Comparative Analysis of PTFE Composite With Different Filler Material Using Taguchi Approach Method

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Abstract- *A comparative analysis of PTFE (Polytetrafluroethylene) composites with different filler material such as glass fiber, molybdenum disulphide, graphite was studied. This study exist tribological properties such as wear and coefficient of friction of PTEF composite material. Wear and friction experiment were carried out on the Pin- On –Disc apparatus at ambient condition. In these study a comparative analysis of three different combination material studied are PTFE+25%glass filled, PTFE+25% glass filled + 5% graphite, PTFE+25%glass filled+5% molybdenum disulphide. Test was carried at velocity 0.5-, 1-, 2 m/s and load 1-, 2-, 3 kg by using Taguchi technique. The present filler addition found to reduce coefficient of friction of PTFE composite material. In these study PTFE+25%glass filled having higher coefficient of friction compared to PTFE+25% glass filled + 5% graphite, PTFE+25%glass filled+5% molybdenum disulphide.*

Keywords: *Orthogonal Array,Pin-On-Disc Apparatus, PTFE Composite, Taguchi Technique, Minitab*

I. INTRODUCTION

Polytetrafluoroethylene (PTFE) is a polymer material use as ideal bearing material. PTFE has properties such as low coefficient of friction, compatibility, embedability, load carrying capacity, fatigue strength, corrosion resistance and hardness. PTFF having good stability for heat from
-270°C to +260°C and economically cheaper friction material compared to conventional frictional material. It is available in white and grey colour [1].

Deepak Bagale et al. study wear analysis of PTFE and its composite under dry condition using Design-Expert and it present that virgin PTFE with addition of bronze and carbon filler decreases wear rate but increasing marginal coefficient of friction.40% carbon filled PTFE having highest wear resistance followed by 40% bronze filled PTFE and Virgin PTFE [2]. S. M. Yadav et al. study the effect of wear variable like applied load, sliding speed, sliding distance on the dry sliding wear condition of PTFE, PTFE with 25% Glass and PTFE with 40% Bronze composites. A plan of experiments, based on techniques of Taguchi, was performed to acquire data in controlled way. It observed that addition of Glass and Bronze particles as fillers increases the wear resistance of thematerial. However, bronze having significant improvement in wear resistance [3].

Luigi Mazza et al. investigate tribological behaviour of PTFF composite using two standard tribological tests approach i.e., pin-on-disc and thrust washer measurements, have been compared with sliding tests performed on composite. The obtained results indicate the different testing methods continuous rotation vs. reciprocating linear movement for the pin-on-disc/thrust washer and sliding tests, respectively, the different techniques provide highly comparable data within the adopted experimental conditions [4]. The effects of filler on the friction and wear behaviour of 15% glass fiber and 25% glass fiber filled PTFE composites under dry friction conditions were studied by Prasad M Patare and Dr G. S. Lathkar. The influence of filler content, sliding duration, test speed and load were also investigated. Experimental results shows that wear rate of PTFE reduced by addition of glass fiber and tribological properties also improved. The friction and wear tests were conducted on pin-on-disc apparatus. For analysis here used Design of Experiment and MINITAB [5].
An attempt has been made to study the wear resistance and coefficient of friction variable on the effect of change in filler material with different load and different sliding velocity. A plan of experiments is based on Taguchi approach.The Taguchi method, which is effective statistical method to relate with responses, was influenced by multi-variables.

II. EXPERIMENT MATERIAL AND METHOD

Materials used for experiment to analyze comparative tribological behaviour, wear and coefficient of friction are PTFE with 25% glass filled, PTFE with 25% glass filled and 5% graphite , PTFE with 25% glass filled and 5% molybdenum disulphide. Experiment were conducted under

loads are 1 kg, 2 kg, 3 kg and sliding velocity 0.5 m/s, 1 m/s and 2 m/s under dry friction condition.

III. EXPERIMNTAL DETAIL

In pin –on –disc TR 20 tribometer, the pin is mounted on a stiff lever, which is a frictionless force transducer. The coefficient of friction is determined during the test by measuring the deflection of the elastic arm. Wear coefficient for the pin material are calculated from the volume of material lost during the test. This normal method used the study coefficient of friction and wear behavior of almost every non porous material combination with or without lubricant. The effect of the test parameters such as sliding velocity, load, contact pressure and varying time allow a close reproduction to the real life conditions of practical wear situations.

In these experiments we used pin size 10 mm diameter and 30 mm length, rubbed against EN31 grade carbon steel counterface. The dry sliding wear tests were performed on pin on disc test setup as per ASTM G99 standard. Figure 1 shows pin –on –disc experiment setup.

Fig 1. Experimental Setup

IV. TAGUCHI APPROACH

Taguchi approach is significant analysis tool for the influence of control variable on performance output. It provides a simple, efficient and systematic approach to optimize design of performance, quality. The method is valuable when design parameters are qualitative and discrete. Taguchi Parameter design can optimize the performance to source of variation parameter. Taguchi approach is consist problem definition, choice of response, selection of factors and levels, selection of orthogonal array, enter factor and level value in selected array chart, perform experimentations per chart value, analysis and interpretation of result. The design of experiment process made up of three main phase: the planning phase, the conducting phase and analysis interpretation phase. The planning phase is the most important phase one of must give a maximum importance to this phase. The data collected from all the experiment in the set are analyzed to determine the effect of various design parameters. This approach is use a fractional approach and this may be completed with the use of orthogonal array. [6]

V. ORTHOGONAL ARRAY AND SIGNAL TO NOISE RATIO

In orthogonal array complete factorial design identify with all possible combinations for a given set of factors, while there are many standard orthogonal arrays available, each of the arrays is present for a specific number of independent design variables and levels. Standard equation for orthogonal array is, Ln(Xm) where n is number of experiment to be conducted, X is number of levels and m is number of factors [2] . Table1 shows three level L27 orthogonal array method.

The experiment observations are further transformed into signal to noise (S/N) ratio. There are several S/N ratios available depending on the type of performance characteristics. The S/N ratio for minimum wear rate can be expressed as “Smaller is better” characteristic, which is calculated as logarithmic transformation of loss function as shown below.

Smaller is better characteristics $S/N= -10 \log 1/n(\sum y2)$, Where n is the number of observations and y the observed data

L_{27}	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	2	2	2	2	2	2	2	2	2
3	1	1	1	1	3	3	3	3	3	3	3	3	3
4	1	2	2	2	1	1	1	2	2	2	3	3	3
5	1	2	2	2	2	2	2	3	3	3	1	1	1
6	1	2	2	2	3	3	3	1	1	1	2	2	2
7	1	3	3	3	1	1	1	3	3	3	2	2	2
8	1	3	3	3	2	2	2	1	1	1	3	3	3
9	1	3	3	3	3	3	3	2	2	2	1	1	1
10	2	1	2	3	1	2	3	1	2	3	1	2	3
11	2	1	2	3	2	3	1	2	3	1	2	3	1
12	2	1	2	3	3	1	2	3	1	2	3	1	2
13	2	2	3	1	1	2	3	2	3	1	3	1	2
14	2	2	3	1	2	3	1	3	1	2	1	2	3
15	2	2	3	1	3	1	2	1	2	3	2	3	1
16	2	3	1	2	1	2	3	3	2	1	2	3	1
17	2	3	1	2	2	3	1	1	2	3	3	1	2
18	2	3	1	2	3	1	2	2	3	1	1	2	3
19	3	1	3	2	1	3	2	1	3	2	1	3	2
20	3	1	3	2	2	1	3	2	1	3	2	1	3
21	3	1	3	2	3	2	1	3	2	1	3	2	1
22	3	2	1	3	1	3	2	2	1	3	3	2	1
23	3	2	1	3	2	1	3	3	3	1	1	3	2
24	3	2	1	3	3	2	1	1	2	2	2	1	3
25	3	3	2	1	1	3	2	3	2	1	2	1	3
26	3	3	2	1	2	1	3	1	3	2	3	2	1
27	3	3	2	1	3	2	1	2	1	3	1	2	3

Table 1 L_{27} (3^{13}) Orthogonal Array

In above table first column represent material, second column represent the load and fifth column represent the sliding velocity, while remaining column represent interaction between them. Table 2 shows level assign for conducting experiment

	LEVEL1	LEVEL2	LEVEL3
MATERIAL	PTFE+25 %Glass Filled (A)	PTFE+25% Glass Filled +5%Graphite (B)	PTFE+25% Glass Filled+ 5%MOS2 (C)
LOAD(kg)	1	2	3
SLIDING VELOCITY (ms^{-1})	0.5	1	2

Table 2 Level Assign for conducting experiment condition

VI. RESULT AND DISCUSSION

Sr. No	Material	Load (Kg)	Velocity (m/s)	Wear (micron)	S/N ratio	C.O.F	S/N ratio
1	A	1	0.5	10	-20	0.21	13.55561
2	A	1	1	17	-24.609	0.22	13.15155
3	A	1	2	10	-20	0.19	14.42493
4	A	2	0.5	11	-20.8279	0.26	11.70053
5	A	2	1	16	-24.0824	0.25	12.0412
6	A	2	2	10	-20	0.27	11.37272
7	A	3	0.5	14	-22.9226	0.26	11.70053
8	A	3	1	13	-22.2789	0.31	10.17277
9	A	3	2	25	-27.9588	0.26	11.70053
10	B	1	0.5	8	-18.0618	0.03	30.45757
11	B	1	1	8	-18.0618	0.03	30.45757
12	B	1	2	17	-24.609	0.05	26.0206
13	B	2	0.5	7	-16.902	0.07	23.09804
14	B	2	1	88	-38.8897	0.03	30.45757
15	B	2	2	44	-32.8691	0.08	21.9382
16	B	3	0.5	23	-27.2346	0.03	30.45757
17	B	3	1	24	-27.6042	0.04	27.9588
18	B	3	2	39	-31.8213	0.06	24.43697
19	C	1	0.5	9	-19.0849	0.03	30.45757

20	C	1	1	16	-24.0824	0.04	27.9588
21	C	1	2	21	-26.4444	0.04	27.9588
22	C	2	0.5	73	-37.2665	0.09	20.91515
23	C	2	1	39	-31.8213	0.07	23.09804
24	C	2	2	36	-31.1261	0.02	33.9794
25	C	3	0.5	23	-27.2346	0.03	30.45757
26	C	3	1	78	-37.8419	0.11	19.17215
27	C	3	2	84	-38.4856	0.09	20.91515

Table3 Result Obtained On MINITAB

Above Table 3 shows smaller is better characteristic for experiment collected result data such as wear and coefficient of friction as per orthogonal array.

The total standard deviation of smaller is better S/N ratio for all the experiments is calculated and listed in Table 3. All the Calculations are performed using MINITAB 17. The response Table 4 and 5 shows the average of selected characteristics for each level of the factors

Table 4 WearTable 5 Coefficient of friction

Level	Material	load	Velocity
1	-22.52	-21.66	-23.28
2	-26.23	-28.20	-27.70
3	-30.38	-29.26	-28.15
Delta	7.86	7.60	4.86
Rank	1	2	3

Level	Material	load	Velocity
1	12.20	23.83	22.53
2	27.25	20.96	21.61
3	26.10	20.77	21.42
Delta	15.05	3.05	1.12
Rank	1	2	3

In above table rank 1 assign highest delta value, rank 2 for second delta value and rank 3 for lowest delta value

VII. CONCLUSION

1. Addition of glass fiber with graphite and molybdenum improves tribological properties such as reduces coefficient of friction and increases wear resistance.

2. Taguchi approach method enabled to analyze successfully the friction and wear tribological behaviour of composites with filler, load, sliding velocity as the variables.

3. In wear and coefficient of friction both rank, material affect the higher followed by load and velocity.

4. In experimental result PTFE with 25% glass filled having highest coefficient of friction compared to PTFE with 25% glass filled, 5% graphite and PTFE with 25% glass filled, 5% molybdenum disulphide having lower coefficient of friction.

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