

Analysis of Tensile Strength In 3D Printer Filaments

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Abstract- An abstract is a brief summary of a analysis article. Now a days, 3D printer plays a major role. ABS and PLA are the most commonly used filaments in 3D printing process. But depends upon its properties like low strength, less accuracy and low finishing quality it will used rarely. so, let we decided to make the composite material with the combination of Polycarbonate with PLA and ABS in various combination mixing ratio and analyse the filament which is suitable for printing process depends upon the surface finishing, tensile strength and heat resistance. Due to sudden load and vibrations on the PLA/ABS objects it gets break due to low tensile strength. So we have tried to prepare a composites composed of acrylonitrile-butadiene styrene copolymer (ABS) and poly lactic acid (PLA) were prepared to develop ABS-based automobile console boxes with improved environmental friendliness And additionally we are trying to reduce the printing time of 3D printer.

Keywords- 3D printer, ABS, PLA, PC, Composite filaments, Heat resistance, Extrude, Testing, composites, Tensile strength.

I. INTRODUCTION

Composites composed of acrylonitrile-butadiene-styrene copolymer (ABS) and poly lactic acid (PLA) were prepared to develop ABS-based automobile console boxes with improved environmental friendliness. ABS/PLA composites without any additives showed extremely poor mechanical properties. Let we decide to create a composite filaments with a mixture of PLA and ABS. Depends upon the different heat resistance of PLA and ABS let we decide to add some polycarbonate with PLA, to increase the heat resistance. After the mixing of PLA and ABS let we extrude the composition as filament which is used in the 3D printer. However, increase in the content of polybutadiene moiety of ABS and introduction of proper compatibilizer and heat stabilizer enhanced the mechanical properties of ABS/PLA composites significantly. From the filament, let me make the samples in 3D printer and testing the samples in UTM.

Selection and extrusion of granules

There are large number of filaments available for printing like PLA, ABS, PC, Nylons, PETG, TPE/TPU, PVB, PVA, BVOH, PEEK, ULTEM(PEI), HIPS, PP, Amphora. Let we see briefly about this filament.

II. PROBLEM IDENTIFICATION AND OBJECTIVES

ABS/PLA composites without any additives showed extremely poor mechanical properties. Let we decide to create a composite filaments with a mixture of PLA and ABS. Depends upon the different heat resistance of PLA and ABS.

- In **PLA**, Heat Resistance is low and less Strength, So durability is low.
- In **ABS**, Curling and Warping is acquired and then cool slowly otherwise it gets cracked. Let we need to be maintain the lab temperature.

The main objectives are,

- For heat resistance, Let we combine the polycarbonate with PLA and ABS to increase the heat resistance.
- For Warping and Curling, Let we combine the PC with PLA and ABS in the ratio of different combination, So it also gets solidify quickly. Also normal room temperature is enough for printing.
- With the help of polycarbonate, PLA and ABS, the strength and durability of the material also increased.

III. METHODOLOGY

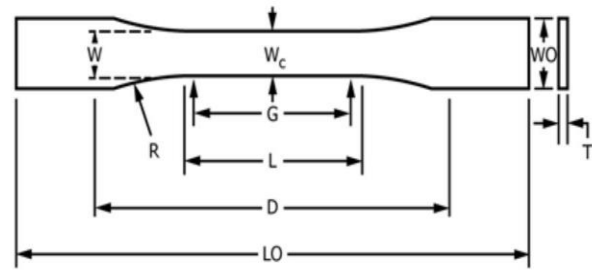


Fig 2: Standard design model

Standard design dimensions

We use the standard ASTM size of ASTM D 638 (Type V) for Standard Test Method for Tensile Properties of Plastics.

Standard design measurements	mm (inch)
Width of narrow section (W)	3.18 (0.125)
Length of narrow section (L)	9.53 (0.375)
Width overall (WO)	9.53 (0.375)
Length overall (LO)	63.5 (2.5)
Gage length (G)	7.62 (0.300)
Distance between grips (D)	25.4 (1.0)
Radius of fillet ϕ	12.7 (0.5)
Thickness (T)	4 (0.16)

From the below table we can draw the design.

IV. ANALYSIS AND MATERIAL SELECTION

There are lot of filaments are available like PLA, ABS, PC, Nylons, PETG, TPE/TPU, PVB, PVA, BVOH, PEEK, ULTEM(PEI), HIPS, PP, Amphora, etc., from that let we selected the most popularly used materials PLA, PC and ABS.

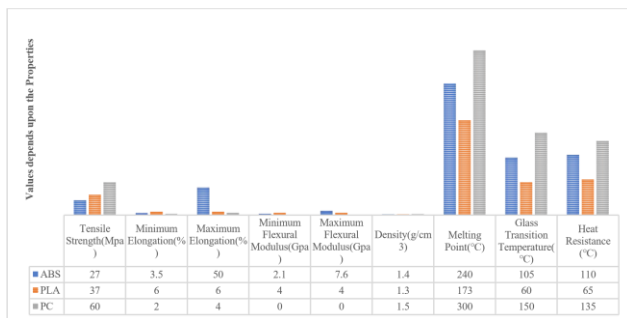


Fig 1: Mechanical Properties.

V. DESIGN

Depends upon the ASTM standard let we decide to use this following design for testing.

Design procedure

- Open solid works 2014
- Click New → part → OK in the dialog box, new window has been created for draw a solid parts.
- Click sketch and select the plane (Front plane), draw the centre rectangle from the origin coordinate. Again let we draw another small rectangle.
- And select tangent arc to draw the fillet radius in between the two edges of the rectangle.
- Hold alt and select the tangent arc and rectangle, which is to be tangency.
- Draw the centre reference lines on horizontal and vertical.
- Select mirror entities, click the entities which is to be mirror and then select the mirror about axis for mirror.
- Finally trim the entities which is not need by selecting the trim entities on trim to closest.
- Dimensions are in mm(millimetre) and also depends upon the ASTM standard as mentioned above.

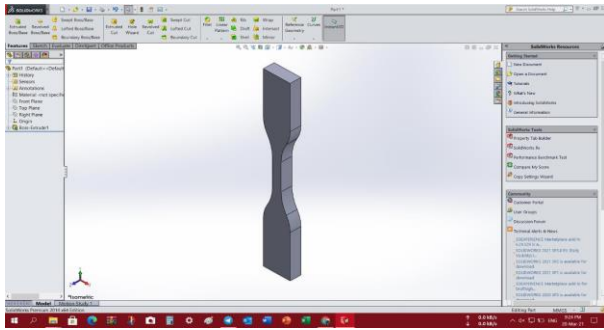


Fig 3: Standard design

VI. VARIOUS COMBINATION OF FILAMENTS

We created a composition of PLA and ABS for improving the strength, accuracy of smooth surfaces and also decrease the production time of the 3D printing. During the mixing of two powdered materials, let we analysed the heat resistance of PLA and ABS. From that let we get, ABS has higher heat resistance when compared to PLA, so while on production PLA get melted quickly than ABS.

As a result, we add some small amount of polycarbonate with PLA to increase the heat resistance. Eventhough, ABS has higher heat resistance, so we take different proportions of samples as

- 70% of PC/PLA and 30% of ABS (Sample 1)
- 60% of PC/PLA and 40% of ABS (Sample 2)

VII. TESTING THE SPECIMENS

After extruding the samples, Let we tested the samples with UTM (Universal Testing Machines).

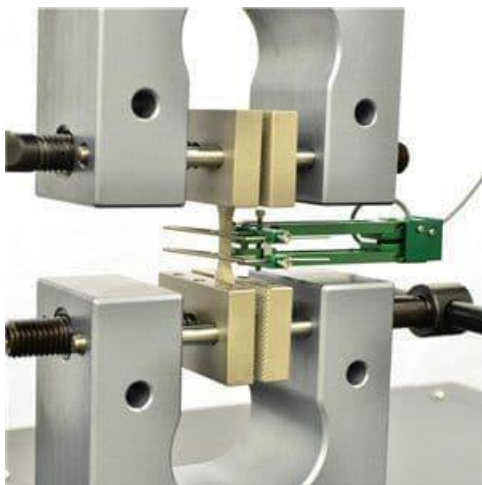


Fig 4: Universal Testing Machine



Fig 5 : Testing Samples

VIII. RESULT

It is the following result combination of PLA and Composite material of PC/PLA and ABS with 70:30 (Sample 1) in analysing software.

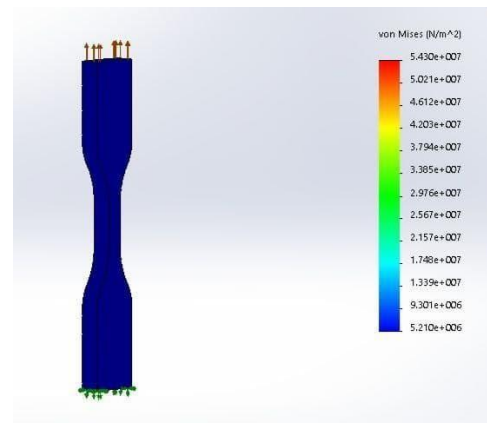


Fig 6 : Before applying load

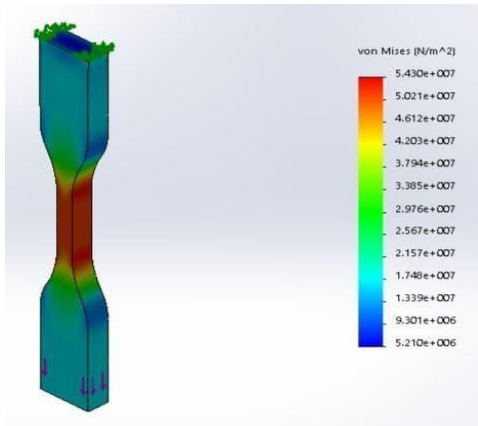


Fig 7 : After applying load

Table1: Stress strain values

STRESS(N/mm2)	STRAIN
54300000.00	0.02030
50220000.00	0.01883
46130000.00	0.01736
42050000.00	0.01590
37960000.00	0.01443
33870000.00	0.01296
29790000.00	0.01150
25700000.00	0.01003
21620000.00	0.00856
17530000.00	0.00710
13450000.00	0.00563

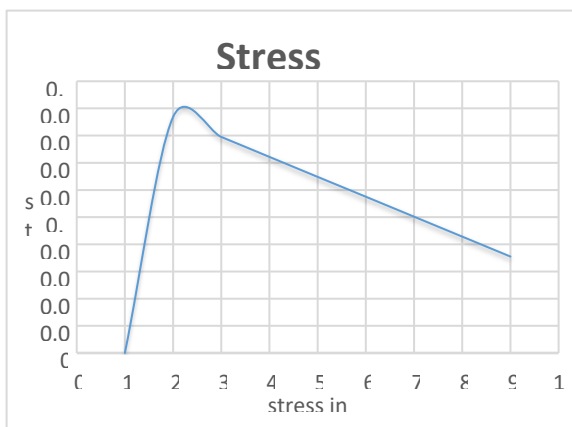


Fig 8: Stress strain curve

In sample 1, toxic content is more when compared to normal PLA, So it cannot be used for food handling purposes like food container, tea cups etc and also cannot be used for medical purposes like medical screw, drug carriers, etc. In Sample 2 (ratio of PLA and ABS in 60:40) unable to heat

on the 3D printer extruder because it requires more than 210 degree celcius and its brittle is high compared to sample 1.

Table 2: Result for sample 1

Print Settings				
	PLA	ABS	SAMPLE 1	UNIT
Extruder nozzle temperature	175 - 190	190- 210	190-210	[°C]
Heat bed temperature	60-70	60-70	60-70	[°C]
Density	1.3	1.04	1.66	[g/cm ³]
Mechanical properties				
Modulus of elasticity	3,500	2900	2,600	[MPa]
Tensile strength	37	27	42	[MPa]
Tensile strain at tensile strength	3.8	4.5	4	[%]
Tensile stress at break	21	19	26	[MPa]
Tensile strain at break	17.2	16	19	[%]
Flexural modulus	4	2.5	2.6	[GPa]

Sample 2 gets break while it was a filament, so after printing it may get break due to the high brittleness.

INCREASING SPEED WITH DECREASING TIME

In 3D printer, let we increase the speed with decrease in time by implementing the following ways

Infill density and wall thickness

Solid prints consist of thicker and stronger outliners and are filled in with honeycomb structure. If you do not use this structure, the 3D print will take a longer time before it is finished. However, if you already use an infill, you still have some options to increase your 3D printing speed. For example: try to reduce your infill even more, but keep in mind that the ratio between the wall thickness and infill remains good. This will prevent 3D models from collapsing

Two print heads

In this method, 3d printer contains two heads. One head is used for printing the main object and another is used for soluble support material, which is get soluble with acetone after the completion of entire object. By using this method let we able to increase the speed and decreasing the production time.

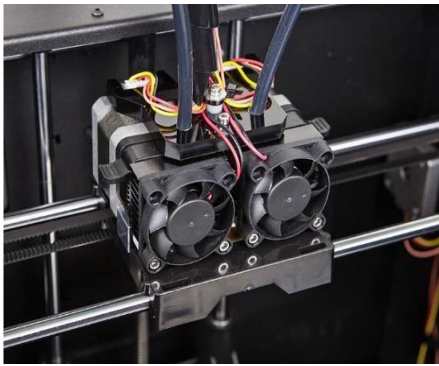


Fig 9 3D Printer with two heads

IX. CONCLUSION AND FUTURE SCOPE

Finally, we have analysed the various mixing proportions of the samples. From the samples, the mechanical properties with higher strength, heat resistance, accuracy of surface finish also increased. And then let we decrease the production time of the 3d printer.

In the future, it improves that all 3D printers will be integrated with smart technologies like sensors and machine learning. These technologies, combined with 3D printing, will significantly increase process repeatability by reducing the risk of build failures.

REFERENCES

- [1] Yury Yuryev, Amar K. Mohanty, Manjusri Misra, “ Novel durable biocomposites from biobased PC/PLA blend matrix system” , 2017.
- [2] P.Ravichandran, C.Anbu, R.Poornachandran, M.Shenbagarajan, K.S.Yaswahnthan, “Design And Development Of 3d Printer Filament Extruder For Material Reuse” , 2020
- [3] Charungkit Chaikewl and Kawee Srikulkit, “Preparation and Properties of Poly(lactic Acid)/PLA-g-ABS Blends”, 2018
- [4] Kazuhiro Hashima, Shotaro Nishitsuji, Takashi Inoue, “Structureproperties of super-tough PLA alloy with excellent heat resistance”, 2010
- [5] S.Aravind Raja , E.Muthukumarab , Jayakrishna.Kc, “A Case Study of 3D Printed PLA and Its Mechanical Properties”, 2014
- [6] ASTM Standards, “Standard Test Method for Tensile Properties of Plastics”, Designation: D638 – 14
- [7] Flash forge finder, “specifications and parameters of the 3D printer”, 2016
- [8] Mi Yeong Jo, Yeon Jong Ryu, Jun Hee Ko, Jin-San Yoon, “Effects of Compatibilizers on the Mechanical Properties of ABS/PLA Composites” , 2012.
- [9] ASM International, “Introduction to Tensile Testing. Let we got an idea about the testing procedures and stress strain curve” , 2004
- [10] Daniel Farbman, Chris McCoy, “Materials testing of 3d printed ABS and PLA samples to guide mechanical design”, 2016
- [11] Bates-Green, K and Howie, T, “Materials for 3D Printing by Fused Deposition”, 2017
- [12] European school fund, Malia, “Domain Group 3D Printing Workshop”, 2013