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Experimental Study of Erosive Wear Characteristics of Various Polypropylene Polymers

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Abstract - *This paper describes the experimental study of erosive wear behaviour of polypropylene thermoplastic polymer (PPUF-01, PPUF-02, PPT-10 and PPT-20) and behaviour of melt flow index of material for erosive wear. The erosive behaviour was investigated by impinging the alumina particles of 50 µm size and various angle of impingement at different velocity and feed rate (abrasive particle) range. The experimental study concluded that severe wear was found at 30° impingement and alumina abrasive particles were embedded in test sample at high angles 60° & 75° and hence this shows the ductile nature of polypropylene polymer. This study also concluded that polypropylene talc filled (PPT10 & PPT20) were maximum wear out as compared to polypropylene unfilled (PPUF01 & PPUF02).The melt flow index also significantly affects the erosive wear behaviour of talc filled polypropylene polymer because value of melt flow index of 20% talc filled polypropylene (PPT20) were severely wear out as compared to 10 % talc filled polypropylene polymer.*

Key Words: *Polypropylene polymer; Melt flow index; impingement angle; erosive wear.*

1.INTRODUCTION

Polypropylene is a to a great degree flexible polymer since its properties can be change to meet particular requirements.[1] Mostly metal and plastic components of automotive have been replaced by the polypropylene polymer based materials because of polypropylene polymer material has significant weight to strength ratio as compare to other engineering materials. It provides the facility to make light in weight automotive and cost reduction.[2] In present, most of the components of automotives made by polypropylene such as Bumpers, Seating, Dashboard, Fuel systems, Body (incl. panels) Under-bonnet components, Interior trim, Electrical components, Exterior trim Lighting, Upholstery, Liquid reservoirs etc.[3] In a automotive vehicle approximately 22% polypropylene based material is used and starting of 2007, 690,000 tons of PP are used in automotive applications.[4,5]

In a polymer material, physical properties depend on the fillers and fibre reinforcement. The mechanical properties, mostly strength and stiffness are affected by the filler and fiber material.[6]

In tribological applications, the wear behavior of a polymer is influenced by both natural properties of its own and tribological system.[7] In this research work, experimental study was primarily centered on materials subjected to erosive wear of various polypropylene thermoplastic polymers due to the high possible use of these materials in many mechanical and structural applications. Hence, Erosion resistance of polymer composites has become a significant material property, particularly in selection of substitute materials. Bumpers and body panels are mostly subjected to air jet erosion in a automotive and with time those are greatly affected by erosive wear. The selected polypropylene grade polymer samples used were as follows, PPUF-01 (unfilled polypropylene), PPUF-02 (unfilled polypropylene), PPT10 (10% talc filled polypropylene) and PPT20 (20% talc filled polypropylene).[8,9]

1.1 Experimental Apparatus

The DUCOM TR-471 Air jet erosion wear tester machine is used for the experiment. The machine is designed to impinge test samples with controlled flux of erodent. The test system is versatile and allows user to control impingement velocity, impingement angle, erodent flux and temperature. The result of the test is reported as the loss of weight of sample. It may be converted to volume loss for comparative of materials. The test to be performed at different impingement angles different holders and fixtures are provided as shown in fig. 1

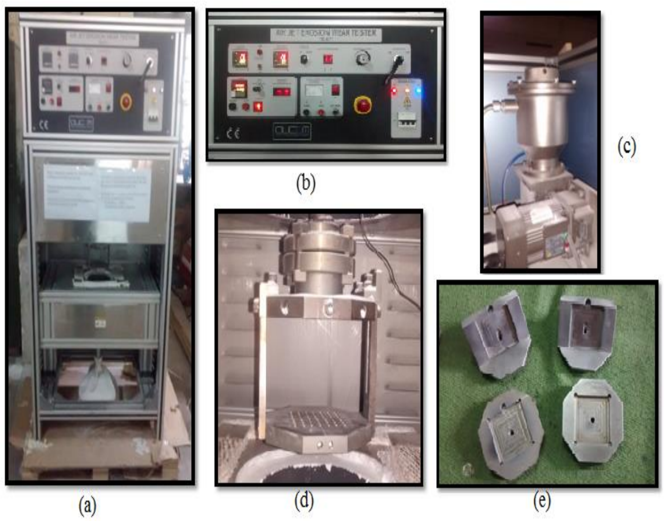

Figure 1: (a) Air Jet Erosive Wear Machine (b) Control panel (c) Hopper (d) Fixture (f) Specimen holder

The test variables are velocity, angle of impingment, erodent, erodent concentration (flux), temperature and time duration. There is separate compressor with the machine used to maintain constant air pressure. To have continuous stream of erodent & air, large quantities of erodent (Al_2O_3) 2 kg is stored in an air tight hopper after removing moisture. Alumina (Al_2O_3) abrasive particles used as erodent particle. The erodent particles are spherical in shape and 50 micron in size.

2. Experimental Procedure

The samples after cutting and cleaning are used for experiment. The hopper is checked and fully filled by pre heated erodent particles. Specimen is firstly weighted on electrical weighing machine and then fixed on the particular angle holder. The test is performed on three different angles 30˚, 45˚and 75˚, and there are separate holders for all angles. Now holder is fixed to the fixture and hydraulic is moved upward to isolate the specimen for outer environment. The timing and all other parameters now adjusted from the control panel of the machine. The air pressure is fixed to 0.85 bar that gives corresponding air velocity as75m/s, frequency is fixed to 15 Hz that gives corresponding discharge as 7.5 gm/min and time period of 10min fixed. After 10 min time period completed the hydraulic is moved down and the specimen is taken out of holder, cleaned by acetone and again weighted on electric weighing machine. The difference in weight is noted as weight loss. And same procedure is continued for all the types of polymers at different angles and two readings are taken at each angle. A graph is plotted between the weight losses at different angles.

Table -1: Specification of Experimental Apparatus

S. No.	Parameter	Unit	Range
1	Velocity	m/s	31 to 100
2	Angle of impingment	degree	15°,30°,45°,60°,75° & 90°
3	Nozzle bore diameter	mm	1.5
4	Sample size	mm	50 X 50 X 5
5	Hopper capacity	gm	2

Table -2: Experimental Test Parameters

S. No.	Factors	Units	Sets
1	Air Pressure	bar	0.85
2	Air Velocity	m/s	75
3	Erodent Discharge Rate	Gram/min	7.5
4	Impingement Angle	Degree	30, 45, 75

2. Result and Discussion

Table -3: Weight loss of Polypropylene

S. No.	Materials	Weight loss at different angles of impact (in milligram)			
		30˚	45˚	60˚	75˚
1.	PPUF-01	0.5	0.7	-1.00	-2.795
2.	PPUF-02	1.05	0.55	-1.26	-1.85
3.	PPT20-05	2.25	1.6	-2.13	-2.69
4.	PPT10-01	1.9	0.75	-2.72	-2.995

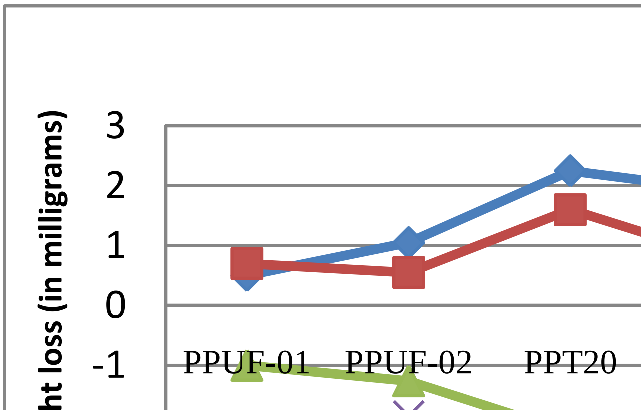

Chart -1: Weight at different angles

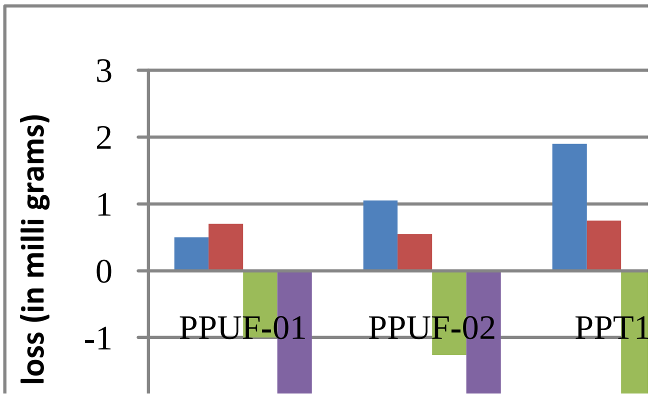

Chart -2: Comparison of weight loss between PP grades

- The maximum erosion wear is observed at 30˚ impingement angle and that shows that the polymer tested under goes ductile failure.
- In case of PPUF-01 and PPCP, the erosion wear values at 30˚are low compared to other polymer samples. This might be because the Melt Flow Index (MFI) values of both are also low and that may led to mechanical strengthening of the surface.
- The alumina (Al_2O_3) erodent particles got embedded into the polymer samples at 60˚ and 75˚ impingement

angles, this also points towards the ductility of polymers.
- The pictures in table 4 shows the erosion pattern and can easily identified specially of 75° impingement angle.

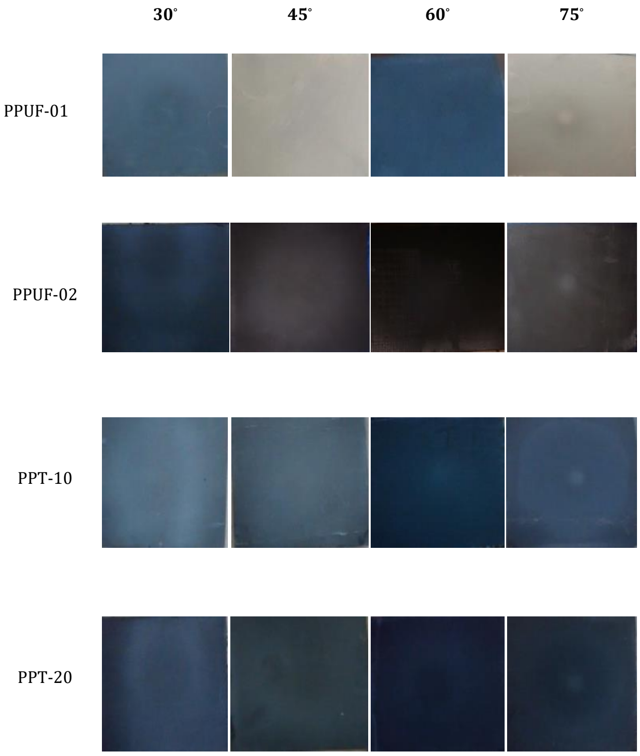

Fig -2: Erosion impressions on samples

3. CONCLUSIONS

The experimental investigation on the effect of erosion wear of different grades of thermoplastic polymers (Polypropylene-PP) was concluded. The experiments lead us to the following conclusions obtained from this study:

- The influence of impingement angle on erosive wear of all grades found maximum weight loss at 30° impingement angle.
- At 60°and 75° impingement angles there is no erosive wear, the erodent get imbedded in the polymer and hence sample weight increased.
- The comparison between PPUF (unfilled) and PPT (talc as filler) shows that the erosive wear of PPT is higher than PPUF.
- The comparison between PPT20 (20% talc) and PPT10 (10% talc) shows that the erosive wear of PPT20 is higher than PPT10 as the value of melt flow index (MFI) of PPT20 is higher than that of PPT10.

The comparison between PPUF-01 and PPUF-02 shows that the erosive wear of PPUF-02 is higher than PPUF-01 as the value of melt flow index (MFI) of PPUF-02 is higher than that of PPUF-01.

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