Composite Wear Actions of Glass Fiber Reinforced Titanates Filled Epoxy Resin

R.Sundaramoorthy, J.Justin Maria Hillary, S.R.Raja Balayanan, K.Kalidas, R.V.Rangarajan

*Abstract***:** *Glass fibre-reinforced polymer composites find numerous applications in today 's aggressive world because of their different benefits such as high wear resistance, strength to weight ratio and low cost. Particle fillers can be further enhanced with the added composite efficiency. Titanates are successfully used as polymer filler to achieve this. A number of these short-glass epoxy composites and the study of their wear behavior are included in current work. They are manufactured and characterized. It also outlines a technique for parametric analysis of the sliding wear behavior, based on Taguchi's test-design approach.*

Keywords **:** *Polymer composites; Titanates; Epoxy; Wear test; Taguchi.*

I. INTRODUCTION

Composite materials consist of two or more engineering materials which remain separate and separate at the macroscopic level during the construction of a single part. There are two types of matrix and component material strengthening available. At least one portion of each form is required. The matrix material contains and supports the material to reinforce the position of the matrix. The reinforcement includes its mechanical and physical features to enhance matrix properties. The matrix's main function is to transmit and protect pressure between reinforcing fibres, and the presence of fibre / part in a composite increases its mechanical features such as strength, stiffness, etc.   A synergistic composition is therefore a mixture of physically and chemically varying two or more micro-components, which are insoluble in one another. The goal is to use the superior qualities of both materials without losing their weakness. The synergy produces material characteristics which do not exist for each part. Due to the broad variety of matrix and reinforcement materials, its design capabilities are amazing [1].

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Multiple lightweight and high strength applications have been replaced effectively by composite materials. The key reasons for these applications are their high strength-to - weight ratio, high strength and high crunching at high temperatures. High resistance and resilience. The reinforcing materials usually are solid and low in a composite, while the matrix is mostly ductile or rough. If the composite is correctly engineered and made, the reinforcing strength is combined with the frame strength to create a variety of desired properties not available in three traditional materials. The intensity of the traditional material depends primarily on the form and quantity of the resin fibre and/or particle compliance.

Composite materials can typically be split into three classes on the basis of matrix materials.

a) Composites Metal Matrix (MMC)
b) Composites of Ceramic Matrix (CMC)
c) Composites Polymer Matrix (PMC)
a) Composites Metal Matrix (MMC)

Metal matrix composites have many advantages over monolithic metals, such as higher module, higher special strengths, higher properties and a lower coefficient of thermal expansion. Therefore composites for metal matrix attributes are actually applicable to a wide range of applications. The nozzle room is burning; housing, roofing, wires, heat exchangers, etc.

b) Composites of Ceramic Matrix (CMC)

The enhancement of facing is one of the key goals of the development of ceramic matrix composites. Naturally it is hoped for and always found the strength and rigidity of ceramic matrix composites.

c) Composites Polymer Matrix (PMC)

The most common use of matrix materials is polymeric materials. That's why two fold.-Two fold. Many structural purposes are in general not enough for the mechanical characteristics of polymers. Their strength and rigidity are especially poor compared to metals and ceramics. Strengthening other polymers is faced by these issues. The second thing to do is to process composites in polymers using matrix, which do not require high pressures or high temperatures. More equipment for the development of simple composites in the polymer matrix is required. This is why composites for polymer matrix were quickly and soon became popular for structural applications. The overall proprieties of the composites are superior to polymer and ceramic parts and are used as composites. Composites, for example, have a module larger than polymers, but not as prone as pottery. [2,3]

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There are two types of polymers:
- Reinforced Fiber Polymer (FRP)
- Particulate matter of Reinforced Polymer (PRP).
- Reinforced Fiber Polymer (FRP)

In fibre-reinforced composites the fibres and the matrix are commonly used. The matrix pastes all the fibres into a single shape and transmits tension between the fibres. Fiber is the primary source of power and consolidation. The loads take their length from the fibres. Filler may also be used to ensure smooth manufacturing, impact particular composite characteristics and/or reduce the product's cost.

The common fibre enhancer, berryllium, beryllium carbides, beryllium oxides, molybdenum, aluminium oxides; glass fibres, polyamides, natural fibre, etc. asbestos, carbon / graphite fibres. Epoxy, phenol, polyester, polyurethanes (PEEK) are included in the matrix materials equally common; vinyl esters, etc. In such resin materials, PEEK is most often used. Second, with its higher cost, epoxy is stable more than PEEK and less recessions are included.

Particulate matter of Reinforced Polymer (PRP).

The improvement is made of ceramics and lenses, including small pieces. Included are mineral particles, particulate matter such as aluminium and amorphous compounds, polymers and black carbon. Parts are used to strengthen matrix modules and minimise ductility in matrixes. The artefacts are also used to minimise the expense of composites. Common, cheap and easily manufactured materials can be matrices and reinforcements. Ceramics and glasses have a high melting temperature, a low density, a high strength, and rigidity as a valuable property. Many pottery are effective electrical and thermal insulators. Certain pottery has unique characteristics; other pottery is magnetic; others are piezoelectric; some of the unusual pottery is very poor at superconductors. Ceramics and glasses are a major downside: An example of particle-reinforced composites is a car tyre of carbon-black particle in a poly-isobutylene elastomeric polymer series. A broad range of interested engineering has been developed by composite polymer materials, particularly in the aerospace industry. New composites, with varied fibre / filler configurations, are currently being developed in worldwide research to allow for different operating conditions. In view of this, a variety of PEEK composites have been made, their reaction to solid particle erosion has been studied, with glass fibre regulation and ceramic filler being reinforced .

II. SURVEY IN LITERATURE

Polymers in different engineering areas have developed a wide interest in the tribological applications compared to metal alloys due to their high strength and low density. They are the lightest, most rational critical material but still a commercially constrained factor for their high prices.

It is also helpful that low-cost fillers are conveniently available, to reduce the expense of the part. An overview of the impacts of this filler inclusion is required to ensure that the mechanical properties of the composites are not compromised adversely by this supplement. The available sources show a significant range of materials suitable for use as polymer fillers .

The purpose of fillers may thus be divided into two simple groups, one for enhancing the mechanical, thermal or tribological characteristics and one for reducing the cost of components. Differently, inorganic oxides were used, like alumina and silica, in widely used polymers like polypropylen and polyethylene[4,5]. Various reports were produced. In the manufacture of particulate reinforced polymer composites, however, there were few steps to use cheap materials such as industrial waste. A significant advantage of particulate enhanced polymer composites is the possibility to configure the products, which makes them as appealing as technological materials. Properties for the control and storage of filling content and matrix mix manufacturing techniques. A substantial matrix selection and reinforcement of a solid particle stage can lead to a composite which, with combinations of strength and frame, is equal or even more than typical metallic materials [6]. Today, also in three orders of magnitude, rough particulate fillers made of ceramic or metal or glass fillers improve the wear resistance of composites substantially [7]. Improved polymers and their performance were very interesting, even recent ones, for their industrial and structural uses composites by the introduction of particulate fillers. Substantial interest. Metal particles reinforced composites have a variety of heaters and electrical products [8] and uses for thermal composites [9] etc. at high temperatures for consumables and polymers with various formats. The low density, high corrosion resistant, comfort in processing and low cost are the explanation for these composites [10]. Several studies have been performed on different ceramics. As Al_2O_3, TiC and SiC, the particle size and volume are increased. [11,12,13]. Composites Polymer / TiO_2 have been synthesised successfully in different forms. Polymer matrices such as silicone elastics [14], polycarbonates [15], polystyrene[16], oral, polyacryls[17], epocyanides[18], polyesters unsaturated [19], polyimides [15]. Titanate pigment is the perfect polymer filler of fine white powder for many engineering applications. In order to investigate titanates as a filler material and the effect on sliding dry, wear and mechanical efficacy of composite characterization of diverse composite filler materials have been studied and the current study has taken place toward this scene. The parameters such as configuration and conditions of use are of primary importance for the design for the necessary composites in order to decide the relation between wear and wear materials to meet various functional requirements. But the influence of any particular control factor in an interacting group is very difficult to understand. The influence of over one parameter on polyester composite sliding use was evaluated in this study. The combined effect of more than one interacting variable is important for the resulting wear rate as in real practise. The research results and its interactions of different parameters rely on an economical, simple experimental approach that is based on the parameter architecture of Taguchi[20]. This experimental technique has been used successfully in the areas wire Electric Discharge Machining (WEDM), metal matrix composite boiling, and corrosion of polymer matrix composites (21, 22 and 23).

III. COMPOSITE PROCESSING

The main materials used are

- Short fibre of E-glass.
- Tinates white powder
- Resin Epoxy

With short E-glass fibres (360 St. Gobian roving) they are improved. The resin Epoxy LY 556, a solvent in the epoxy matrix of the product. The generic name of Bisphenol A Diglycidyl Ether. The epoxy resins (Araldite LY 556) and the related low-temperature Hards treatment (HY951), as indicated by a weight ratio of 10:1, are paired with the epoxy resin and hardener of Ciba Geigy India Ltd. Fiber, epoxy resin and densities are respectively 259000 g / m^3 and 1100000 g / m^3 for the electronic glass modules 72500 MPa and 3420 MPa.

The fibre load (the weight of the fibre in the glass composite) is retained for all samples at fifty percent and consists of three different composites: zero wt percent filler; 10 wt percent Titanates and 20 wt percent Titanates. The casting is made for about 24 hours for optimal curing at room temperature. Using a diamond cutter, special sizes suitable for physical characterization and erosion assessment are removed.

IV. WEAR TEST SLIDING

In pin-on disc friction and wear monitoring tests, the performance of these composites is checked under the dry sliding environment. ASTM G 99 (DUCOM supplied) rig. Figure 1 as seen in the experimental form. The counterbody is a hard-floor stainless steel disc (EN-32, length 72 HRC, strength range 0.6 Ra). The sample is extracted stationarily by means of a lever, when a regular force is applied. In a series of experiments there are three sliding speeds of 2.2. 2.7 and 3.1 m / s with 0.01KN normal load and 0.02 KN with three loads 0.03KN independent. The surface layer loss of the composite material is measured with Accuracy + or -0.1 mg and the accurate electronic balance wear rate. This will then mean the term "volume reduction" (mm^3 / N-m)

$$S = \frac{\Delta m}{\rho t V_s F_N}$$

Where,

'M'   - the loss of mass over   the test time (gm)
'ρ'   - the composite density (gm / mm^3)
't'   - the length of the test (sec)
'Vs' - the pace sliding (m/sec)
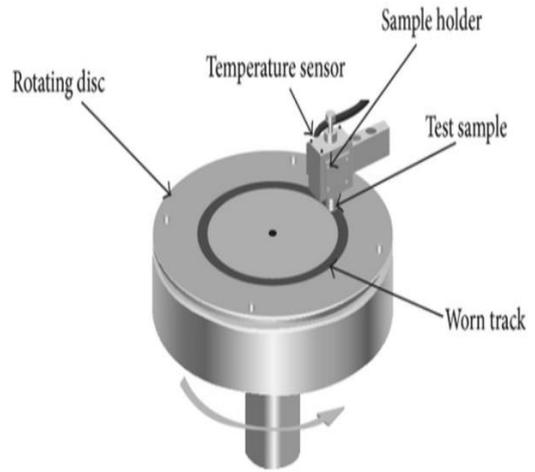'F_N' - the standard average load (N).

Fig. 1: Pin-on - Disk schematic diagram

V. EXPERIMENTAL CONCEPTION

Experiment design is an important way of designing and assessing the impact of control factors on performance quality. The collection of control variables is mainly the stage in the experimental design. There are a variety of parameters included; such the variables cannot be identified as quickly as possible.

Table 1 is carried out in wear tests. Service terms the measurements are performed at the model design temperature in Table 2.In this review the output of the set is considered under three separate conditions, that is to say, sliding velocity, the normal load, the contents of the pad and the sliding distance at three levels in L27(3^{13}). Table 2 shows a test parameter and each column includes a test condition which is just a level mixture of parameters.

The studies are turned in the relationships into signal noise (S / N). Many functions are possible based on the shape of the S / N. For the minimum wear rate, the S / N ratio is smaller and better, as shown below, the loss function can be calculated as logarithmic transformation.

The smaller is the better: S/N = -10 log 1/n Σy^2

Where n is the number and where y is the details. "The smaller the better (LB) is the change from the above S / N ratio to a decreased wear rate. Regular linear graph 2 assigns orthogonal causes and connexions to individual columns series.

Table 1 : Control factors for the experiment and levels

			Level		
	Control Factors	Units	I	II	III
A	Sliding velocity	m/sec	2.2	2.7	3.1
B	Normal load	KN	0.01	0.02	0.03
C	Filler	%	0	10	20
D	Sliding distance	m	2000	4000	6000

The experimental designs: the first column is a slided speed (A), the second column standard load (B), the fourth- and third-column element (C) column is filled in and the fourth sliding (D) columns $(A*B)_1$ and $(A*B)_2$ respectively, and the sixth and second charge relations $(B*C)_1$ and $(B*C)_2$ are the measurement allotments for the usual load (A) and sliding (B), respectively . The experimental configuration is as follows: In order to estimate the interaction between normal load (B) and filler (C) information, the eighth and eleventh column are assigned $(A*C)_1$ and $(A*C)_2$ respectively, to estimate the interaction of sliding (A) to filler(C) data. In the remaining columns the face error columns are assigned.

Specific factors A and C however are more significant in terms of production statistics. This is seen in terms of their performance and the correlation of factors A and C have the least influence on wear rate, and the D has the least effect on the particular wear rate of this report. Consequently, further studies may be overlooked as element D and relationship A C. More statistical analysis is required to justify / obey the insignificant factor and insignificant analysis of the relationship variance.

Table 2 : Test conditions with L27 orthogonal array results

S.No.	A	B	C	D	Wear rate	S/N ratio
1	2.2	0.01	0	2000	1.0435	-0.6005
2	2.2	0.01	10	4000	0.1974	13.0323
3	2.2	0.01	20	6000	1.1451	-1.3895
4	2.2	0.02	0	4000	0.1074	17.537
5	2.2	0.02	10	6000	0.3089	9.5027
6	2.2	0.02	20	2000	0.0878	18.9288
7	2.2	0.03	0	6000	0.4111	7.1833
8	2.2	0.03	10	2000	0.1186	16.8319
9	2.2	0.03	20	4000	0.0444	23.1478
10	2.7	0.01	0	4000	0.1393	15.6622
11	2.7	0.01	10	6000	0.3984	7.4400
12	2.7	0.01	20	2000	0.1061	17.6229
13	2.7	0.02	0	6000	0.3479	8.5432
14	2.7	0.02	10	2000	0.2185	12.245
15	2.7	0.02	20	4000	0.206	12.7028
16	2.7	0.03	0	2000	0.9981	-0.2234
17	2.7	0.03	10	4000	0.9784	-0.0545
18	2.7	0.03	20	6000	0.5237	5.1883
19	3.1	0.01	0	6000	1.0951	-1.0101
20	3.1	0.01	10	2000	0.6132	3.8759
21	3.1	0.01	20	4000	0.4062	7.2814
22	3.1	0.02	0	2000	1.1887	-1.7072
23	3.1	0.02	10	4000	0.8544	1.0913
24	3.1	0.02	20	6000	0.4128	7.1495
25	3.1	0.03	0	4000	1.2998	-2.468
26	3.1	0.03	10	6000	1.0425	-0.5924
27	3.1	0.03	20	2000	0.8504	1.1309

Table 3 : Signal to Noise Ratio Response Table

Level	A	B	C	D
1	9.749	5.654	3.544	2.294
2	7.567	8.33	5.816	4.566
3	0.414	3.745	8.37	7.12
Delta	8.085	3.335	3.576	2.326
Rank	1	3	2	4

Specific factors A and C however are more significant in terms of production statistics. This is seen in terms of their performance and the correlation of factors A and C have the least influence on wear rate, and the D has the least effect on the particular wear rate of this report. Consequently, further studies may be overlooked as element D and relationship A C. More statistical analysis is required to justify / obey the insignificant factor and insignificant analysis of the relationship variance.
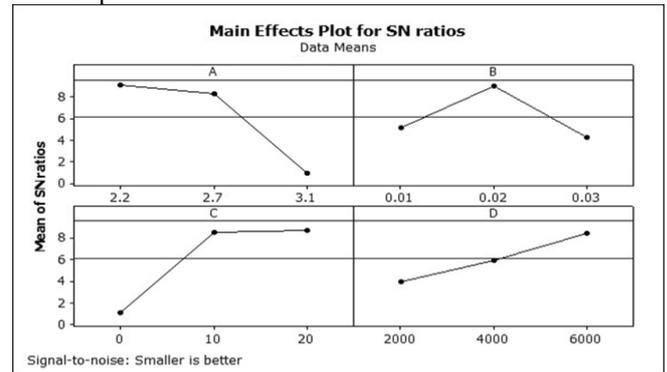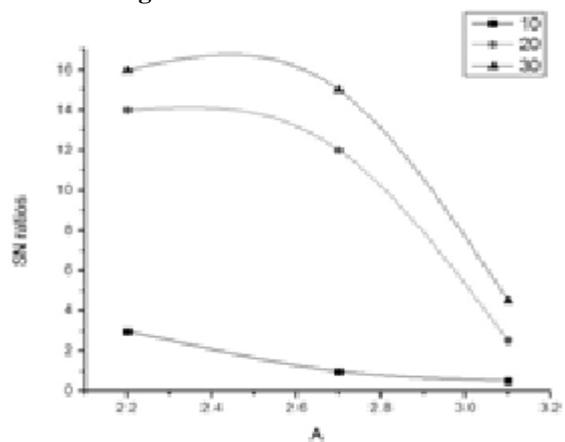

Fig. 2 : Effect of wear control factors

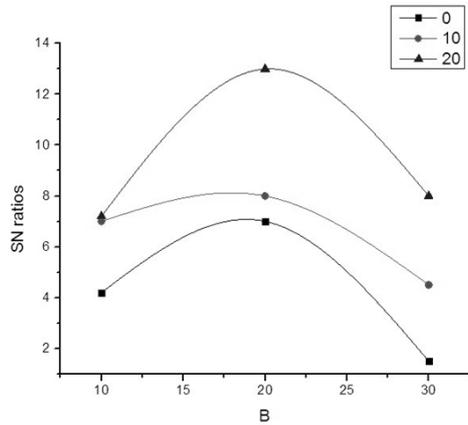**Fig 3. Wear rate interactive map from A and B**

Fig 4 : Wear rate interaction map between B and C
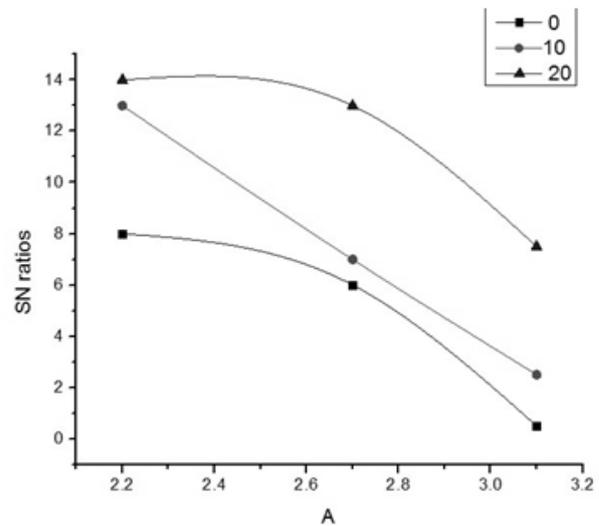

Fig. 5. Graph of interaction between A and C

VI. THE RESULTS OF THE ANOVA VARIABLES

Table 4. Unique wear rate ANOVA Table

Source	DF	Seq SS	Adj SS	MS	F	P	Rank
A	1	1.19423	1.19423	0.58461	10.535	0.006	1
B	1	0.34997	0.34997	0.16249	3.225	0.106	3
C	1	0.42595	0.42595	0.20047	3.885	0.077	2
D	1	0.08679	0.08679	0.03089	0.945	0.427	4
A x B	3	1.25532	1.25532	0.29508	5.525	0.027	1
A x C	3	0.12487	0.12487	0.01247	0.625	0.643	3
B x C	3	0.40964	0.40964	0.08366	1.855	0.228	2
Error	5	0.32124	0.32124	0.03271			
Total	25	4.343					

The study of the variance Map (ANOVA) should be drawn up to evaluate the order of the key variables for insight into the results of various factors influencing the result. The ANOVA wear rate results are seen in Table 4. This investigation is undertaken at a confidence level of 5 percent. The last column in the table displays the priority order of relations and variables.

Table 4 will observe sliding velocity (p = 0.006). Bottom features are affected by the material (p=0.077) and daily loads (p=0.106). The rate of wear and sliding distance factor have less effects on real cost of wear. The associated consistency of the fibre may therefore be ignored for further analysis. However, the contribution value and the regular fibre quality load level (p=0.228) that is to say slipping fibre on the wear rate and the rest of the contact Include (p=0.643) is less relevant for a wear rate contribution.

VII. CONCLUSIONS

The dry wear of these composites can be tested with experimental taguchi models, using different loads and sliding speeds. Taguchi technique provides a functional alternative, a structured approach to managing systems. The key feature is the rate of sliding of the effect of speeds, other aspects such as material filling and interactions have been found to be able to consistently quantify the importing charge
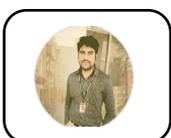
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