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Tribological and Thermal Characterization of Glass Fiber - A Review

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Abstract

This present paper reviews about thermal and wear behavior of glass fiber Reinforced composites. It involves the effect of different fiber length, volume fractions of fibers that impregnated with various polymer matrixes. Scanning electron microscopy describes worm surface of glass fiber reinforced composites and bonding between fiber and matrix phase.

Keywords: *Glass fiber; Scanning electron microscopy; Thermal behavior; Tribological.*

1. INTRODUCTION

Today's Material Manufactures sectors are seeking to produce high strength to weight ratio materials. Fiber reinforced composites are the materials which compensate the manufactured need, though plenty of fibers category available in existing market. Among these fibers natural fiber have high strength, low weight, easy to manufacture and biodegradability than synthetic fiber. But their thermal and tribological behaviors is low than synthetic fibers. Here synthetic fibers leed their advantages over natural fiber by means of greater thermal and tribological properties. Various synthetic fibers are glass fiber and carbon fiber. Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glass-makers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. Glass fibers can also occur naturally, as Pele's hair. Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively light weight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP). This structural material product contains little air, is denser than glass wool, and is an especially good thermal insulator. Fig. 1 shows processing of glass fiber.

Fig. 1: Processing of glass fiber (a-b) raw materials (c) processing technique (d-e) glass fiber roll and Glass fibers.

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In this present work processing techniques of glass fiber, source and raw material for glass fiber has been studied. Tribological and thermal behavior of glass fiber with various polymer matrixes was studied.

2. EXPERIMENTS

2.1 Friction and Wear Test

Friction and wear test experiments were carried out on glass fiber reinforced composites with different matrix phases. Their experiments and processes were elaborated below. Friction test was done with Chinese standard –GB 3960-83[26] with sample size of 25*25*15 mm^3. The specimen cleaned with ultrasonically, acetone and thoroughly dried before testing. Friction and wear test of paper based composed friction is conducted on QM1000-11 friction tester in oil lubricated condition. Friction test consist of flywheel, lubrication system, temperature control apparatus, operating system. Pressure was maintained like 0.5, 1.0 and 1.5 Mpa. Rotating speed was carried at 1000, 2000 and 3000 rpm. Machine oil with kinematic viscosity of 28.8 - 35.2 mm^2/s and inertia was 0.1 kgm^2 at 40 ºC temperature (Ke-ZhiLi *et al*. 2014). Friction and test performed with abrasive wheels of load 250 g at ASTM D4060 and wear rates for PVC, WPVC, glass fiber reinforced specimen size was 120*120*3 mm^2 and then sliding distance of the specimens were 0.5 to 2.0 km. Specific wear rate (k) was measured by determination of weight loss of test specimen (Narongrit *et al*. 2012b). Friction and wear test was performed on pin-on-die tribometer where normal load imported on pin with pneumatic cylinder and disk rotation speed is controlled by an electric motor. Disc & pin measured on mean radius of contact by 2 mm from the surface .the following conditions were maintained during testing.

2.2 Thermal Properties

Pin diameter = 14 mm.
Thickness = 16 mm.

Pin was rubbing against cast iron disc with diameter of 80mm and thickness 22mm mean friction is equal to 32mm.

Ti =50 ºC
Tf =350 ºC increase- disc (1^{st} sequence),
30 times cycles with pressure=1.8 µpa(2^{nd} sequence)
Sliding velocity = 9 m/s

During on contact temp raise is 50 ºC increase (pin in tough with disc)

During pin at half contact temperature decrease 50 ºC (Du-Xin Li *et al*. 2013).

Here the load are applied with several speed ranger which helps in the measurement of wear and friction values at the end of the pulley placed the shaft where the iron weight is added With the ranger of load applied the speed is reduced where the reading were marked load increase-speed decrease-friction increase roughness maintained at 100 mm (Yuan *et al*. 2012).

2.3 Measurement of Thermal Expansion Co-Efficient (CTE)

Measuring the change of the length as thermal environment changes, the linear expansion coefficients of Specimen at different temperatures were measured. To find the linear expansion of co-efficient the specimen size was 2*2*25 mm and experimental instrument PIL402C (Ke-ZhiLi *et al*. 2014). Thermal coefficient of expansion of PEEK was measured using the strain gauge at 77K room temperature. Quartz used as a reference specimen because of its low coefficient of thermal expansion (Li *et al*. 2010).

2.4 Scanning Electron Microscopy (SEM)

SEM test was conducted on glass fiber rein forced composites specimens who were used to test friction and wear test. SEM images were used to determine interfacing between fiber and matrix phase, worm surface of wear specimens. Cavities that were produced because of removal of matrix phase or fiber content can determine by SEM images. Micro mechanism that involved in wear can be ensured by SEM images.

3. RESULTS & DISCUSSIONS

3.1 Friction and Wear Test Results

Analysis of wear behavior of glass fiber has been investigated through fig. 2. Glass fiber impregnated with polyamide 6/polytetrafluro ethane and polyvinyl chloride also hybridized with wood and paper. Maximum 2.0 km distance was maintained to determine wear behavior. It is to be noted that rate of wear decreases when glass fiber content increases, but this was not suitable all composites. Wear rate alters when co-material in hybrid composite changes. Based on the percentage of co-material wear rate of composite will changes. Here fiber length and size also most important factor foe wear rate. From fig. 2. 15 wt% of glass fiber influences better wear rate among all the composite types. This shows how glass fiber content decreases wear rate in composite material among other composites.

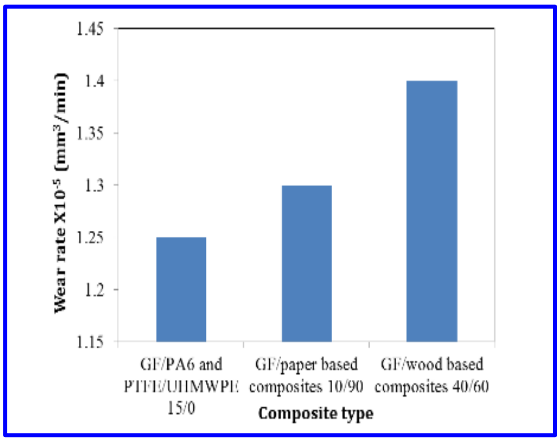

Fig. 2: Wear behavior of glass fiber reinforced with various matrix materials

3.2 Thermal Behavior of Glass Fiber Reinforced Composites

3.2.1 Coefficient of Thermal Expansion (CTE) results

Thermal expansion of glass fiber reinforced composites results based on precipitation of matrix phase and dispersion of fiber content. At 135 ºC physical expansion co-efficient of glass fiber reinforced composite material is decreased, 250 ºC physical expansion co-efficient of glass fiber reinforced composite material of material normally increased. When temperature rose to 250 ºC to 400 ºC physical expansion coefficient decreased due to precipitation of matrix (Ke-ZhiLi *et al*. 2014). Glass fiber has very low co efficient of thermal expansion, which ranges from $5*10^{-6}$ k^{-1} to $12*10^{-6}$ k^{-1} with different components CTE of neat PEEK - $46.5*10^{-6}$ K^{-1} and 30 % glass fiber reinforced PEEK has CTE of $-14.4*10^{-6}$ K^{-1} and we can maintain the temperature at 77 K - 295K to reduce thermal expansion values (Li *et al*. 2010).

3.3 Scanning Electron Microscopy Images

Fig. 3. shows various images of scanning electron microscopy, these images reveals that fiber matrix bonding and worm surface of various glass fiber reinforced composites. Fig 3(a) reveals worm surface of GF/paper based composites. This shows excess of fiber contents so the wear occurs on glass fibers, matrix phase loss their contents factually low. Bonding between glass fiber and matrix phase was shown in fig 3(b). Glass fiber lose their content in low level when it was composited with PA6 matrix. It was ensured in fig 3(c) it is to be noted that when matrix phase increases wear of glass fiber content decreases also it decreases loss in composites.

Worm surface of glass fiber reinforced with PEEK composites was shown in fig. 3(c). Naturally PEEK has greater wear resistance; this reassures low wear on glass fiber reinforced PEEK composites also it ensured in fig. 3(d).

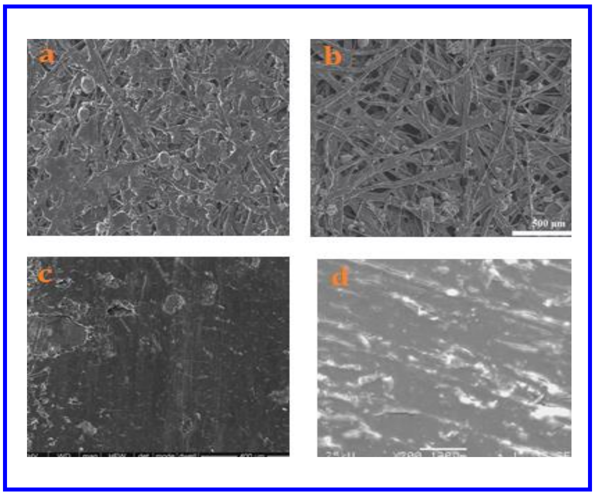

Fig. 3: SEM images of glass fiber reinforced composites a) worm surface of Gf/paper based materials, b) micro images of bonding between glass fiber rein forced composites, c) worm surface of GF/PA6 composites and d) worm surface of GF/PEEK composites

4. CONCLUSION

Multifunctional behavior of glass fiber could be predicted through this present review also we could arrive following conclusion.

- Glass fiber has very low wear rate when it is impregnated with matrix materials. In glass fiber reinforced hybrid composites also wear rate decreases when glass fiber content decreases.
- Glass fiber has very low coefficient of thermal expansion. It can be used to manufacture as thermal resistance materials.
- Scanning electron microscopy reveals bonding between finer and matrix materials. Mechanism of wear behavior could be predict through SEM images.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

Amar Patnaik, Investigations on micro-mechanical and thermal characteristics of glass fiber reinforced epoxy based binary composite structure using finite element method, Comput. Mater. Sci., 62(47), 142–151(2012). doi:10.1016/j.commatsci.2012.05.020

Du-Xin Li, Tribological properties of solid lubricants filled glass fiber reinforced polyamide 6 composites, Mater. Desig., 46(2), 809-815(2013). doi:10.1016/j.matdes.2012.11.011

El-Tayeb, N.S., Friction and wear properties of E-glass fiber reinforced epoxy composites under different sliding contact conditions, Wear, 192(28), 112-117(1996). doi:10.1016/0043-1648(95)06770-1

Ke-ZhiLi, Tribological and mechanical properties of glass fiber reinforced paper-Based composite friction material, Tribol. Int., 69(18), 156-167(2014). doi:10.1016/j.triboint.2013.08.003

Li, L. F., Mechanical and thermal expansion properties of glass fibers reinforced PEEK composites at cryogenic temperatures, Cryogenics, 50(18), 84-88(2010). doi:10.1016/j.cryogenics.2009.12.003

Meia, L. H. I., Glass fibre recycled poly (ethylene terephthalate) composites: mechanical and thermal properties, Polym. Test., 24(4), 507–512(2005). doi:10.1016/j.polymertesting.2004.11.011

Narongrit Sombat sompop, Effects of wood constituents and content, and glass fiber reinforcement on wear behavior of wood/PVC, Composites, 43, 2721–2729(2012b). doi:10.1016/j.compositesb.2012.04.031

Srivastava, V., Gautam, S. P., Agarwal, V. C. and Mehta, P. K., Glass waste as coarse aggregate in concrete, *J. Environ. Nanotechnol.*, 3(1), 67-71(2014).

Yuan Shujie, Experimental investigation on thermal physical properties of an advanced glass fiber, composite material, Phy. Proce., 25(4), 339-344(2010). doi:10.1016/j.phpro.2012.03.093