemed@azu.edu.ly

Mondher Wali
dept. Mechanical Engineering
National Engineering School of Sfax
Sfax, Tunisia
mondherwali@yahoo.fr

Neila Khabou Masmoudi
deptMechanical Engineering
National Engineering School of Sfax
Sfax, Tunisia
neila.masmoudikhabou@enis.tn

***Abstract*—**Additive manufacturing (AM) techniques are an effective tool for the manufacture of complex and difficult shapes in various fields, and the most important of this technology is the FDM technique in which several materials are used, and the most important and common of these materials is ABS-PLA, so it was chosen in this study.

This study aimed to accurately compare the mechanical properties of ABS-PLA so that we can employ these properties in the industrial field as required. Many tests have been performed to see the difference between ABS and PLA materials in terms of mechanical properties, such like hardness test, impact test and tensile test. Results were discussed and analyzed upon.

Keywords: 3D printer, temperature, mechanical properties PLA, ABS, FDM

I. Introduction

Additive manufacturing technology is an advanced manufacturing technology used for fabricating parts layer by layer directly from a computer aided design (CAD) data file. The process builds objects by adding material in a layer by layer fashion to create a three-dimensional (3D) part, offering the benefit to produce any complex parts with shorter cycle time and lower cost compared to traditional manufacturing process. Additive manufacturing technology is widely used in engineering for customized products, functional models, pre-surgical models and conceptual models. This technology is finding its applications in many fields of engineering and industry, such as aircraft, dental restorations, medical implants and automotive products. With increased competition in the world economy, designers and production engineers face the challenge of producing products more quickly than ever to meet customer requirements and achieve competitive edge. Additive manufacturing process offers an efficient technique of building complicated geometry to shorten the design and production cycle time at the lowest cost due to the absence of any tooling needs [1–6]. There are many commercial additive manufacturing systems available in the market such as fused deposition modeling (FDM), direct metal deposition (DMD), 3D printing, selective laser sintering (SLS), inkjet modeling (IJM) and stereo-lithography (SLA). These systems differ in the manner of building layers and in the types of materials that can be fabricated by these processes safely

. FDM has been widely used in additive manufacturing technology that provides functional prototypes in various thermoplastics due to its ability to produce complex geometrical parts neatly and safely in an office-friendly environment. FDM was developed by Stratasys Inc. in the optimum process conditions is an important task for production engineers. It plays an important role to ensure quality of products, improve dimensional precision, avoid unacceptable wastes and large amount of scraps, enhance productivity rates and reduce production time and cost.

II. Methodology

2.1. Materials

In this study, a comparison was made between PLA and ABS materials in terms of mechanical properties

2.2. Experimental procedures

2.2.1 Specimen preparation

Samples shown in Figure: 1 were designed as 3D model according ISO 527 standard with Solid Works CAD software for impact test and tensile test using a designing software and transferred to 3D slicing interface program to be printed.

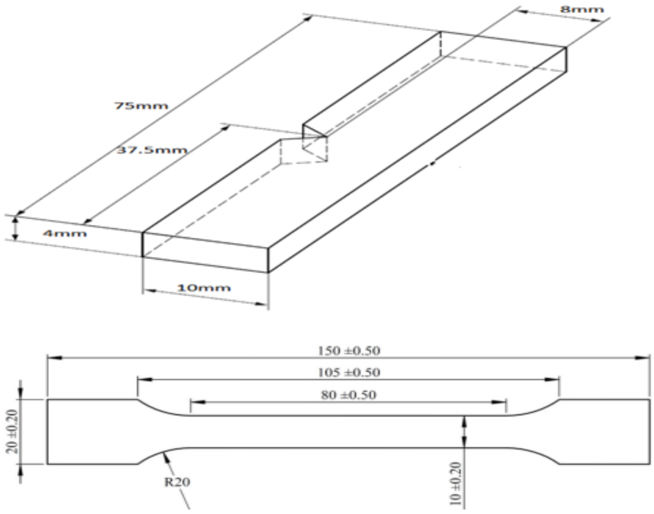

Figure 1. Dimensions of 3D printed Samples

For each type of mechanical test, 3 specimens were prepared and tested for both materials, and then the average value was taken for data analysis in order to improve accuracy and reliability of the experimental data. Figures 2(a,b) show the 3D printer used in this study, and the printer settings are given in the following table.

	ABS	PLA
infill	100%	100%
Printing temperature	240C^0	C^0 220
Build plate temperature	80C^0	60C^0
Print speed	mm/s 55	mm/s 60
Fan speed	100 mm/s	100 mm/s
Layer height mm	0.2 mm	0.2 mm

Fig:2a, Open 3D printer

Tensile tests for samples under the same condition were conducted with tensile test machine shown in Figure 3. Hardness tests for samples were conducted with hardness test machine shown in Figure 4.

Fig3. Impact Tensile Test Machine

Fig.4. Hardness Test Machine

Fig.5. Tensile Test Machine

III. Results

As was detailed in Table 1. ABS specimens were tested and Table (1) and figures: 5(a,b).

Fm: tensile strength

FP: yield strength

Ft: elastic limit

Table1: shows the results of the tensile test

	Fm (KN)	FP (KN)	Ft (KN)	Elong (mm)	Impact
ABS	0.812	0.797	0.579	1.7772	0.513
PLA	1.610	1.577	1.004	1.510	0.1.30
From ABSto PLA	97.8% ↑	98% ↑	73% ↑	12.8% ↑	294 % ↑

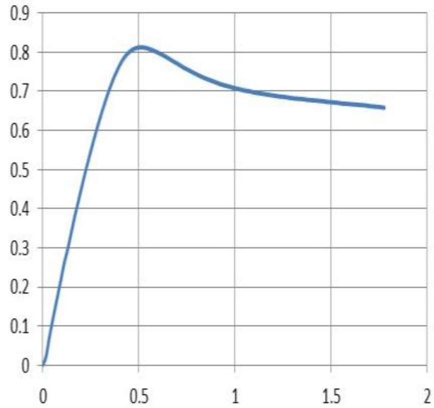

Fig: 5a, Tensile test curve for enclosed 3D printer

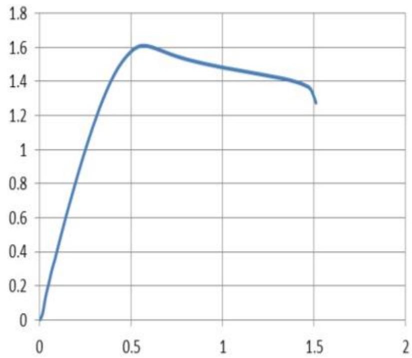

Fig:5b, Tensile test curve for an open 3D printer

The appearance of the 3D printed tensile test ABS and PLA specimens are shown in Fig: 6 (a,b)

Figure 6a. ABS 3D printed specimens

Figure 6b. PLA 3D printed specimens

IV. Discussions

The results showed an increase in Tensile Strength by (97.8%) in PLA and also an increase in yield strength by (98%) for PLA and an increase in Elasticity limit by (73%).

Also, an increase was observed in elongation, -Impact, with a percentage of (12.8%) and (294%).

As we noticed when testing the Hardness, a very large affinity between ABS – PLA.

V. Conclusions

1- Tensile Strength -yield Strength the highest in PLA

2- The penetration and scratch resistance Hardness is to be almost the same for both ABS / PLA.

3- The impact resistance of ABS is higher than the PLA.

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