EXPERIMENTAL COMPARISION OF ABS-LIKE RESIN AND ABS FILAMENT USED IN ADDITIVE MANUFACTURING

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Abstract: Some of the most popular types of additive manufacturing, often researched, are FDM (Fused Deposition Modeling) and SLA (Stereolithography) manufacturing. Researchers in the field have turned their attention to the development of new materials that meet certain requirements such as increased mechanical properties. This study aims to experimentally compare ABS-like materials used in SLA manufacturing with ABS material used in FDM manufacturing. Therefore, an experimental design was created in which the UV exposure times of the layers were varied both during the fabrication and the post-processing stages, after which tensile tests were performed using laboratory equipment. The results obtained from the SLA fabrication were compared with FDM fabricated parts and small differences in tensile strength could be observed.

Keywords: *additive manufacturing, fused deposition modeling, tensile strength, stereolithography*

1. Introduction

The continuous development of additive manufacturing technologies has led to new advanced materials with increasingly better mechanical properties. Among such materials used in FDM additive manufacturing is ABS (Acrylonitrile Butadiene Styrene). Research in the field has also led to the development of similar materials for SLA (Stereolithography) additive manufacturing, where resin-like materials are used, and in this case a type of resin similar to ABS material (ABS-like resin) has emerged. There is a number of research studies in the literature that analyse the differences between FDM and SLA parts. Overall, these are based on the differences in manufacturing method [1], surface quality [2], mechanical properties [3], printing precision [4] and overall resulted quality [5].

Taken individually, there has been a lot of research on both ABS filament [7-9] and ABS-like resin [10, 11]. However, the literature provides limited information on comparative studies between the two. In [12] a comparison between the two materials in terms of mechanical properties was performed and it was shown that there is a clear variation in both FDM and SLA tensile strength depending on the printing direction. However, the specimens used by the authors were made by the PolyJet method and were not subjected to post-processing by UV curing.

This paper aims to study the comparison between FDM and SLA according to printing parameters and curing time. The specimens were manufactured using a 3D printer produced by Prusa company, model i3 MKS S+ for the case of FDM parts and an Anycubic Photon S printer for the case of SLA parts. Due to the limited size of the SLA printer, the specimens were made according to ISO 527 type 2BA and tensile tests were performed using a laboratory stand.

The experimental results revealed overall small differences between the two types of materials studied when the uv exposure was low.

2. Experimental setup

2.1. Experimental plan and materials

For the comparative study between the 2 materials, an experimental design (Table 1) was carried out, where the printing parameters for the SLA manufactured parts were varied. The results allowed the plotting of the variation graphs for the studied factors. Subsequently, the results in Table 1 were compared with the results obtained for the case of specimens made using the FDM printing method (Table 2).

Table 1: Experimental plan for SLA parts

Nr. Exp.	Material	Exposure time, [s]	Curing time, [s]
1	ABS-like	5	30
2			60
3			100
4		8	30
5			60
6			100
7		10	30
8			60
9			100

. **Table 2:** Experimental plan for FDM parts

Nr. Exp.	Material	Infill type	Infill [%]
1	ABS	Cubic	30
2			60
3			100

ABS filament, produced by Devil Design, Mikolow Poland, was used in the experiments. The technical specifications and chemical composition according to the data sheets [13, 14] were listed in Table 3.

Table 3: ABS material properties.

Mechanical properties			
Tensile strength, MPa	Tensile elongation, %	Density, g/cm3	Vicat Softening Temperature, °C
42.168	30	1.04	94
Chemical composition			
Acrylonitrile-butadiene-styrene copolymer			
Aluminium powder		0.1 – 0.25 %	

In the case of ABS-like resin parts, resin produced by SUNLU was used, with technical specifications according to the data sheets provided by the manufacturers [15] in Table 4.

Table 4: ABS-like material properties.

Mechanical properties			
Tensile strength, MPa	Tensile elongation, %	Body Contraction, %	Elongation at break, %
20-35	15-25	70-80	15-25

2.2. Sample preparation and testing equipment

To achieve the objectives stipulated in the first part of the paper, specimens with dimensional shape according to ISO 527-2 type 1BA were used (Figure 1).

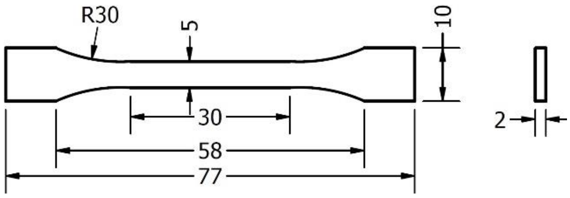


Figure 1: *Test specimens dimensions*

In the case of ABS parts made by the FDM method, a Prusa i3 MKS S+ 3D printer was used for manufacturing (Figure 2) using the printing parameters presented in Table 5.

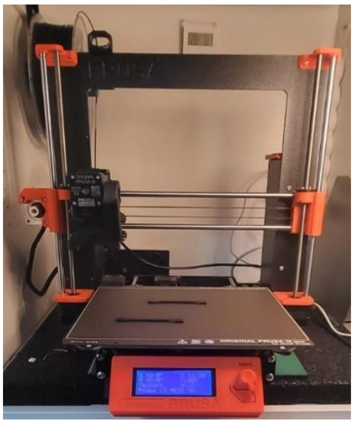
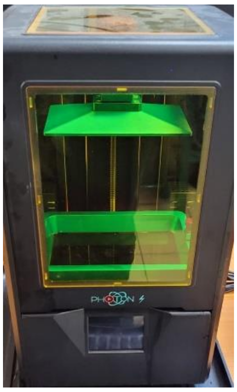


Figure 2: *Used 3D printer*

Table 5: Printing parameters for FDM parts

Parameter	Value	Parameter	Value
Layer height	0.2 [mm]	Printing temperature	245 [°C]
Nozzle	0.6 [mm]	Build platform temperature	100 [°C]
Infill type	Rectilinear	Print speed	45 [mm/s]
Printing direction	XY flat	Top/Bottom layers	2

For ABS-like resin parts made by the SLA method, an Anycubic Photon S 3D printer (Figure 3.a) was used for fabrication using the printing parameters shown in Table 1 and 6. UV exposure was performed using a curing station produced by Elagoo, model Mercury Plus 2.0 (Figure 3.b).



a. SLA printer

b. Curing station

Figure 3: *Used 3D printer and curing station*

Table 6: Printing parameters for SLA parts

Parameter	Value	Parameter	Value
Layer height	0.05 [mm]	Printing direction	XY flat

The printing direction for both types of specimens, based on the recommendations of articles that have studied the performance of 3D printing directions [10,12], has remained constant along the Y-axis, flat on build platform (Figure 4).

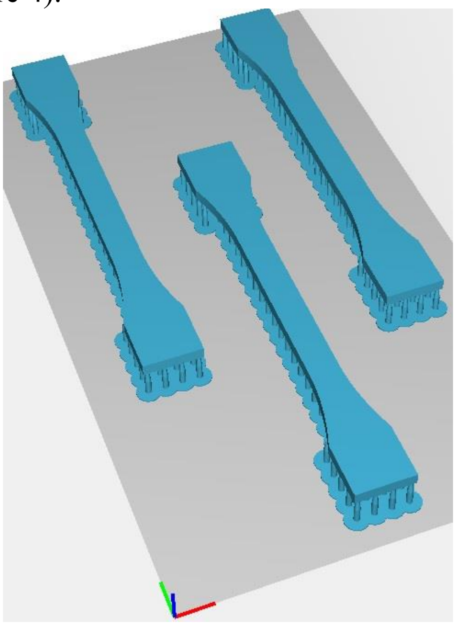


Figure 4: *Used 3D printer and curing station*

The tests were performed on the laboratory equipment shown in Figure 5 and thoroughly described in [16].

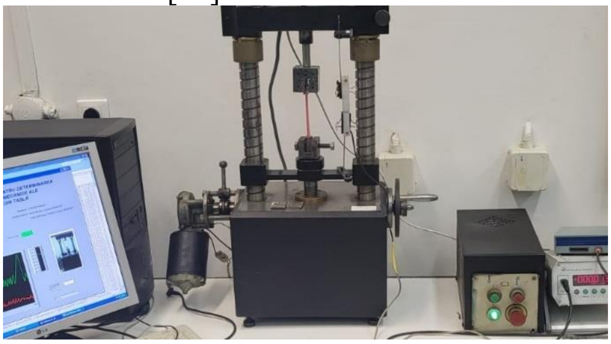


Figure 5: *Tensile testing laboratory stand*

3. Results and discussions

The experimental results obtained were listed in Tables 7 and 8, on the basis of which the variation plots in Figures 6 - 8 were made.

Table 7: Obtained values for SLA prints

Nr. Exp.	Material	Exposure time, [s]	Curing time, [s]	Tensile strength, [MPa]
1	ABS-like	5	30	10.00
2			60	10.62
3			100	11.87
4		8	30	12.49
5			60	13.12
6			100	13.75
7		10	30	13.70
8			60	14.37
9			100	14.98

. **Table 8:** Obtained values for FDM parts

Nr. Exp.	Material	Infill type	Infill [%]	Tensile strength, [MPa]
1	ABS	Cubic	30	9.370
2			60	10.62
3			100	11.24

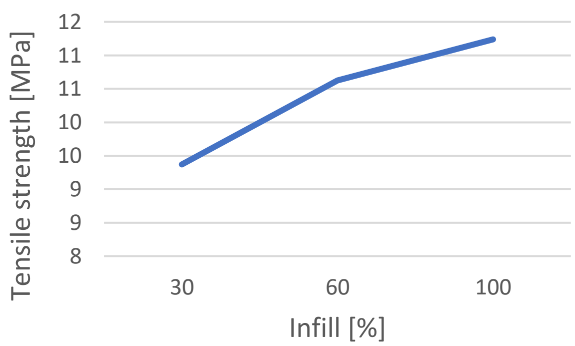


Figure 5: *Tensile testing laboratory stand*

Figure 8 represents the variation of recorded values for FDM printed parts, where it can be seen that the force required to break the specimens increases for higher values of the infill.

Figures 9 and 10 represent the variation of the recorded values for SLA printed parts and the comparison with the values obtained for FDM printed parts.

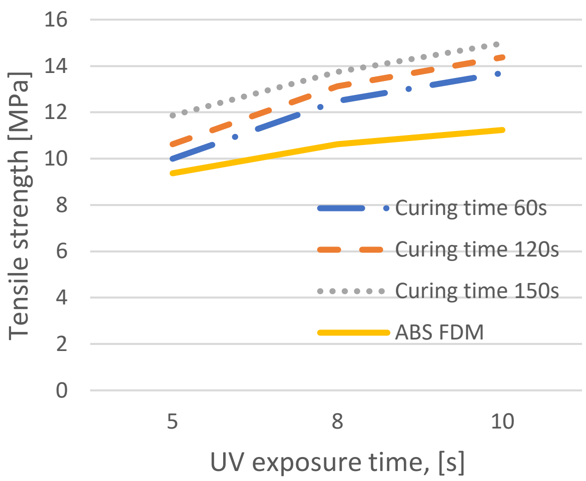


Figure 9: *Variation of tensile strength as a function of exposure time of the layers*

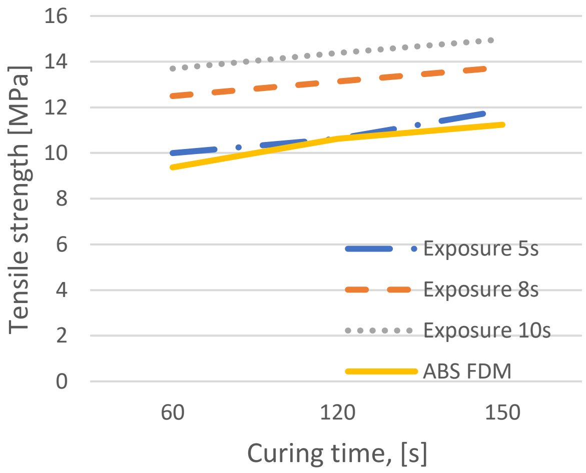


Figure 10: *Variation of tensile strength as a function of curing time*

The results show that as the duration of UV exposure increases, both for the actual printing process and for post-processing, the tensile strength of the specimens increases, the recorded values showing a linear variation.

Regarding the difference between SLA printed parts and FDM printed parts, it can be seen that ABS-like parts have a higher overall tensile strength than the other parts. However, the strength is also given by the UV exposure time for each layer, where parts exposed for 5 seconds showed close values with parts produced by the FDM method.

4. Conclusions

Studies on the mechanical properties of materials used in additive manufacturing are numerous but the field still presents opportunities for research. The main purpose of this paper is to compare the tensile strength between FDM printed parts and SLA printed parts. For the study, an experimental design was carried out where it was possible to observe the variation of the tensile strength of ABS-like parts depending on the duration of exposure to UV rays both during the printing process and in the post-processing stage specific to this type of manufacturing. Moreover, the variation of the tensile strength of FDM printed parts as a function of infill are similar to the results of other researchers [16], thus providing higher confidence on the values obtained also for the case of parts obtained by the SLA method from ABS-like material.

Experimental results have shown that, in general, SLA printed parts have a higher tensile strength than FDM parts. However, in SLA manufacturing, when a short UV exposure time was used during the printing process, the parts showed tensile strength values very close to FDM parts.

Based on the results obtained, it can be concluded that, using a longer UV exposure time, ABS-like parts show higher tensile strength than parts made of ABS by the FDM method. However, in the FDM process, the mechanical properties of the parts is given by a large number of factors such as the infill pattern (cubic, gyroid, etc.), factors that have not been studied in this paper, and in this regard will be subjected in future studies.

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