A Study of Wear Rate Epoxy Resin filled with SiO_2 particle and Glass fibers

Harith I. Jaffer* ***Sinaa I.Husaen**** ***Nadia A. Ali****

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Abstract:

This research is devoted to study the effect of different in weight percentage of Sio_2 particles and glass fibers (5, 10, 15, 20) wt. % on the wear rate epoxy resin.
The results show that the value of hardness increase with the increase for the weight percentage of reinforcing particles and fibers, while the wear rate decrease with the increase the load level of the reinforcing particles and fibers .
The largest value of the hardness, and the lowest value of the wear rate for epoxy reinforced with 20% of SiO_2, the wear rate increase in general with increasing the applied load.

Key words: - epoxy resin, glass fibers, sio_2, wear rate

Introduction:

Polymer based materials are finding increasing use in many applications owing to their strength,lightness, ease of processing and availability of wider choice of systems [1]. One of the areas where their use has been found to be particularly advantageous is the situation involving contact wear. Due to the low coefficient of friction and also the ability to maintain loads, some specific grades of polymer are used in place of the traditional metal based materials in recent times [2]

Polymers are usually characterized by low moduli and strength. Epoxy, as a thermoset material, has a low wear resistance. Additions of glass fibres improve the elastic modulus and tensile strength and can improve the wear resistance.[3]
A Composite in engineering sense is any materials that have been physically assembled to form one single bulk without physical blending to foam a homogeneous material. The resulting material would still have components identifiable as the constituent of the different materials. One of the advantage of composite is that two or more materials could be combined to take advantage of the good characteristics of each of the materials.
Usually, composite materials will consist of two separate components, the matrix and the filler. The matrix is the component that holds the filler together to form the bulk of the material. It usually consists of various epoxy type polymers but other materials may be used. Metal matrix composite and thermoplastic matrix composite are some of the possibilities. The filler is the material that has been impregnated in the matrix to lend its advantage (usually strength) to the composite. The fillers can be of any material such as carbonfiber, glassbead, sand, orceramic.[4]
Composites can be classified into roughly three or four types according to the filler types:

1. Particulate
2. Short fiber
3. long fiber
4. laminate

*University of Baghdad, College of Science, Department of Physics

Hardness is the measure of how resistant solid matter to various kinds of permanent shape change when a force is applied. Macroscopic hardness is generally characterized by strong intermolecular bonds, however the behavior of solid materials under force is complex, therefore there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness. Hardness is dependent on ductility, elasticity, plasticity, strain, strength, toughness, viscoelasticity, and viscosity. Common examples of hard matter are ceramics, concrete, metals, and super hard materials, which can be contrasted with soft matter [5]

Wear is the progressive loss of material due to interacting surfaces in relative motion. It is quantitatively measured as the specific wear rate was (defined as volume loss per sliding distance and load [10–6 mm3/Nm]) of a material. Numerous distinct and independent mechanisms are involved in the wear of a polymer. These include:

• Abrasive wear – “cutting” caused by hard irregularities on the countersurface.

• Fatigue wear – failure of the polymer due to repeated stressing from hard irregularities on the countersurface.

• Adhesive wear – loss of polymer by transfer and adhesion to the countersurface.[6]

Suresha et al [7] investigated the friction and wear behavior of glass-epoxy composite with and without graphite. They fabricated neat glass-epoxy composite and graphite filled glass-epoxy composite with three different percentages of filler. They concluded the graphite filled glass epoxy composite shows higher resistance to slide wear as compared to plain glass-epoxy composites.

Zhang et al [8] investigated the mechanical properties and wear properties of silicon carbide (SiC) and alumina (Al2O3) whisker- reinforced epoxy composites.Silicon carbide and alumina whiskers can significantly improves the flexural modulus and wear resistance of the epoxy composites.

M. A. Zamzam[9] investigated the wear rate of glass- epoxy composites . Epoxy, as a thermoset material, has a low wear resistance. Additions of glass fibres improve the elastic modulus and tensile strength and can improve the wear resistance. The composites were prepared by pultrusion of the glass fibres after saturation of epoxy. The fibre volume fraction was varied up to 50%. The wear resistance increases with increasing the sliding velocity, with decreasing the applied contact pressure and with selecting the most favourable glass fiber volume fraction.

B. Suresha [10] investigated the Friction and Dry Slide Wear of Short Glass Fiber(SGF) Reinforced Thermoplastic Polyurethane(TPU) Composites , The results reveal that the slide wear loss increases with increasing load/sliding velocity. The coefficient of friction increases with increase in sliding velocity. The coefficient of friction and wear rate of the composites decreased with increase in SGF content. Further, 40% SGF reinforced TPU composite exhibited lower friction coefficient and wear rate than 20 and 30% SGF reinforced TPU composites.

Materials and methods:

Hand Lay-up technique has been adopted for making glass fibers-epoxy and Sio_2 –epoxy. Epoxy resin was used as a matrix (Mastertop 1230 plus), adhesive grade room temperature supplied by Iranian BASF construction chemical,The epoxy resin is mixed with the hardner in the ratio 1:2 by weight,the density of mixed material 1.79Kg/m^3 .The fibers material used is glass fibers, The short random E-glass fibers with various length, supplied by mow ding LTD.U.K.,density 2540Kgm^{-3} ,fiber diameter 3.13nm.The filler material used is Sio_2 of piratical size 3.5μm.molar mass 60.084gm,melting point 1710 ^oC, Boiling Point 2230 ^oC, Density~2.6 g/c^3 . This research to study different weight percentage for glass fibers and SiO_2 (5,10,15,20)%,different applied load (10,15,20)Newton at time(10)minutes,and study the hardness test for epoxy composites (EP+G.F and EP+SiO_2).

Devices:-

Wear test:-Wear machine consists of an arm metal Flat containing the sample holder to install And a metal disk rotating motor connection Power, speed of disk (500 cycles /Minutes), and the hardness of disk made of iron 9269HBas shown in . (Figure1)

Fig (1) Wear test

And the rate of wear and tear of the mathematical relation
The following**: [11] Wear rate = ΔW/ D_S ….(1) (gm. / cm)**

ΔW :- difference of the mass sample before and after test (gm)

ΔW = W1-W2 ... ... (2)

Is calculated from the following relationship, distance
Slide(S_D) (Cm)

$S_D = 2 \pi r n t$ ... ... (3)

Note that:
r:- radius from the center of the sample to
Center of the disc(Cm)
N:- Number of sessions of the disk (r / min).
T:- Test time (minutes).
In this paper we examine the impact of pregnancy hanging in the wear of rate ,was the applied load (10,15,20)Newton .

Hardness test:-It was measured hardness of the samples in a manner shore(D) and the device used for this test type(shore D Hardness tester TH 210) that is a tool that stitches in needle the surface of the sample and then register the number which comes out on the screen of the device .

Results and Discussion:

1-wear rate:-

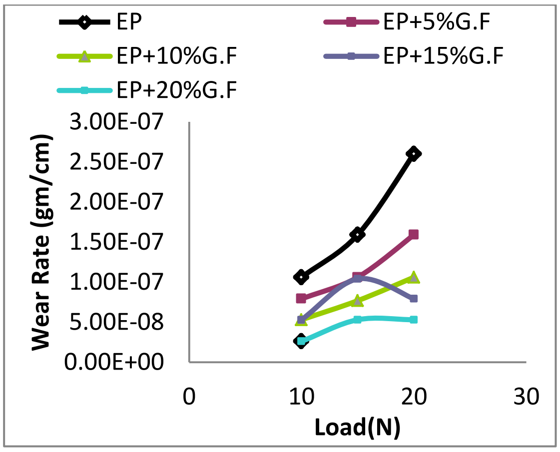
1-1 effect of loading the wear rate

The applied load was very important parameter which effected on the fraction between the surface of sample and disc will increase the temperature between them. Table (1) shows the values for the wear rate for SiO_2 and glass fibers additives in general, all samples appear increase in wear rate with increase applied load. But Sio_2 fillers give lower values for wear rate, because the particles for SiO_2 (3.5μm)will distribute informally in to the sample and the hardness for Sio_2 more than the matrix ,so that the fraction between the surface of sample and disc will decrease .

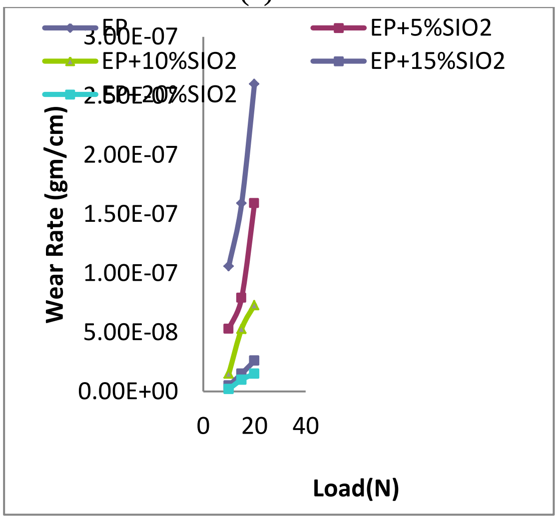
For fibers, the fibers will randomly distribute inside the sample and there are rich resin will form between fibers, so that the hardness for their samples will decrease and the fraction will increase.

Table (1) wear rate values as a function applied load

SAMPLE	Wear Rate at load(10N)	Wear Rate at load (15N)	Wear Rate at load(20N)
EP(Pure)	$1.06*10^{-7}$	$1.59*10^{-7}$	$2.6*10^{-7}$
EP+5%G.F	$7.9*10^{-8}$	$1.06*10^{-7}$	$1.59*10^{-7}$
EP+10%G.F	$5.3*10^{-8}$	$7.6*10^{-8}$	$10.6*10^{-8}$
EP+15%G.F	$5.3*10^{-8}$	$10.4*10^{-8}$	$7.9*10^{-8}$
EP+20%G.F	$2.6*10^{-8}$	$5.3*10^{-8}$	$5.3*10^{-8}$
EP+5%SiO_2	$5.3*10^{-8}$	$7.9*10^{-8}$	$15.9*10^{-8}$
EP+10%SiO_2	$1.5*10^{-8}$	$5.3*10^{-8}$	$7.3*10^{-8}$
EP+15%SiO_2	$0.5*10^{-8}$	$1.5*10^{-8}$	$2.6*10^{-8}$
EP+20%SiO_2	$0.2*10^{-8}$	$1.0*10^{-8}$	$1.5*10^{-8}$



(a)

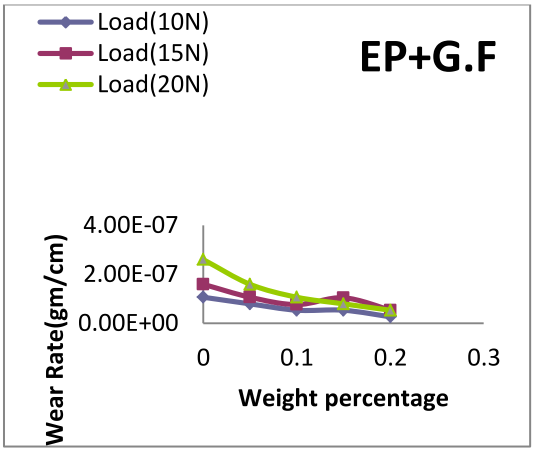


(b)

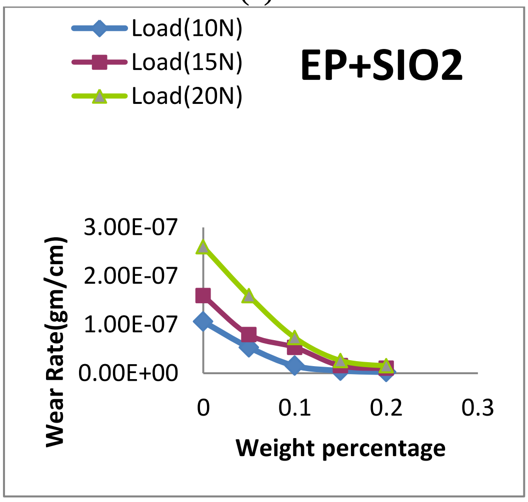
Fig (2) wear rate as a function load (a) epoxy resin reinforced with glass fibers (b) Epoxy resin reinforced with SiO_2 piratical

1-2 effect of percentage weight the wear rate

Wear rate decreases with increase in weight percentage for all the samples ,but the wear rate of the epoxy resin reinforced with SiO_2 particle is better than chopped glass fibers because the fibers not dispersion along the sample and the random of orientation of fiber , which indicates that the silica particles resistance friction, as in Figure(3), and the hardness for the surfaces for SiO_2 composites were increasing as increases in percentage weight for SiO_2 as shown in table (2).



(a)



(b)

Fig(3) wear rate as a function weight percentage (a) epoxy resin reinforced with glass fibers (b) Epoxy resin reinforced with Sio_2 piratical

Table(2) values hardness for epoxy composites

Material	Hardness(shorD)
EP	75.3
EP+5%G.F	76.5
EP+10%G.F	78.3
EP+15%G.F	80.6
EP+20%G.F	82.7
EP+5%SiO2	79.2
EP+10%SiO2	82.7
EP+15%SiO2	85.3
EP+20%SiO2	88.4

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دراسة معدل البلى لراتنج الايبوكسي المضاف اليه دقائق السليكا والياف الزجاج

حارث ابراهيم جعفر*   سيناء ابراهيم حسين*   نادية عباس علي*

* قسم الفيزياء - كلية العلوم – جامعة بغداد

الخلاصة:

يهدف البحث الى دراسة اضافة دقائق السليكا والياف الزجاج بنسب وزنية (5و10و15و20)% معدل البلى لراتنج الايبوكسي بينت النتائج بان الصلادة تزداد بزيادة نسب اضافة مواد التقوية بينما معدل البلى يقل مع زيادة نسب اضافة مواد التقوية, حيث اعلى قيمة للصلادة واقل قيمة لمعدل البلى كانت لمتراكب الايبوكسي المقوى بنسبة 20% من السليكا وان معدل البلى بصورة عامة يزداد بزيادة الحمل المسلط