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Evaluation of Mechanical and Tribological Properties of Composite Materials

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Abstract: **This project gives "Evaluation of Mechanical and Tribological Properties of Composite Materials" advance mechanical properties of composite material and making a new composite material with the help of preparation of specimen and performs various tests. Composite material are used in various place due to their light weight such as aerospace, automotive, smart material and chemical industries. This project works represent the results of mechanical and tribological test of composite. The mechanical and tribological properties of 20wt. % short glass fiber reinforced 80 wt. % POM and 20 wt. % PTFE blend were studied. Tensile strength of the POM/PTFE blend reinforced with 20wt. % short glass fiber is high when compared with pure polyblend. i.e. its value increases from 46.5N/mm^2 to 75.36 N/mm^2 which is a 63% increase.**

Keywords:* *composite materials, Fillers, Mechanical properties of composite material, scanning electron microscopy.

1. INTRODUCTION

The development of composite materials and related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are multifunctional materials having unprecedented mechanical and physical properties that can be tailored to meet the requirements of a particular application. Many composites also exhibit great resistance to high-temperature corrosion and oxidation and wear. These unique characteristics provide the mechanical engineer with design opportunities not possible with conventional monolithic (unreinforced) materials. Composites technology also makes possible the use of an entire class of solid materials, ceramics, in applications for which monolithic versions are unsuited because of their great strength scatter and poor resistance to mechanical and thermal shock. The objective of the project is to examine the mechanical and tribological behavior of short glass fiber reinforced Polyoxymethylene (POM) and polytetrafluoroethylene (PTFE) polymer blend composites for brake applications of automobile. The mechanical and tribological properties of 20wt. % short glass fiber reinforced 80 wt. % POM and 20 wt. % PTFE blend were studied. This work is believed to be helpful for understanding the function of short glass fiber in POM / PTFE polymer blend and to understand the mechanism of polymer blend and their association with the short glass fibers during their mechanical and tribological performances under various abrading distances & loads for tribological / aerospace / automobile applications.

2. BACKGROUND OF COMPOSITE MATERIALS

They studied the mechanical and tribological properties of blends in different compositions. It was found that the polymer blends greatly improved the mechanical properties of PA66/HDPE. The frictional coefficients of the blends with different compositions were almost same and approximately equal to that of pure HDPE. Tribological studies showed that the blends with 80% vol. of PA66 exhibited the best wear resistance.They studied the mechanical and tribological properties of the PEEK-PTFE blend and showed the behavior of the same blend under various wear modes of the abrasive nature. They also studied the adhesive wear behavior of the same blend and showed that, with increase in PTFE content to the blend decreases the coefficient of friction in all wear modes. From the literature survey and also as per our knowledge, very less work has been carried out on the Polyoxymethylene and PTFE blend reinforced with short glass fibers. On the other hand, polymer blending is one of the fascinating methods for polymer modification.

3. EXPERIMENTAL OBSERVATION

A. All test specimens were injection molded from the pelletized polyblend material obtained from co-rotating extruder. The temperature maintained in the two zones of the barrel was zone 1 (265 ºC) and zone 2 (290 ºC) and mold temperature was maintained at 27 ^{0}C. Finally, the specimens are produced as per ASTM.

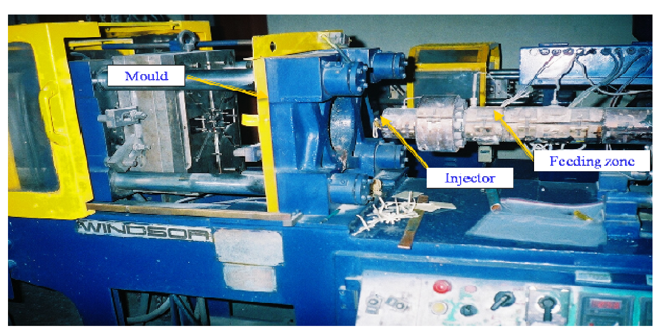


Fig. 1: (Schematic Diagram of an Injection Molding Machine)

B. The tensile test is the most widely used test to determine the mechanical properties of materials. In this test, a piece of material is pulled until it fractures by using Universal tensile testing machine (UTM, JJ Lloyd, London, United Kingdom, capacity 1–20 kN) .

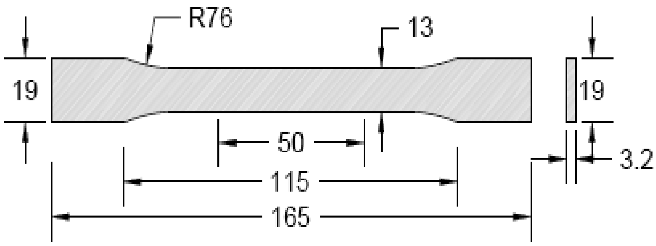


Fig. 2(Drawing showing ASTM D 638)

C. Tensile tested specimens of 80wt. % of POM and 20wt.% of PTFE, also 20wt.% of short glass reinforcement to the blend.

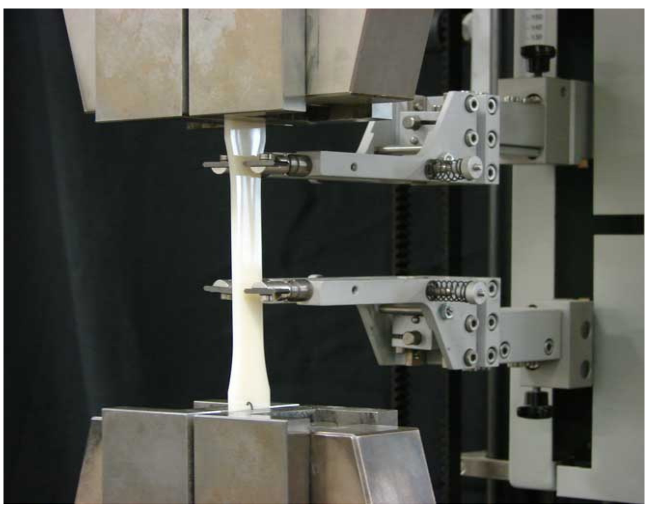


Fig. 3 Computerized Universal Testing Machine

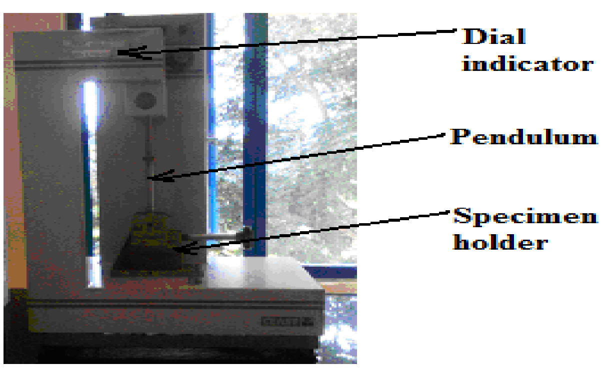


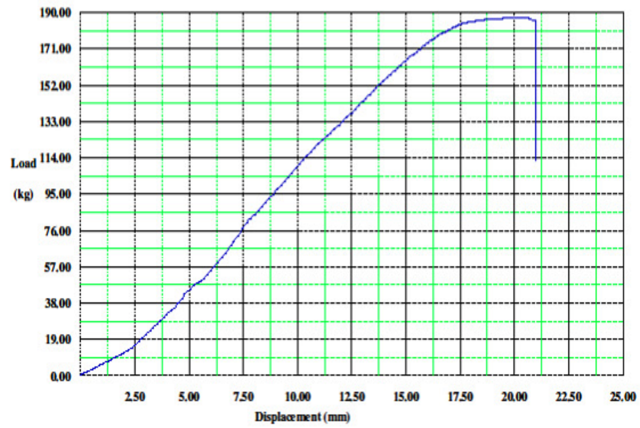
Fig. 4 (Schematic Diagram of an Impact Tester)

Table 1 (Console Table of Mechanical Properties)

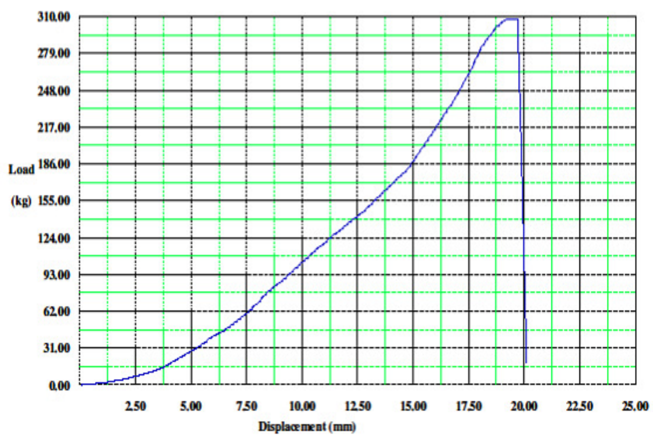
SL. NO	PROPERTIES	TEST METHOD	UNITS	POM /PTFE (1A)		POM /PTFE/SGF (2A)	
1	Density	ASTM D 792	gr/cc	1.48	1.47	1.5	1.51
2	Melt Flow Index	ASTM D 1238	gr/10min	NF	NF	NF	NF
3	Tensile Strength (5mm /Min)	ASTM D 638	MPa	46.03	46.97	75.78	74.95
4	Tensile Elongation at Yield	ASTM D 638	MPa	16.5	17.77	17.13	15.44
5	Flexural Strength (2 mm /Min)	ASTM D 790	MPa	78.25	79	116.2	102.6
6	Flexural Modulus	ASTM D 790	MPa	2547.8	2850	4747.9	5025.5
7	Izod Impact Strength at (3.2 mm/s)	ASTM D 256	J/m	41	42	31.25	32

Table 2 (Experimental Details of Tensile Test for Pure Blend Composite (POM /PTFE)(1A) and POM/PTFE/SGF Composites)

Material	1A (POM/PTFE)	2A (POM/PTFE/SGF)
Load Limit (kg)	700	
Travel Limit (mm)	500	
Peak Load (kg)	187.1	308
Break Load (kg)	187.1	308
Elongation at Peak Load (mm)	20.19	19.7
Elongation at Break Load (mm)	19.78	19.7
Yield Load (kg)	187.1	308
Elongation at Yield Load (mm)	19.78	19.7
Specimen Length (mm)	165	
Specimen Width (mm)	13	
Speed (mm/min)	5	
Area (Sq. mm)	41.6	
Tensile strength at Peak Load	460.384	757.874
Tensile strength at Break Load	460.384	757.874
% Elongation at Peak	17.56	17.13
% Elongation at Break	17.20	17.13
Yield Strength (Kg/Sq.cm)	460.384	757.874
% Elongation at Yield	17.20%	17.13%
Young's Modulus (MPa)	832.51	1769.0



(a)



(b)

Fig. 5. Load v/s Displacement Curve For a) POM/PTFE Blend Composite and b) POM/PTFE/SGF Composites

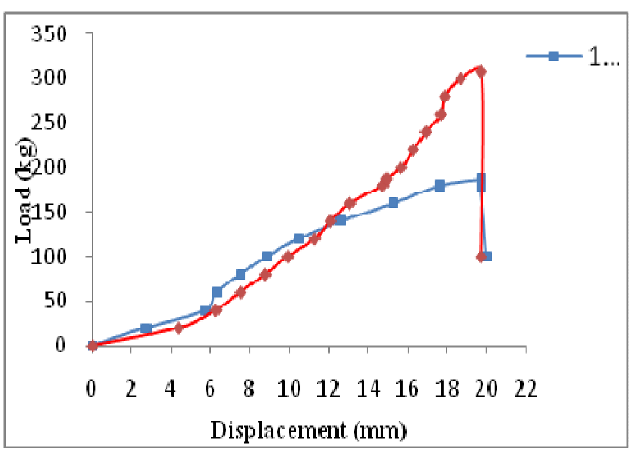


Fig. 6 (Comparative Graph of load v/s Displacement of POM/PTFE and POM/PTFE/SGF Blends)

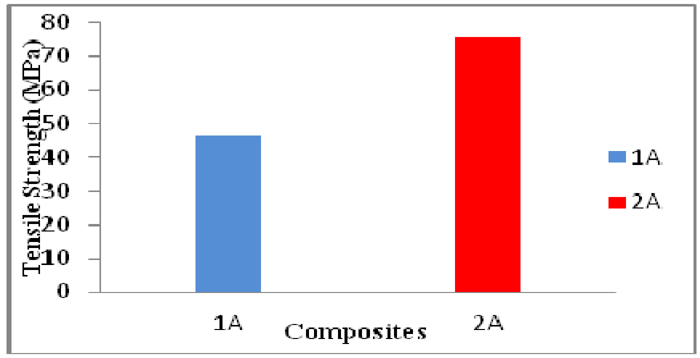


Fig. 7 (Graph Showing Tensile Strength of POM/PTFE Blend and POM/PTFE/SGF Polymer Blend)

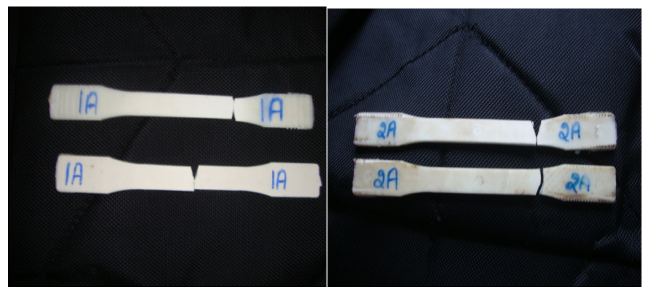


Fig. 8 (Specimens After Tested In Universal Testing Machine (a) POM/PTFE Blend and (b) POM/PTFE/SGF Polymer Blend)

TRIBOLOGICAL PROPERTIES

Material ID	Time in min	Weight before wear	Weight after wear	Weight loss	Wear volume (mm^3) x10^3	Sp. wear rate mm^3/Nmx10^6
1A	5	2.53500	2.5342	0.0008	0.543	0.367
	10	2.54630	2.5414	0.0016	1.084	0.3615
	15	2.50336	2.49976	0.0022	1.491	0.3314

Table 3(Wear Volume Data for POM/PTFE Blend Composites at 5N)

Material ID	Time in min	Weight before wear	Weight after wear	Weight loss	Wear volume (mm^3) x10^3	Sp. wear rate mm^3/Nmx10^6
1A	5	2.53500	2.5342	0.0008	0.543	0.367
	10	2.54630	2.5414	0.0016	1.084	0.3615
	15	2.50336	2.49976	0.0022	1.491	0.3314

Table 5.(Wear Volume Data for POM/PTFE/SGF Blend Composites at 5N)

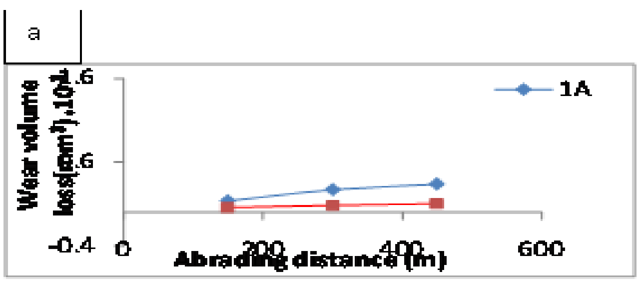
Material ID	Time in min	Weight before wear	Weight after wear	Weight loss	Wear volume (mm^3) x10^{-3}	Sp. wear rate mm^3/Nmx10^{-6}
2A	5	2.54043	2.54040	0.00008	0.0533	0.071
	10	2.55300	2.55212	0.00012	0.08	0.053
	15	2.53400	2.53272	0.00015	0.1	0.044

Table 6 (Wear Volume Data for POM/PTFE/SGF Blend Composites at 10N)

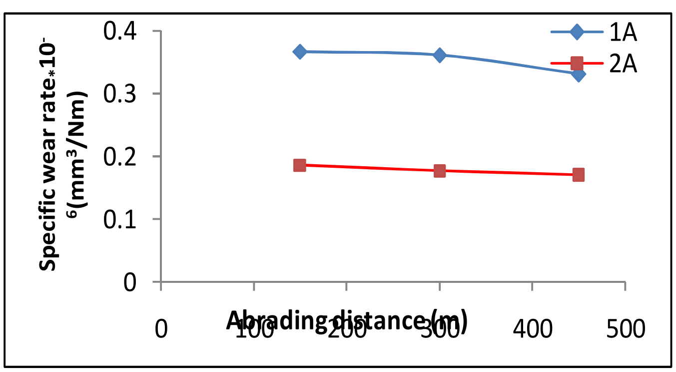
Material ID	Time in min	Weight before wear	Weight after wear	Weight loss	Wear volume (mm^3) x10^{-3}	Sp. wear rate mm^3/Nmx10^{-6}
2A	5	2.57426	2.57384	0.00042	0.28	0.186
	10	2.56100	2.55944	0.00080	0.533	0.177
	15	2.58200	2.52581	0.00115	0.766	0.170

Table 4 .(Wear Volume Data for POM/PTFE Blend Composites at 10N)

Fig. 8 (Wear Volume Loss of POM/PTFE and POM/PTFE/SGF at (a) 5N and (b) 10N)



(a)



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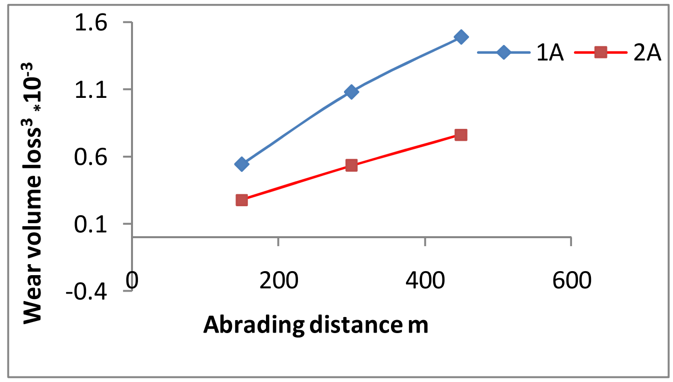

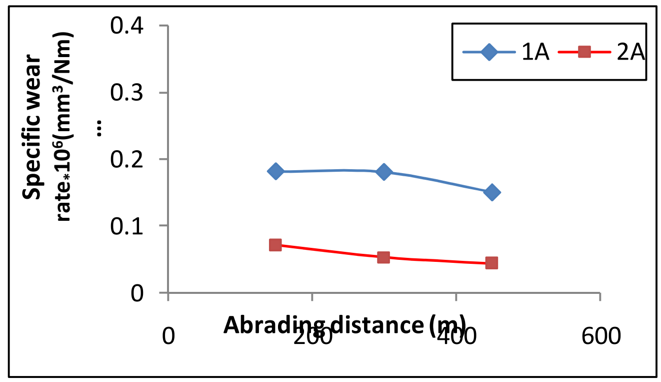

Fig. 9 (Specific Wear Rate of POM/PTFE and POM/PTFE/SGF at (a) 10N and (b) 5N)

4. CONCLUSIONS

Mechanical Properties

- The combination of 80wt. % POM/ 20wt. % PTFE polymer blend is the best blend for the mechanical aspects of polymer composites.
- Tensile strength of the POM/PTFE blend reinforced with 20wt. % short glass fiber is high when compared with pure polyblend. i.e. its value increases from 46.5N/mm^2 to 75.36 N/mm^2 which is a 63% increase.
- Ductility of the polymer blend decreases with increase in glass fiber reinforcement.
- Flexural strength of SGF reinforced POM/PTFE blend polymer composites is increased when compared the same with neat blend. The flexural strength of the polyblend is 78.62 N/mm^2 and SGF reinforced POM/PTFE polymer blend is 109.4 N/mm^2, which is 39.14% increase.

Tribological Properties

- Adhesive wear data reveal that the wear volume tends to increase near linearly with increasing abrading distance and strongly depends on the applied load for all the composites tested. It was observed that the wear performance is improved for POM/PTFE/SGF polymer blend composites due to inclusion of definite weight percentage of SGF.

- The specific wear rate is also decreases with increasing distance but increases with increase in applied load. The results revealed higher adhesive nature of POM/PTFE/SGF compared to POM/PTFE polymer blend.
- Abrasive wear shows that the wear volume loss of neat blend greatly increased with increase in abrading distance abraded against coarse 180 grit SiC abrasive paper.
- The wear volume loss of neat blend greatly increased with increase in abrading distance abraded against coarse grit, increase in normal load increases the contact stresses, depth of penetration of the grit on the sample surface and hence the wear volume loss.

Scanning Electron Micrography

- Scanning electron microscopy reveals that the composite photomicrographs indicate that there is severe damage on the worn surface. The polyblends are damaged more severely than that of the SGF reinforced polymer blend composites.
- Fracture process leads to more fiber breakage and some fiber removal due to the ploughing and cutting action.

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