Evaluation of Wear Behaviour OFPLA & Abs Parts Fabricated by Operate FDM Technique with Distinct Orientations

C. Rajesh, N. Venkata Niranjan Kumar, G. Gowthami

Abstract--- Soft rapid tooling is one of the technology especially implemented to produce plastic components out of low melting point polymer by introducing it in to high melting polymer mould. By this technique parts or prototypes will be produced in less number for design verification, getting approval for actual production of product and as well as mould etc. Fused Modelling(FDM) is one of the additive Deposition manufacturing technology produced to parts in an additive manner. So far, several polymers like Acrylonitrile Butadiene Styrene (ABS), polyamide, poly lactic acid (PLA) were used for parts production in this domain. During the course of process engineering polymers may undergo wear because of the processing conditions like pressurized material in let, temperature etc. Choosing correct polymer for such application is a very important aspect. In the paper a comparison between 3D printed poly lactic acid polymer specimens and Acrylonitrile Butadiene styrene specimens fabricated through FDM technique will be tested for evaluation of difference between its wear rate, frictional force and friction coefficient. when printed with different printing orientations.

Keywords--- Acrylonitrile Butadiene styrene, 3D printed poly lactic, FDM technique

I. INTRODUCTION

Additive manufacturing is a manufacturing practice in which parts are built through layer upon layer addition of material on the report of given in the form of a CAD model. It is stated as the process of joining materials to produce objects from 3D model data, usually layer upon layer, as contrary to subtractive manufacturing processes. Additive manufacturing can serve in a Better way when compared with other manufacturing technologies. The Process chain in general consists of five basic steps starting with 3D modelling, data conversion and transmission, checking and preparing, building and post processing. According to the standard of the model and part in Steps 3 and 5 respectively, the process may be repeatupto acceptable model or part is attained [1-2]. The plastic distortion of thermoset epoxy resin with polyamine hardenerable to be clearly notice for the load vs displacement curves at modest loading rate, and became low for those at high loading rate [3]. The results of contact loads (70-200 N) and sliding speeds (0.2-2 m/s) on dry-sliding wear attributes of epoxy resin loded with 68.5 wt.% of crushed-silica particles (20-40 lm) at every contact load, the volume dropping increases in over a domain of low sliding speeds[4].



Fig. 1: Additive Manufacturing process diagram v



Fig. 2: Schematic diagram of Stereo lithography

The ABS/PA6 composites exhibited Peak erosion rate at 30 whereas minimum erosion rate at 90 angle of impingement. Maximum erosion rate was seen in only to ABS/PA6 hybrid composites-10% glass fiber reinforcement indicated the best erosive wear resistance compared to the other composites [5]. The 3D printing technology is a very well-rounded option for creating prototypes and even end-use parts. FDM industrial grade machines are capable of creating end use parts for short run manufacturing." FDM technology is able to produce parts to 0.005" (.127mm) tolerance consistently and reliably without tooling and moulding costs[7-9].

II. OBJECTIVES & METHODOLOGY

Objectives : 1. To study the influence of fused deposition modelling process parameters such as "part-built orientation on the wear rate of specified PLA & ABS matériel."

2.To find the wear rate, frictional force & coefficient of friction of the materials at variable machine parameters like different loads on pin, sliding speed (RPM of the disc).



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Table1: Physical Propretes Of PLA [6]					
Value					
Polylactic Acid (PLA)					
(C3H4O2)n					
157 - 170 °С					
49 - 52 °C					
61 - 66 MPa					
48 - 110 MPa					
1.24					
0.0037 - 0.0041 in/in					



Fig. 3: Fused Deposition Modeling

III. METHODOLOGY

Parameters for Specimen Modelling

The specimen that need to be designed for wear testing is in the shape of a cylinder. In this process we adopted ASTM G99-04 standards. The parameters are derived according to American Society for Testing and Materials (ASTM) standard dimensions. For designing current specimens, a standard dimension (ASTM G99-04) are adopted. Specimen dimensions are as follows:Height=30 mm&Diameter = 12 mm

Fused Deposition Modeling (FDM) Process

In this technique, Thermoplastic filaments are heated are extruded from a tip that moves in the x-y plane. In this process the CAD models are directly made of plastics by extruding a thermoplastic filament of semi molten state through a heated nozzle in a prescribed pattern onto a platform. The nozzle is moved over the platform in the required geometry of the part as per the dimensions and specifications given in the CAD data. When the platform is lowered, the second layer is deposited upon the first layer. The process is repeated until the required object is built.

The mostly used materials in this process are ABS which offers good strength, elastomer (96 durometer, polyphenol sulfone), polycarbonate, poly lactic acid and investment casting wax which extend the capabilities of the method further in terms of strength and temperature range [11].

Procedural Steps for Fused Deposition

1. DESIGN OF SPECIMEN, 2. CONVERSION OF CAD FILE IN TO STL FORMAT, 3. CONVERSION OF STL FILE IN TO CAM FILE, 4. PRINTING OF MODEL



Fig 4: Specimen designed in CATIA



Fig 5: Specimen printed through FDM

Experimental Procedure & Analysis

EXPERIMENTAL PROCEDURE: 1 PREPARE EOUIPMENT FOR TEST. 2. **SPECIMEN** PINCLAMPING, 3. SET WEAR TRACK RADIUS AND INSTALL SPECIMEN, 4. SETTING DISK SPEED, 5.APPLYING NORMAL LOAD, 6. CONDUCT THE TEST AND NOTE THE OBSERVATIONS

Parameters for wear test on the specimens

Specimens were checked for the evaluation of the wear rate. Out of which 4 Specimens were made up of PLA material with the following part fabrication parameters. and rest of the 4 specimens are made up of the ABS polymeric material. The both sets of Four specimens printed with same parameters were tested with similar wear testing settings such as Constant RPM, Load, Disk radius etc [13-15].



Fig 6: PLA Specimens with varied orientations



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Fig 7: PLA Specimens after removing supports



Fig 8: ABS Specimens with varied Orientations



Fig 9: ABS Specimens after removing supports

Pin-on-Disk wear testing is a method of characterizing the coefficient of friction, frictional force, and rate of wear between two materials. Multiple configurations are available depending on your goals and objectives. Common specifications include: ASTM G99, ASTM G133 and ASTM F732. Pin-on-disk wear testing can simulate multiple modes of wear, including: unidirectional, bidirectional, omnidirectional, and quasi-rotational[10].



Fig 10: DUCOM 20 LE Tribometer wear testing



Fig 11: Different parts of pin on disk apparatus

The following tabulated Parameters were kept constant for testing the specimen s printed at different orientations i.e. $0^{0},45^{\bar{0}},60^{0},90^{0}$ respectively for both materials ABS and PLA.

The wear Rate of the specimen can be calculated by using below formulae:

Mass Loss of the Specimen Can be calculated =Initial mass of the Specimen-Final mass after testing

Percentage Wear=Mass lossX100/initial mass.

Specific wear rate=Mass loss/Density X Time X Rubbing Speed X Load.

Mass loss can be calculated by measuring initial mass as well as the final mass of the spécimens [12].



Fig 12: Digital balance for finding mass loss. Table 2: Pin on disc paramètres

Parameter	value
Fill Density	100%
Wear track Radius	50mm
Testing Time	10 min
Disk RPM	1000RPM
Load	50N

IV. **RESULTS AND DISCUSSIONS**

The results observed in various tests are noted. The results of ABS and PLA are as follows :

Test Results For Specimens Printed With PLA With Variable Orientations

After variable orientation plots i.e., 0°,45°,60°,90° respectively it is to be depicts that printed specimen wear increases with an increase in time.



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And the frictional force is high in the initial limits and decreases with respect to time. With an increase in the time of exposure of pin the coefficient of friction is high at the initial limits and later on decreases in terms of peaks and valleys with $-0^{0},45^{0},60^{0}$ orientation.





The above plots are for 90° orientations, depicts that wear increases linearly with an increase in time Frictional force increases gradually with an increase in time and reduced with an increase in time of sliding. Coefficient of friction increases gradually in the initial limits and continues increasing in terms of peaks and valleys and starts decreasing with an increase in time.

Test Results for Specimens Printed With Abs With Variable Orientations

After variable orientation plots i.e., 0°,45°,60°,90° respectively it is to be depicts that printed specimen wear increases with an increase in time. Frictional force increases in terms of peaks and valleys with an increase in time. Coefficient of friction increases gradually in the initial limits and continues increasing in terms of peaks and valleys and increases with respect to time. with $-0^{0},45^{0},60^{0}$, orientation.



Graphs 4,5&6 : Plot for time Vs Wear, frictional force &coefficient of friction for 90° orientation



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Comparative Study between Wear Vs Frictional Force For Specimens Printed With Various Orientations I.E., 0°,45°,60°,90°FOR PLA & ABS





Graphs 7&8: Comparative graph between wear vs frictional force Specimens with PLA &ABS

For both PLA &ABS specimens printed with 0° orientations frictional force is linear and negative wear was achieved. For specimens printed with 45° orientations a max of 900 & 500 microns was achieved at a friction rate of 36N & 95N. For specimens printed with 60° a max of 1150 & 2000 microns was achieved. The specimen printed with 90° orientation yielded a maximum wear of 1300 & 2300 micron.

Table 3:	Wear test	results of PLA	& ABS	spécimens
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Print Specimen	PLA					A	BS	
Orientation	00	450	600	900	00	450	600	900
Initial Mass	3.3725	3.4592	3.4898	3.3378	3.0211	2.9923	3.1458	2.9451
Final Mass	3.3698	3.3660	3.3508	3.2356	2.6949	2.9765	2.5271	2.5659
Mass Loss (gm)	0.0027	0.0932	`0.139	0.1022	0.3262	0.0158	0.6187	0.3792

V. CONCLUSIONS

- Total four specimens fabricated at variable printing 1. orientations of $0^{0}.45^{0}.60^{0}.90^{0}$ of two different materials were tested.
- The Wear test was carried out at certain constant 2 Parameters like load 50N, time 10min, and at a disk RPM at 1000.
- Very slight effect of part-built orientation was 3. observed in both the Engineering polymers PLA and ABS.
- The wear rate was found to be maximum at 90° 4. orientations in both the materials.
- The maximum wear rate of 1300 microns was 5. achieved for the specimen printed with 90^0 flat orientations and with PLA material and a 2300 micron was achieved for specimen printed with ABS material.
- 6 Coefficient of friction is a scalar value, meaning the direction of the force does not affect the physical quantity.
- The wear rate & frictional force is found to be 7. maximum in ABS material when compared with PLA with respect to the selected printing. parameters.

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