Reciprocating Friction and Wear Characteristics of Al Particulate Glass Epoxy Composites

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ABSTRACT

An experimental study has been carried out to investigate the reciprocating friction and wear characteristics of woven glass epoxy composites filled with Al particulate using a reciprocating friction and wear tester. The fiber weight fraction has been kept constant at 60 wt% and Al wt% is varied as 0, 5, 10, and 15%. The composite is fabricated in hand lay-up technique followed by light compression moulding. Friction and wear behavior under dry reciprocating condition has been presented as function of reciprocating distance keeping reciprocating frequency and normal load constant at 30 Hz and 1.0 Kg respectively. Composites having 5 and 10 wt% Al powder exhibit less friction and wear loss as compared to unfilled glass epoxy composite whereas 15 wt% Al filled glass epoxy composite reports highest friction and wear loss. An attempt has been made to observe the distribution of fiber and Al particles in the composite, and to correlate the wear behavior using Scanning Electron Microscopy (SEM) observations.

KEYWORDS

Al Particulate, Epoxy Composite, Friction, Glass Fiber, Reciprocation, Wear

INTRODUCTION

Epoxy resin and glass fiber both are the most widely used constituents of the composite industries. Epoxy resin, due to its excellent adhesion to many reinforcements, high hardness, and excellent resistance to humidity, good mechanical and thermal properties coupled with process ability (Wang, Zheng & Zheng, 2011) has become popular among the polymers. Properties that have made glass fibers so acceptable include low cost, high production rates, high strength, high stiffness, relatively low density, non-flammable, good chemical resistance, relatively insensitive to moisture, able to maintain strength properties over a wide range of conditions, good electrical insulation (Wallenberger, Watson & Li, 2001). In general, glass fiber reinforced epoxy matrix composites have been increasingly used for numerous engineering purpose such as seals, gears, rollers, cams, wheel, clutches and bearings due to high specific strength and high modulus, better tribological properties, wide varieties of availability and design flexibility as compared to metal based counterparts. In particular, the woven fabric composites are getting acceptance in many engineering applications such as in circuit board, marine, aerospace, transportation and other industries for several reasons. They are commonly used in industry to manufacture composite components due to their ease of use, improve structural performance and reduction in cost. They provide better resistance to impact than unidirectional composites and display behavior that is closer to that of a fully isotropic material (Abot, Yasmin, Jacobsen & Daniel, 2004; Park & Jang, 1998; Bijwe & Rattan, 2007).
Glass fiber reinforced polymeric composites traditionally show poor wear resistance and high friction due to the brittle nature of the reinforcing fibers. Modification of woven fabric reinforced composites by incorporation of fillers has been a popular research activity in the plastics industry since the properties of resultant materials may be significantly changed by the introduction of fillers and fabrics (Zaini, Fuad, Ismail, Mansor & Mustafah, 1996). Addition of abrasive fillers, however, enhances not only wear resistance, but also coefficient of friction of glass/epoxy composites. If coefficient of friction increases, it may lead to heat buildup, which, in turn, might cause thermal degradation/aging of the polymer matrix. Hence, it is essential to reduce coefficient of friction by judicious choice of filler(s). The reason to incorporate filler into a polymer is two-fold; (a) first to improve the wear resistance, mechanical and thermal properties and (b) to reduce the cost of the final product. In the last two decades, various filler and fiber materials have emerged as a subject of extensive research. A good amount of research has already been conducted with organic or inorganic particles filled glass epoxy composites (Suresha, Chandramohan, Prakash, Balusamy & Sankaranarayanasamy, 2006; Debnath, Sampathkumaran, Seetharamu, Thomas & Janardhana, 2005; Suresha et al., 2006; Shivamurthya, Siddaramaiah & Prabhswamy, 2009; Raju, Suresha, Swamy & Kanthraju, 2013; Mohan, Mahesha & Raja, 2014; Debnath, Singh & Dvivedi, 2013) to improve the tribological as well as mechanical properties based on the continuous sliding (pin and disc) mode of contact. In a comparison of reciprocating and continuous sliding wear, Ward (1970) has shown that under similar conditions of load, speed and nominal area of contact, a higher wear rate is obtained during reciprocating sliding. In most of the cases fiber orientation relative to the rubbing surfaces has not been considered. From tribological aspects of composites as end product, its behavior depends on the types of contact between the mating surfaces and on the fiber orientation relative to the surface of action (Sung & Suh, 1979; Chang, 1983; Cirino, Friedrich & Pipes, 1998).

Aluminium possesses low weight, high strength, superior malleability, easy machining, and excellent corrosion resistance, good thermal and electrical conductivity. Aluminium is also very easy to recycle (Bhattacharya, 1986). Several researchers have attempted to explore the mechanical, friction and wear behavior of Al particle filled glass epoxy composites considering different process parameters. Vasconcelos, Lino, Baptista & Neto (2006) studied the tribological behavior of epoxy, aluminum particles and epoxy-aluminum-milled glass by considering thermal conductivity and wear resistance. Vasconcelos, Lino, Magalhaes & Neto (2005) employed charpy impact tests to determine toughness of epoxy, aluminum and milled fiber composite. Most of the findings are based on either randomly oriented or unidirectional oriented fiber composites. Extensive literature survey reveals that no significant work has been done to explore the use of Al particle as filler for mechanical and tribological properties of woven glass epoxy composites. Though there may be many benefits of using Al filler in polymer composites, but the use of these materials as tribo materials is still in the nascent stage of research. Therefore, the present work is an earnest endeavor to fill this void. In the present research work, the effects of addition of Al filler in woven glass epoxy composite reciprocating against a hardened steel counter face (ball) under dry and normal atmospheric condition have been studied. This work would be a great help in understanding the function of Al powder in glass epoxy composite.

**EXPERIMENTAL WORK**

**Materials**

Woven glass fabrics made of 360 gsm, containing E-glass fibers of diameter 5-10 μm, orientation 0/90°, density 2.59 gm/cm³ has been used. Figure 1(a) and Figure 1(b) show the image of woven E glass fabric and the geometry of the fiber orientation respectively. The matrix system is a combination of medium viscosity epoxy resin (ARALDITE CY 205 IN) with glass transition temperature (T_g)-108°C and curing agent hardener (HY 951) at room temperature. The filler used for this study is aluminum powder (purity 98.70%). Some details of the constituent matrix materials and the properties of epoxy resin, glass fiber, and Al powder have been shown in Table 1 and Table 2 respectively.
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