Effect of Carbon, Bronze and Glass Fiber Particles on PTFE

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ABSTRACT

The paper reviews the tribologial behavior of polytetrafluroethylene (PTFE) composites with filler materials such as Bronze, GF & Carbon under parameters like varying load, sliding distance and velocity on pin on disc apparatus. The highest wear resistance found for composites with containing PTFE+25% C followed by PTFE+25% GF & PTFE+25% Bronze composition.

Keywords - Analysis of variance, Filler materials, Pin on disc, PTFE composites, Wear.

1. INTRODUCTION

Polytetrafluroethylene (PTFE) is nowadays finding increasing utility in high performance mechanical seal due to unique properties like high chemical resistivity, low coefficient of friction and high temperature stability. But, Pure PTFE has high wear rate and abrasion resistance, leading earlier failure and leakage problem in the seals. The wear rate of PTFE can be significantly decreased by addition of suitable filler materials. In the past PTFE is filled with conventional filler materials such as glass fibers, graphite, carbon fibers, etc. To satisfy current increasing demand of PTFE in various fields its undesirable properties can be minimized by addition of filler materials. In present work PTFE is filled with Bronze, Glass fibers & Carbon. The wear resistance of PTFE composites is higher as compared to pure PTFE.

1.1. Materials

Material purchased from Ritu Polymers, Thane Maharashtra as follows:

Material	Chemical Composition in Wt.%
I	25% Glass fiber filled PTFE
II	30% Bronze filled PTFE
III	25% Carbon filled PTFE

The material is purchased in the form of circular Rod with dimensions 12 mm Diameter & 30 mm length.

1.2 Experimental Procedure

The Wear and Friction Monitor TR 20 LE-PHM-400 DUCOM is used to investigate wear characteristics of pure PTFE and their composites as per ASTM G 99-95 standards. Complete Arrangement of Experimental Set Up is shown in Figure.1 below. The Specifications of Wear and Friction Monitor TR 20 LE-PHM-400 DUCOM is shown in Table 2 below.

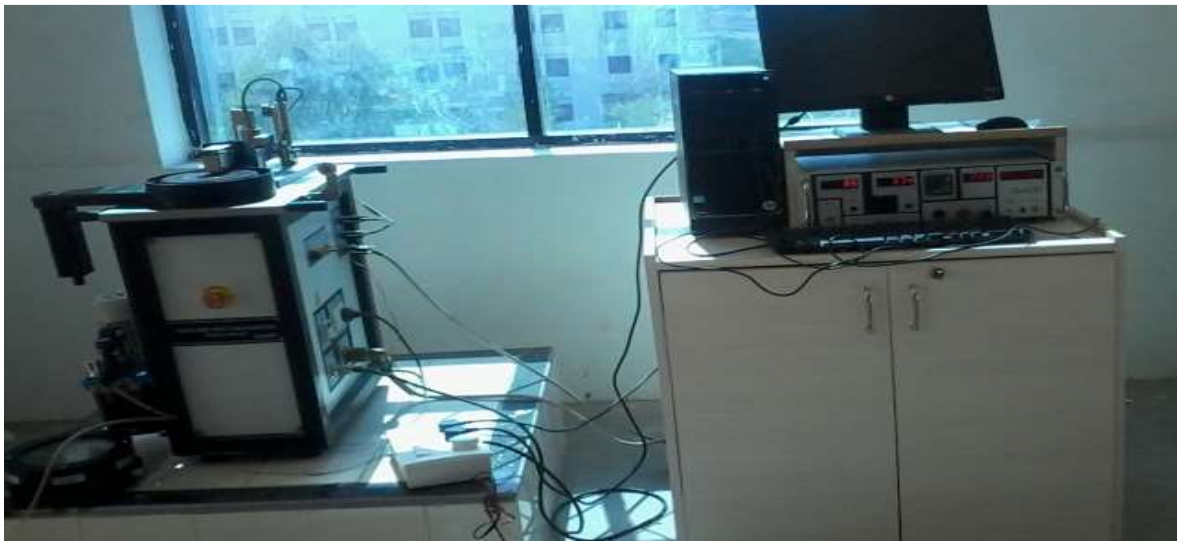


Fig.1. Complete Arrangement of Experimental Set Up

Table 2. Specification of Pin-on-Disc Friction and Wear Monitor Tr-20

SR. NO.	PARAMETERS	VALUES/Remarks
1	Specimen Size	3 to 12mm diameter 25 to 30 mm length
2	Disc Size	165 mm × 8 mm thick
3	Wear Track Diameter	50 mm to 140 mm
4	Sliding Speed Range	0.5 m/s to 10 m/s
5	Normal Load	5N to 200N Max.
6	Disc Rotating Speed	200 to 2000 rpm
7	Friction Force	0 to 200 N
8	Wear Measurement Range	-2000 micrometer to 2000 micrometer
9	Temperature	Ambient to 400°C
10	Environmental & Lubrication Chamber	Top Portion Detachable for clamping the Specimen : Tests for Dry, Heated & Lubricated Conditions

Level→	Low	Medium	High
Load (Kg)	2	4	6
Speed (RPM)	500	700	900
Sliding distance (Km)	1.5	3	4.5
Code	-1	0	+1

1.4. Experimental Result

Table 3. Result Data of Material I (PTFE + 25% GF)

SR. No	Load (Kg)	Speed N in (PRM)	SD L in (Km)	Velo. Of Sliding (V_r) in m/s	Time T in (Min)	Wear Rate in (microns)	COF μ
1	**2**	**500**	**1.5**	**2.61**	**9.54**	**15.54**	**0.1830**
2	**2**	**700**	**3**	**3.66**	**13.64**	**19.42**	**0.1741**
3	**2**	**900**	**4.5**	**4.71**	**15.91**	**20.55**	**0.1802**
4	**4**	**500**	**3**	**2.61**	**19.15**	**25.22**	**0.1754**
5	**4**	**700**	**4.5**	**3.66**	**20.49**	**26.33**	**0.1690**
6	**4**	**900**	**1.5**	**4.71**	**5.30**	**18.03**	**0.1706**
7	**6**	**500**	**4.5**	**2.61**	**28.73**	**39.12**	**0.1570**
8	**6**	**700**	**1.5**	**3.66**	**6.83**	**19.33**	**0.1537**
9	**6**	**900**	**3**	**4.71**	**10.61**	**19.58**	**0.1601**

Table 4. Result Data of Material II

SR. No	Load (Kg)	Speed N in (PRM)	SD L in (Km)	Velo. Of Sliding (V_r) in m/s	Time T in (Min)	Wear Rate in (microns)	COF μ
1	**2**	**500**	**1.5**	**2.61**	**9.54**	**18.22**	**0.1779**
2	**2**	**700**	**3**	**3.66**	**13.64**	**22.22**	**0.1764**
3	**2**	**900**	**4.5**	**4.71**	**15.91**	**23.44**	**0.1633**
4	**4**	**500**	**3**	**2.61**	**19.15**	**27.09**	**0.1708**
5	**4**	**700**	**4.5**	**3.66**	**20.49**	**28.33**	**0.1724**
6	**4**	**900**	**1.5**	**4.71**	**5.30**	**17.55**	**0.1692**
7	**6**	**500**	**4.5**	**2.61**	**28.73**	**44.77**	**0.1499**
8	**6**	**700**	**1.5**	**3.66**	**6.83**	**21.72**	**0.1582**
9	**6**	**900**	**3**	**4.71**	**10.61**	**23.24**	**0.1601**

Table 5. Result Data of Material III

SR. No	Load (Kg)	Speed N in (PRM)	SD L in (Km)	Velo. Of Sliding (V_r) in m/s	Time T in (Min)	Wear Rate in (microns)	COF μ
1	**2**	**500**	**1.5**	**2.61**	**9.54**	**12.72**	**0.1894**
2	**2**	**700**	**3**	**3.66**	**13.64**	**13.87**	**0.1897**

4	4	500	3	2.61	19.15	17.08	0.1797
5	4	700	4.5	3.66	20.49	18.10	0.1620
6	4	900	1.5	4.71	5.30	14.42	0.1802
7	6	500	4.5	2.61	28.73	22.65	0.1692
8	6	700	1.5	3.66	6.83	14.72	0.1587
9	6	900	3	4.71	10.61	15.59	0.1596

1.4.1. Sample Calculations

For material no.1 & for reading no.1
We have, W=19.62 N, N=500 rpm, L=1.5 Km, Wear Track Dia. =100mm=0.1 m

Velocity of sliding $Vr = \frac{\pi \times d \times N}{60}$ m/s

$$\therefore \quad Vr = \frac{\pi \times 100\times10^{-3} \times 500}{60} \text{ m/s}$$

$$\therefore \quad Vr = 2.6179 \text{ m/s}$$
$$\therefore \quad Vr = 2.62 \text{ m/s}$$

Sliding distance $L = Vr \times T$ ……..m

$$\therefore \text{ Time} \quad T = \frac{L}{Vr} \text{ Sec}$$

$$\therefore \quad T = \frac{1500}{2.62}$$

$$\therefore \quad T = 572.5190 \text{ Sec}$$
$$\therefore \quad T = 9.54 \text{ min}$$

In this way we can find out velocity of sliding and time for all materials

1.5. ANOVA of Wear

The adequacy of the models is tested using the analysis of variance (ANOVA) technique. It is a statistical tool for testing null hypothesis for designed experimentation, where a number of different variables are being studied simultaneously. ANOVA issued to quickly analyze the variances present in the experiment with the help of fisher test (F test). This analysis was carried out for a level of significance of 5%, i.e. the level of confidence 95%.

The ANOVA analysis for wear was carried out for all the three samples I to III. The ANOVA tables for the same are given below.

ANOVA of Material I (PTFE + 25% GF)

Software Used: Minitab 18

Table 6. Analysis of Variance

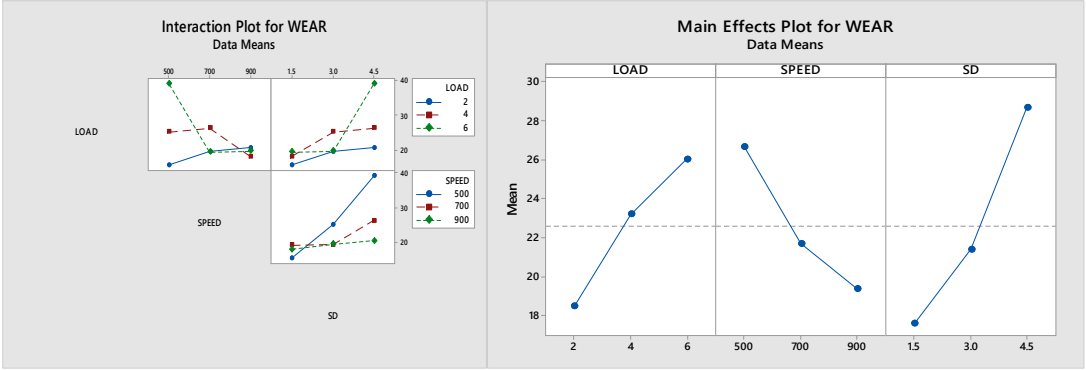
Source	DF	Adj SS	Adj MS	F-Value	P-Value
LOAD	2	86.28	43.14	2.08	0.325
SPEED	2	82.08	41.04	1.98	0.336
SD	2	188.68	94.34	**4.55**	**0.180**
Error	2	41.50	20.75		
Total		8	398		

It is found that the parameter **SD** is most significant parameter affecting wear followed by load and speed. F value is found to be larger for speed.

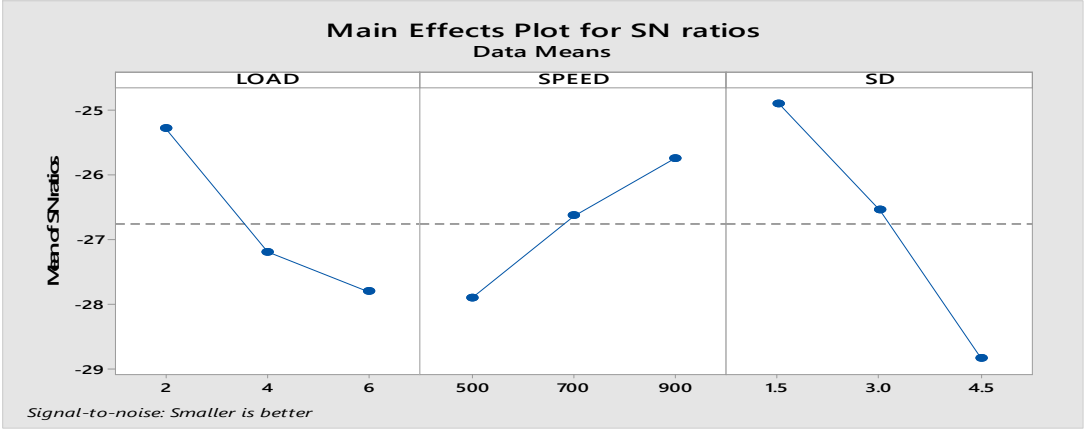
Regression Equation

WEAR = 22.57 - 4.07 LOAD_2 + 0.62 LOAD_4 + 3.44 LOAD_6 + 4.06 SPEED_500 - 0.88 SPEED_700 - 3.18 SPEED_900 - 4.94 SD_1.5 - 1.16 SD_3.0 + 6.10 SD_4.5

Graph 1. Interaction plot of wear for Material I & Main effects plot for Wear of Material I



1.6. DOE Using Taguchi Method



Graph 2. SN Plot for Material I

Table 7. Response Table for Signal to Noise Ratios

Smaller is better

Level	LOAD	SPEED	SD
1	-25.28	-27.90	-24.89
2	-27.19	-26.63	-26.55
3	-27.80	-25.74	-28.84
Delta	2.52	2.17	3.95
Rank	2	3	1

- Addition of filler materials such as GF, bronze and carbon to PTFE causes an increase in hardness and wear resistance, while the coefficient of friction is slightly increased.
- SD is most significant factor on effect of wear followed by Load & Speed
- Depending upon Load, Velocity of sliding and Sliding distance, material used in this study can be ranked as 25% carbon filled PTFE > 25% GF filled PTFE > 30% bronze filled PTFE for their wear performance.

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