Effect of Post Curing On Rare Earth Particulates Filled Polymer Composite

Vithal Rao Chavan[1], Veerabhadrappa Algur[2], K R Dinesh[3], K Veeresh[4], Sridhar Gouda[5]

[1]Research Scholar, Department of Mechanical Engineering, Rao Bahadur Y Mahabaleswarappa Engineering College, Ballari

[2]Associate Professor, Department of Mechanical Engineering, Proudhadevaraya Institute of Technology, Hosapete

[3]Principal, Department of Mechanical Engineering, Government of Engineering College, Raichur

[4]Principal, Department of Mechanical Engineering, Rao Bahadur Y Mahabaleswarappa Engineering College, Ballari

[5]Assistant Professor, Department of Mechanical Engineering, Proudhadevaraya Institute of Technology, Hosapete

Abstract:-This work is also about to make newer materials in the composites, which make better compared to other composites. The Lapox L-12 resin, E Glass fiber material and cerium oxide, which the one of the family member of the rare earth materials in the periodic table. The combination of these materials are used to study the tensile strength, Rockwell hardness and also examined the volumetric wear rate and coefficient of friction in sliding wear mechanism, in two condition i.e. with post curing (of 100ºC for a period of 60 Min) and without post curing. However, due to post curing temperature the strength got increased mean while increase in the cerium oxide percentage the strength also got reduced as temperature is increase the viscosity got decreased and most of the resin is been consumed with cerium oxide, hence there is decrease in strength. Whereas the volumetric wear rate decrease with increase in filler content up to 20% filler addition then it increases with increase in the filler content, corresponding coefficient of friction decreases with increase in the filler content and later with increase in the filler content increase the coefficient of friction. SEM analysis reveals the detail of the wear characteristics; the volumetric wear rate is also increased to all the test specimens. As the load and tangentially velocity is increased the wear also increased.

Key words: Frictional force, Rare earth particulates, Volumetric wear rate,

I. INTRODUCTION

Composites are well known for their superior quality, i.e. like low density, good strength and wear resistance compared to monolithic materials (metals), however the fabrication cost comparison between metal and composite, composite are costlier. In order to cut down the cost, easily and cheaply available fillers are recommended, but filler material should not degrade on the origin properties of composites, rather it should improve the mechanical,tribological and thermal properties [1].

Addition of particulate fillers has revealedboundlessbenefits and so has lately been the subject of significant interest. Which lead to improve the performance of the hybrid composites, in various applications such as gears, cams, breaks, clutches, bearings, wheels and bushes. The significant effect of the CaCO3 and CaSO4 filled vinyl ester composites has been studied. The wear test is conducted on pin on disc by varying load, speed, % of filler material and distance at room temperature [2].

The E-glass woven fabric-epoxy (LY 556) (GE) composites have been fabricated with varying amountsof silicon oxide (SiO2) by compression molding followed by hot curing. Thefabricated composites werecharacterized by mechanical properties such as tensile behaviour, flexuralbehaviour. The effect of silica content on the sliding wear propertiessuch as wear loss, specific wear rate and coefficient of friction at constant distance and velocity with different loads by usingpin-on-disc machine. Wear out surface of all the composites were studied using scanning electron microscopy (SEM) [3].

II. MATERIAL DETAILS

Chopped E-glass fabric (300 GSM) of plain weave construction, Epoxy (L12) a transparent dense fluid with high viscosity served as the matrix in the composite. It is a thermosetting resin with high molecular weight, Hardener (K6) Epoxy curing agent K-6 is a low viscosity room temperature curing liquid hardener is fixed as 10:1and Cerium oxide It is a whitish yellow powder with the chemical formula CeO2 and Density 1.162 gm/cc

III. SAMPLE PREPARATION

a) **Incorporation:** The experimentation has been considered for four different compositions of Cerium oxide reinforcements in epoxy matrix i.e. (10%, 20%, 30%, and 40%). The premeditated weights of cerium oxide powder are added to the epoxy as per the composition. The blend is stirred using an ultrasonic mixer (sonicator) for 10 minutes with a pulse time of 5 seconds. We get a thin white liquid to which hardener K-6 (10 wt. % of the amount of epoxy) is mixed and stirred well manually for about 20 minutes.

Table 1: The amount of Cerium oxide and epoxy used for a batch of each composition

Specimen	Composition		
	Resin	Fiber	Filler Material
1	100%	-	-
2	60%	40%	-
3	60%	30%	10%
4	60%	20%	20%
5	60%	10%	30%
6	60%	-	40%

b) **Moulding:** From the varied compositions, cylindrical compacts are made. A cylindrical die is made from the PVC wiring pipes of 150 mm length and 10 mm diameter. After preparing the mould, the mixture is poured into the pipes and is left to solidify for 24 hours.

Fig.1. Preparation of cylindrical rods

Fig.2. Preparation of laminates

c) **Post-curing of samples:**4-5 samples of each composition were post-cured in an oven for 30 minutes at 100^{0}C. This was done to investigate the variation inthe thermal and tensile properties of the composite with curing temperature.

Fig.3. Muffle furnace

IV. EXPERIMENTATION

There are different tests have been conducted on GFRP composites, where different mechanical tests like tensile test, hardness test and wear test have been revealed the information about characterization of a GFRP composites.

Tensile test have been carried out on universal tensile testing machine according to ASTM standards. Initially the composites with and without heat treatment has to be measured by suitable dimensions, i.e. specimen original length, area of the specimen, final length of the specimen after fracture, maximum load rate, maximum ultimate strength of a material, yield strength of a material, % age elongation of a material.The tensile test had been carried out at room temperature and in conformity with ASTM D3039 standards.

The determination of the Rockwell hardness of a material involves the application of a minor load followed by a major load, and then noting the depth of penetration, hardness value directly from a dial, in which a harder material gives a higher number.It is typically used in engineering and metallurgy. Its commercial popularity arises from its speed, reliability, robustness, resolution, and small area of indentation.

Wear Test:-Pin on disc sliding wear test apparatus: Test set-up used in the study of wear test is capable of creating reproducible sliding wear situation accessing the sliding wear resistance of the prepared samples. It consists of a pin on disc, loading panel and a controller.

Fig.4. Ducom pin on Disc sliding wear test apparatus.

The entire test was carried out using a "DUCOM friction and wear monitor" machine at normal atmospheric conditions. The wear test was carried out for the treated and untreated samples of each composition. The wear rate was observed from the wear distance v/s time plot obtained. The variation in the coefficients of friction with curing temperature and increasing marble powder content was also investigated. Care was taken to clean up the sample surface before and after each test to prevent any form of damage to it. All the tests were carried out with a track diameter of 70mm.

V. RESULT AND DISCUSSIONS

Tensile test and Rockwell hardness is carried out for the different proportionate filled of cerium oxide and tested for the without post curing and with post curing. the result reveals that unfilled of cerium oxide and without post curing i.e. at 40 wt% of E-glass fibre and 60 wt % of Lapoxl-12 resin higher value compared with the other samples as shown in the Fig.5.& Fig.6 It is revealed that fracture is due to Delamination of the fibres. Delamination of the fibre may be found due to weak bonding between the fibres. The fracture due to delamination of the fibre decreased as the percentage of cerium oxide is increased because cerium oxide is layed up along with epoxy as the percentage of cerium oxide increases E-glass fibre percentage decreases this is done to maintain constant volume. However due to post curing temperature, the tensile strength got increased mean while increase in the cerium oxide percentage the strength also got reduced as temperature is increased the viscosity got decreased and most of the resin is been consumed with cerium oxide, hence there is decrease in strength.

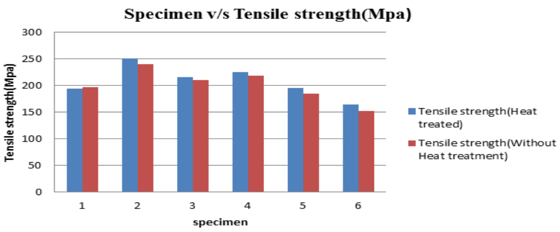

Fig.5. comparison of tensile strength graph

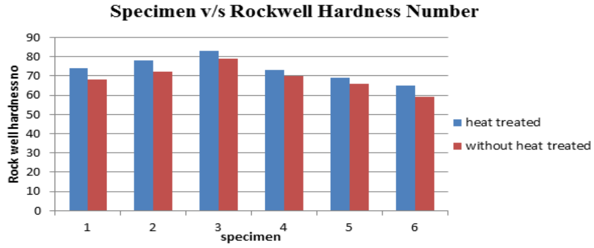

Fig.6. comparison of RHN graph

Hence, the composite of 20 wt% of E-glass fibre,20 wt% of cerium oxide and 60 wt % of Lapoxl-12 resin can be utilized and also reduce the usage of the fiber, when compared with 40 wt% of E-glass fibre and 60 wt % of Lapoxl-12 resin.

Wear test

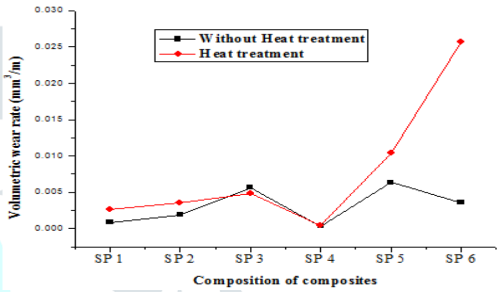

Fig.7. Effect of composition on volumetric wear rate

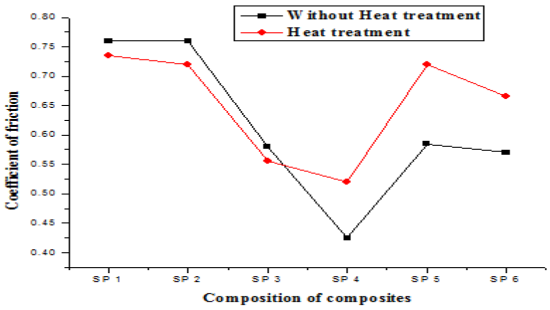

Fig.8. Effect of composition on coefficient of friction

From the Fig.7 & Fig.8 it is understood that increase in filler content decreases the volumetric wear rate up to 20% filler addition then it increases with increase in the filler content. The corresponding coefficient of friction decreases with increase in the filler content and later with increase in the filler content increases the coefficient of friction.

With increase in the filler content, the volumetric wear rate is decreased due to the hardness of the filler content later it is decreases due to the increase in the volume fraction of the filler content.

The coefficient of friction is decreased with increase in the filler content. Due to coefficient of friction is inversely proportional to the frictional force. As frictional force increases the corresponding coefficient of friction decreases.

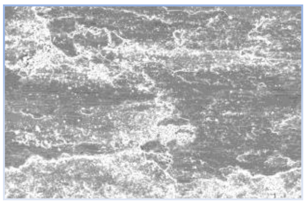

Fig.9. SEM micro graph of Sp-3, Speed-2.45m/s, applied load 20 N.

The increase in noise and friction coefficient was associated with grooving and progressive oxidation of the metal surface. A typical view of the worn surface after extensive sliding under steady state conditions is given in fig., which shows a prow at the end of a groove. The prow was believed to consist of a mixture of heavily deformed metal and metal oxide.

Adhesive wear: adhesive wear is that during wearing plastically deformed asperities will get weld with the sliding disc and the same is separates by tearing action. The shallow teared surface appeared rough and wear loss takes place. Due to its shallow depth the mild wear occurs in fig.9

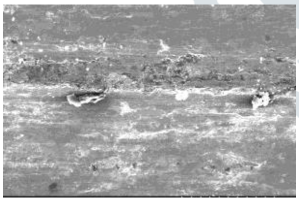

Fig.10.SEM micro graph of Sp-4, Speed-2.45m/s, applied load 20 N.

Fatigue wear: The term fatigue is broadly applied the failure phenomenon where a solid is subjected to cyclic loading involving tension and compression above a certain critical stress. Repeated loading causes the generation of micro cracks, usually below the surface, at the site of a pre-existing point of weakness. On subsequent loading and unloading, the micro crack propagates. Once the crack reaches the critical size, it changes its direction to emerge at the surface, and thus flat sheet like particle is detached during wearing. In fig.10. This is like fretting wear but the flake will separates in fatigue wear whereas small

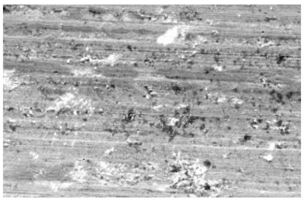

Fig.11. SEM micro graph of Sp-5, Speed-2.45m/s, applied load 20 N.

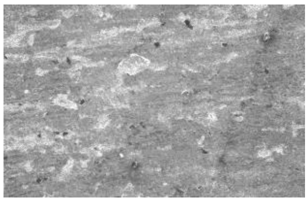

Fig.12. SEM micro graph of Sp-6, Speed-2.45m/s, applied load 20 N.

From the Fig.11. &.Fig.12.It is observed that with increase in the normal load at the particular sliding speed, the volumetric wear rate is increased for all the specimens. An increase in the wear rate takes place with an increase in load and tangential velocity, reaching a maximum value and leading to a change in wear surfaces and wear debris from the presence of oxide to the presence of metallic particles. For loading conditions above the maximum in wear rate, plastic deformation of the sliding surfaces is predominant

VI. CONCLUSIONS

From the above results, the following are the conclusions were drawn.

1. The hardness value for heat treated specimens shows higher than the without heat treated specimens.
2. The volumetric wear rate is decreased with the addition of filler material upto 20%.
3. Te coefficient of friction is also less value for 20% filler material.
4. Adhesive wear mechanism is observed.

REFERENCES

[1] C. Allen, A. Ball, "A review of the performance of engineering materials under prevalent tribological and wear situations in South African industries", Tribology International, vol. 29, No. 2 pp. 105-116, 1996.

[2]. Sandeep Kumar, Sant Ram Chauhan , " Mechanical and Dry Sliding Wear Behavior of Particulate Fillers CaCO3 and CaSO4 Filled Vinyl ester Composites, "International Journal of Composite Materials 2012, 2(5):101-114 DOI: 10.5923/j.cmaterials.20120205.06

[3]. B. Shivamurthy, Siddaramaiah and M.S. Prabhuswamy, "Influence of SiO_2 Fillers on Sliding Wear Resistance andMechanicalProperties of Compression Moulded Glass Epoxy Composites," Journal of Minerals & MaterialsCharacterization & Engineering, Vol. 8, No.7, pp513-530, 2009jmmce.org Printed in the USA. All rights reserved.

[4]Vithal Rao Chavan et al, Effect of The Tribological Behaviour of Hematite Filled Hybrid Composites – A Taguchi Approach International Journal of Engineering Research And Advanced Technology, Special Volume. 02Issue.01, May-2016, ISSN: 2454-6135.

[5] V Algur, et al, Analysis of Wear Behaviour of a Heat Treated Modified ZA-27 Alloy by Taguchi Technique. IntJour of Rec and Innov Trends, 2 (2014).

[6] Veerabhadrappa Algur, V et al, Optimization of Friction performance of a Heat Treated Modified ZA-27 AlloyUsing Design of Experiments. International Journal of Current research, 7 (2015) 11526-11533.

[7] Hanumantharaya R, Ananda Kumar K M, Prem Kumar B G ,Vikas G ,Ashok Kumar G P," Friction and Dry Sliding Wear Behaviour of Granite - Fly Ash Filled Glass Epoxy Composites," International Journal of Innovative Research in Science, Engineering and Technology(An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 7,July 2014.

[8] B. Suresha, G Chandramohan, P R Sadananda Rao, P Sampathkumaran, S Seetharamu&Varathavenkateswarlu, " Friction and slide wear characteristics of glass-epoxy and glass-epoxy filled with SiCp composites" Indian Journal of Engineering and Material Sciences.

[9] Kishore, P.Sampathkumaran, S.Seetharamu, Vyantheya, S.Murali and R.K. Kumar, SEM observations of the effect of velocity and load on the slide wear characteristics glassfabric- epoxy composites with different fillers, wear, 237 (1), (2000) 20-27.