Enhancement in Mechanical Properties of Polyphenelene Sulphide (PPS) Composite with Filler Material Glass Fiber and Carbon Fiber

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Abstract- **This work describes the wear behavior of polyphenylene sulphide composites was investigated according to normal load and speed. Two types of materials were studied: first, with 30 % glass fiber, and second, with 30 % carbon fiber. tests were performed on the universal tribometer TR-20, using a pin-on-disc device. The friction coefficient and wear rate for the composites were analyzed. As a result of experimental tests, it was established that polymer composite with polyphenylene sulphide, carbon fibers, and glass fiber exhibit good wear behavior under operating conditions. The effect on the friction and wear nature of PPS polymer composites has been improved, with addition of Glass Fiber (GF) and Carbon Fiber (CF) at room temperature. The objective of this work will be to study the friction and wear properties of PPS filled with CF and GF at room temperature as well as to increase mechanical behavior of PPS without loss of mechanical properties with addition of suitable filler such as GF & CF.**

Index Terms: **Composites, Filler material, PPS, GF, CF.**

I. INTRODUCTION

A. Polyphenylene sulfide

It is an organic polymer consisting of aromatic rings linked with sulfides. Synthetic fiber and textiles derived from this polymer are known to resist chemical and thermal attack. Polyphenylene sulfide (PPS) is a partially crystalline, high temperature performance polymer that has the chemical structure shown in the figure on the right. This polymer has a high melting point of approximately 280°C, excellent chemical resistance and is inherently flame retardant. It possesses self-extinguishing properties without the addition of any flame retardant chemical additives.

Fig 1.1 Partially Crystalline Structure Of Polyphenylene Sulfide (PPS)

Polymeric materials have been replacing metallic materials used as friction and wear parts for many years. It is often found that, however, the unmodified homo polymer could not satisfy the demands arising from the situations where a combination of good mechanical and tribolgical properties is required. Polymer blending is a fascinating method for polymer modification because it has simple processing and unfolds unlimited possibilities of producing materials with variable properties. Some researchers studied the tribological properties of polymer blends and pointed out that the friction and wear properties varied continuously with the compositions for most polymer blends and the optimal properties were obtained at a certain composition, although some data reported were conflicting Unfortunately, the studies on the tribological properties of polymer blends are very limited.

B. Glass Fiber

These fibers are most widely used and they are least expensive of all the fibers. These composites have very high specific strength, but they are not rigid hence limited to service temperatures below 200^0 C.

Applications:These composites are used in automotive and marine bodies, leaf springs, sporting goods, chairs, storage containers etc.

C. Carbon Fiber

These fiber composites have lower density high strength and higher stiffness to weigtht ratio.

An important property of this composite is its low coefficient of thermal expansion which gives better dimensional stability.

Application: these fiber composites are used in sports aircraft and helipcopter components(structures and satellites), motor cases, etc.

II. PROBLEM DEFINITION

In the petroleum, chemical industry and coalmines where high temperature is often evolved, special materials have to be used. The high wear rate at high temperature is a serious problem in a large number of industrial applications such as elevated temperature compressor piston rings and bearings. Meanwhile to meet the combination of light weight and high strength demands polymer based materials are increasingly applied in many industries. However, at temperatures above 180^0C is a challenge for most of the polymer composites.

III. MATERIALS AND METHODS

This chapter describes the details of processing of the composites and the experimental procedures followed for their characterization and tribological evaluation. The raw materials used in this work are:

1. Polyphenylene Sulphide (PPS)
2. Glass Fiber (GF)
3. Carbon Fiber (CF)

A. Processing of The Composites

The following grade of composites material used for specimen preparation from following source.

PPS Neat (unfilled) (Trade name Perfect Polymer, Pune)

PPS with adding Glass Fiber and Carbon Fiber (Trade name Perfect Polymer, Pune)

Sample preparation for Wear Test Disc

The disc of diameter 165 mm and thickness 8 mm is selected as the rotating counter surface. The tungsten carbide coated En 8 steel is to be select. The disc having four equidistance holes at 145 mm pitch circle diameter.

Pin Size - The specimens for wear test were prepared of diameter 12 mm and height 30 mm. For hardness test specimens were prepared of diameter 12 mm and height 30 mm.

Table 3.1 Designation of Composites

Specimen	Compositions
C1	PPS 100%
C2	PPS + 30% Glass Fiber
C3	PPS + 30% Carbon Fiber

Operating parameters were selected for the studies.(Select from the Catalog Polymer Ball Bearing From SKF)

Loads applied: 110 N and 210 N

Temperature: at room temperature

- Sliding velocity: 0.71m/s and 1.09 m/s

$V= (\pi DN) / 60$

where, D = Diameter of shaft.

N = Bearing speed in rpm

$V= (\pi\times0.012\times1750) /60$

$V = 1.09$ m/s

$V= (\pi\times0.012\times1140) /60$

$V = 0.7$ m/s

B. Experimental Setup

Fig 3.1 Pin on Disc Apparatus.

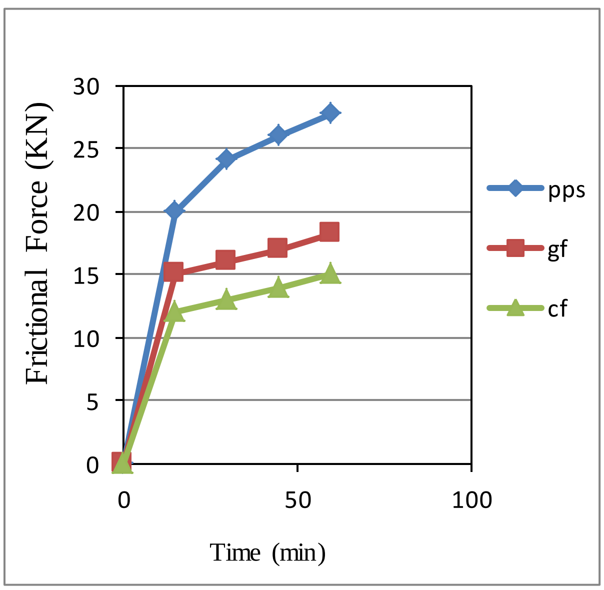
Table 1: Wear, Coefficient of Friction, Normal Load at 110 N, Velocity 0.7 m/s at Room Temperature

Sr. No.	Material	Frictional force (N)	Wear (µm)	Coefficient of Friction (µ)
1	PPS	27.7	98	0.25
2	PPS+ 30%GF	18.2	61	0.16
3	PPS+ 30%CF	15.0	31	0.13

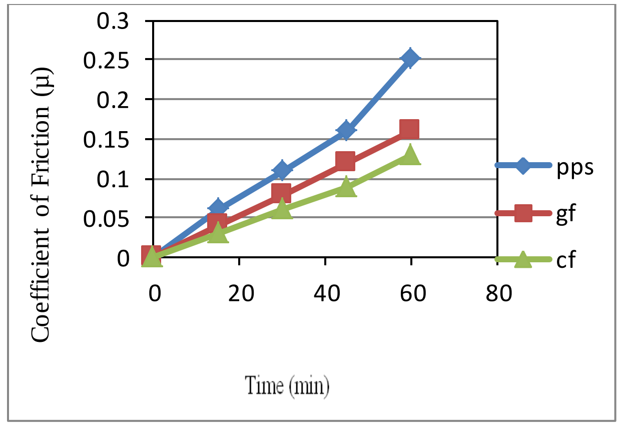
Table 2: Wear, Coefficient of Friction, Normal Load at 210 N, Velocity 1.09 m/s at Room Temperature

Sr. No.	Material	Frictional force (N)	Wear (µm)	Coefficient of Friction (µ)
1	PPS	51.4	205	0.24
2	PPS+ 30%GF	36.9	118	0.18
3	PPS+ 30%CF	28.4	60	0.14

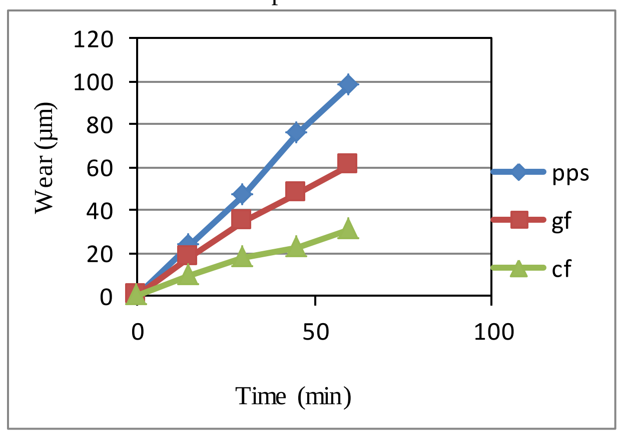
IV. RESULTS AND DISCUSSION



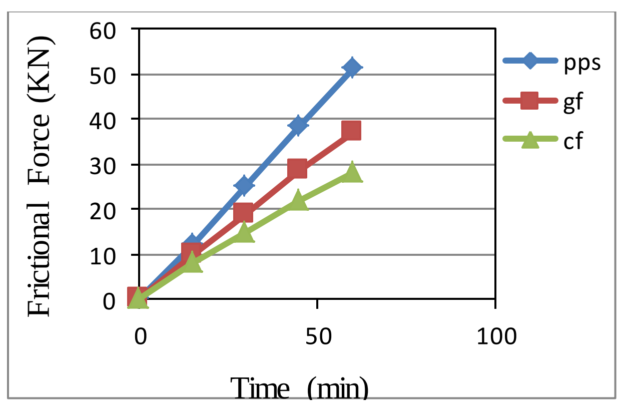
Graph : Frictional Force Vs Time for Normal Load at 110 N, Velocity 0.7 m/s at Room Temperature.



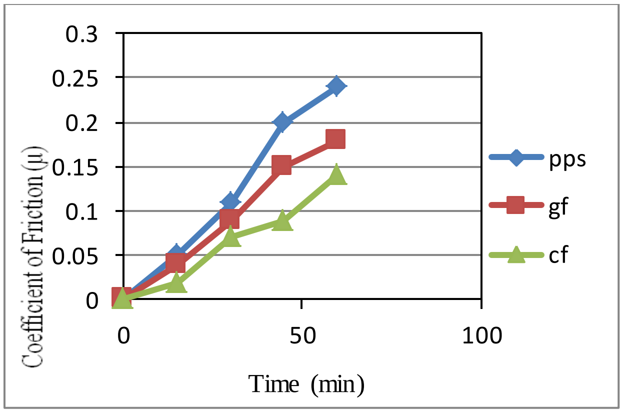
Graph : Coefficient of Friction Vs Time for Normal Load Load at 110 N, Velocity 0.7 m/s at Room Temperature



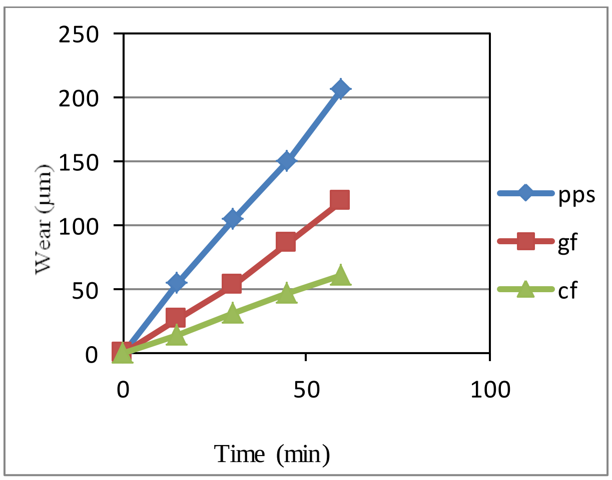
Graph : Wear Vs Time for Normal Load at Load at 110 N, Velocity 0.7 m/s at Room Temperature



Graph : Frictional Force Vs Time for Normal Load at 210 N,Velocity 1.09 m/s at Room Temperature



Graph : Coefficient of Friction Vs Time for Normal Load at 210 N,Velocity 1.09 m/s at Room Temperature



Graph : Wear Vs Time for Normal Load at 210 N,Velocity 1.09 m/s at Room Temperature

- **For Pure PPS , PPS with 30% Glass Fiber and PPS with 30% Carbon Fiber for at Load at 110 N, Velocity 0.7 m/s at Room Temperature.**
- From the above graph of Wear Vs Time plotted above for the pure PPS test pins, it is observed that, initially material wear increases with time and after certain time wear curve becomes almost stable. Stability of wear curve depends on how strongly the transfer film adhered and continued till its breakage. From the graph of coefficient of friction vs. time it is observed that coefficient of friction increases with time. Also from the graph of Frictional force vs time it is observed that frictional force increases with time.
- For Pure PPS , PPS with 30% Glass Fiber and PPS with 30% Carbon Fiber for Normal Load at Load at 210 N,Velocity 1.09 m/s at Room Temperature
- From the above graph of Wear Vs Time plotted above for the pure PPS test pins, it is observed that, initially material wear increases with time and after certain time wear curve becomes almost stable. Stability of wear curve depends on how strongly the transfer film adhered and continued till its breakage. From the graph of coefficient of friction vs. time it is observed that coefficient of friction increases with time. Also from the graph of Frictional force vs time it is observed that frictional force increases with time.

V. CONCLUSION

After the pin-on-disc tests taken, we noticed that friction coefficient and specific wear rate values are lower for pure PPS, compared to PPS with 30 % GF composite and also compared to PPS with 30 % GF composite. These results are explained by the two different composites, which consequently exhibit different types of wear. In case of PPS composite, the particles of glass fiber and carbon fiber produce the decrease in friction between the contacting surfaces, adhesion wear is dominant, and the formation of a transfer film occurs. The transfer film, consisting particles of PPS and glass fiber, carbon fiber has an important effect on the mechanical behavior of the composite PPS , along the sliding distance. We noticed that wear particles adhering to the worn surface of the pin and disc.The results obtained for composite PPS GF 30 show that the increase in sliding speed has a greater influence on the mechanical behavior compared to the increase in contact pressure applied during pin-on-disc test. PPS GF30 composite and PPS CF30 shows a strong abrasive wear causing a high coefficient of friction and micro cracks on the surface of the pin, due to the broken fragments of glass fiber and carbon fiber. Thus, the surface of steel pin is scratched and undergoes a material loss.

Specific wear rate of PPS composite is about one order of magnitude smaller compared to that of composite PPS GF 30. When the contact pressure increases, the specific wear rate increases for the PPS GF30 composite, and decreases for PPS composite. When testing PPS GF30 composite, partial loss of material from the steel pin could adhere on the wear trace of the disc. However, we could notice a mutual transfer of material between disk and pin, which has effect on the specific wear rate. Finally, the results provide data and recommendation for possible mechanical application of PPS and PPS GF30 and CF30 composites.

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