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Study Of Tribological Behavior Of Polymer Concrete Composite

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ABSTRACT: The main aim of this study is assess the wear resistance of polymer concrete composite (PCC).Polymer concrete composite is a composite material realized with resin and aggregates.The Unsaturated polyester resin was used for binding the aggregates.The silica foam and glass fibers were introduced in the composition as filler.The fiber percentage and silica foam was constant, the unsaturated polyester resin and the silica sand dosages were varied.The prepared specimens were tested at room temperature by using differents loads(4,6,8,10,12)N for constant testing time and differents times for constant testing load (12 N).The resulted wear rates were calculated for each sample apart with.variation the previous variables. To produce more precise idea about the wear characteristics of all test specimens when used them in tribology engineering applications, the study of wear rates was carried out for differents compositions at constant temperature when the above mentioned variables were fixed.

Keywords: Abrasive wear, resin, Unsaturated polyester, Polymer Concrete, tribology
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1 INTRODUCTION

Wear is the removal of material from or the impairment of the solid surface resulting from friction or impact.Wear is an important phenomenon that occurs in all polymer applications in one form or the other [1].The process of `wear' may be variously defined but most generally it is quantitatively measured in terms of the mass, or volume, loss from a sliding or eroding contact.The sequence of events is invariably as follows.Mechanical forces, frictional work, impact forces,contact fatigue stress, cavitation forces and so on induce damage in the contact members[2]. The rate of removal is generally slow, butsteady and continuous[7].Wear mechanisms may be briefly classified as mechanical, chemical and thermal wear. 'Mechanical wear', 'chemical wear' and 'thermal wear' are terms used to describe briefly wear mechanisms occurring.These three descriptions of wear are necessary to characterize wear briefly; however, they are not sufficient to introduce wear models for wear rate predictions.(1) 'Abrasive', 'adhesive', 'flow' and 'fatigue' wear.(2) Corrosive Wear.(3) Melt and diffusive wear[6].For polymeric systems there is also the very signifcant prospect of marked environmental influences, which will include the role of lubricants as well as the often-dominant consequences of frictional heating.There are at least three ways in which the subject may be rationalized by a simple review such as this (see Fig.1). The choice of approach depends upon the audience; here the three established methodologies are offered together as each has a unique value. Several authors studied the wear debris generation mechanism for polymers by macroscratching tests.Dr. Awham M.H et al (2010), studied the wear of Epoxy and Unsaturated polyester resins in different conditions by different loads(10,20)N and various testing times with different sliding distances.They obtained that epoxy resin undergoes higher wear rates than unsaturated polyester resin[1]. Dr.Abdul Raheem K. et al (2012) studied the effects of filler materials such as (Fe2O3, CaCO3, CaO, Cement, Ca(OH)2 on unsaturated polyester resin content. Generally, showed that addition of cement with percent (10 % wt) get lower wear rate for unsaturated polyester resin[9].

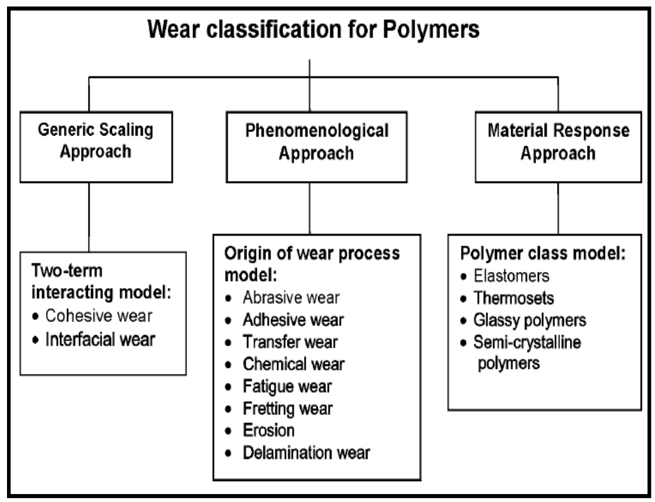

Fig. 1. Simplifed approach to classifcation of the wear of polymers

In this research,Polymer Concrete (PC) is used to study its tribological behavior.PC is a composite material in which resin is used as binder for aggregates such as Sand or gravel instead of Portland cement [3]. PC is an inert product that can be cast in almost any shape [4].Due to its rapid setting, high strength properties and ability to withstand a corrosive environment.It is increasingly being used as an alternate to cement concrete in many applications, construction and repair of structures, highway pavements, bridge decks, waste water pipes and decorative construction panels[5]. The three compositions in this study used fixed concentrations. This concentrations are (85,65,55,40,25%) unsaturated polyester resin of all specimens group and (15,35,45,60,75%) sand as a aggregate in group-1 and (4%) silica foam as a filler with (11,34,41,56,71%) sand in group-2 and (1%) fiber glass with (4%) silica foam and (10,25,40,55,70%) sand in group-3. This filler is used between aggregate and silica foam and also in different concentrations to provide a more comprehensive assessment of the effect of silica foam on the elasticity modulus of PC compounds. From fig 2 , the wear process model of PC is abrasive wear that it is phenomenon approach for this class of materials.Abrasive wear occurs whenever a solid object is loaded against particles of a material that have equal or great-

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er hardness. The particles or grits may remove material by microcutting, microfracture, pull-out of individual grains. The way the grits pass over the worn surface determines the nature of abrasive wear.The literature denotes two basic modes of abrasive wear:

1-Twe body
2-Three-body abrasive wear.

Two-body abrasive wear is exemplified by the action of sand paper on a surface.Hard asperities or rigidly held grits pass over the surface like a cutting tool.In three body abrasive wear the grits are free to roll as well as slide over the surface,since they are not held rigidly. The two and threebody modes of abrasive wearare illustrated schematically in Figure 2 [8]:

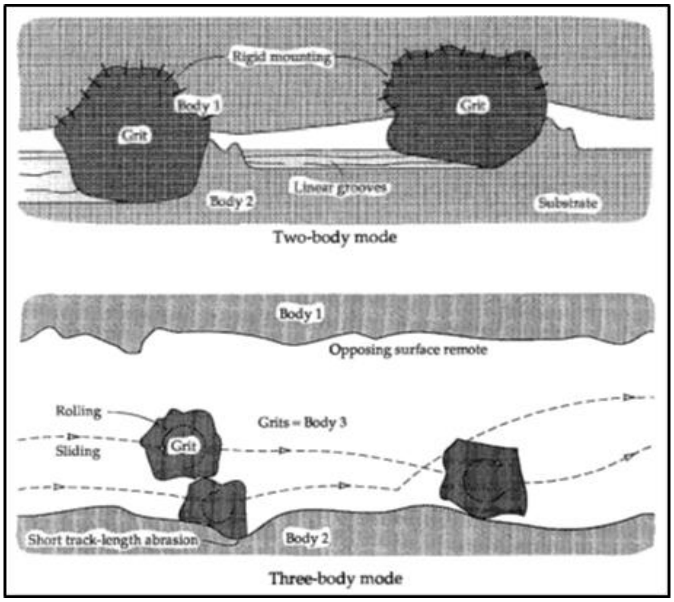

Fig. 2.Two and three-body modes of abrasive wear.

2. Experimental Part

2.1. Materials

2.1.1 Resin

Unsaturated polyester resin (UPS) was used as the matrix in the preparation of composite material polymeric and manuf actured by the (Industrial Chemical of resins Co. LTD) in Saudi Arabia. This resin transforms from liquid to solid state by adding (Hardener) and this hardener is manufactured by the company itself and it is a (Methyl Ethyl Keton Peroxide) coded (MEKP) and be in the form of a transparent liquid. It is added to the unsaturated polyester resin 1% percent at roomtemperature, and in order to increase the speed of hardening, catalyzer materials on interaction is used as a catalyst (Catalyst) called accelerators. Cobalt Napthenate which are mixed directly with the resin and manufactured by the same company.

2.1.2 Aggregate Aggregate used in PC with gradation of 0-2mm , 2-8mm and 8-16mm. In this research, we used it between 0-2mm. Silica sand is the main component of the polymer Concrete used in this study. It is brought from (General Company for Mechanical Industries in Al-Eskandria).

2.1.3 Filler

Silica foam is used as filler in order to achieve chemical resistance, impact and erosion strength and to increase bonding between matrix and reinforcement phase. Silica foam was brought from "Nippon AEROSIL CO. LTD JAPAN, NFPA, NO.77-1984".

2.1.4 Fibers

In this research glass fibers used from type (E - Glass) as strengthening phase in the form of choppy glass fibers, average diameter of filament for this choppy glass fibers is (4–6 µm) and with length is (10-15 mm).These fibers provided by (Mowding LTD. UK) , English Company.

2.2. Mixture Design

By rule of mixture, design of mixtures for all groups are showed in the following manner:

GROUP-*1*:
Samples for studying the effect of silica sand particles volume fraction with particle size rang (300µm ≥ p.s > 74µm), as in Table (1-1).

TABLE 1-1
GROUP-1 SAMPLES

Material NO	Silica sand (%W)	UPS (%W)
1	15	85
2	30	65
3	45	55
4	60	40
5	75	25

GROUP-2: The effect of particle size and volume fraction for silica sand particles on UPS matrix with added 4% silica foam (0.02-0.5 µm) for all samples, these samples are displaying in Table (1-2).

TABLE 1-2
GROUP-2 SAMPLES

Material NO	Silica sand+4% Silica foam (%W)	UPS (%W)
1	11	85
2	26	65
3	41	55
4	56	40
5	71	25

GROUP-3:
Samples with different volume fractions of silica sand and adding percent of silica foam is 4% at (0.02-0.5 µm) and fiber glass 1% as in Table (1-3). Figure (2) shows the specimens used in this research.

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TABLE 1-3
GROUP-3 SAMPLES

Material NO	Silica sand+4% Silica foam +1%fiber glass (%W)	UPS (%W)
1	10	85
2	25	65
3	40	55
4	55	40
5	70	25

2.3. SAMPLE PREPARATION

The moulds used for casting of the specimens comprised of a square steel frame measurments (2*2*2 cm) which was fastened to a wooden plate.The surface of all specimens under study were cleaned and grinded to become smoother (without scratches) before the test. Sensitive electronic balance (type-AE160, Metler, 4 digits) was used to measure the weights of samples before and after the wear test.Figure3 shows these specimens.

Fig 3: specimens

3.WEAR TEST TECHNIQUE :

(Pin **-** on **–** Disc) test apparatus which produced by local company named(Micro test company-Fig 4)was used to measure the wear rates of the previous prepared samples, the used Pin in this work is made from carbide steel material.The wear tests were performed at room temperature with different variables included:-

- The applied loads: (4,8,12) N respectively at No.of cycle (150 rpm) , (R=0.8 cm), (t=3.19 min)and distance is (25 m).
- The testing time (t): (1.59 , 3.59, 5.58, 9.57) min respectively at load (12 N), No.of cycle (150 rpm) , (R=0.8 cm).

Fig 4: Pin on Disc Instrument

The wear rates are calculated according to the following equation:-

Wear rate (W.R) = ΔW/SD…………………………………...(1)

Where:
W: is the weight loss of the specimen before and after the wear test (gm), ΔW=W1-W2.
SD: is the sliding distance (cm).

SD = 2 πNRt…………………………………………………...(2)

Where:
T : is the sliding time (min).
N:is the no.of revolutions of the rotating disc (rev. /min).
R: is the radius of disk (cm).

4.RESULTS AND DISCUSSION

The relations of wear rate (W.R) versus percentage of sand aggregate (%W) for all groups at load (4, 8, 12)N and versus time (min) are shown in Figs.(5, 6, 7, 8) respectively.Generally,the wear rate increases with increase of the applied load for all groups.Group-1 and Group-2 showed higher (W.R) than Group-3 due to existence of particles aggregate (sand , silica foam) only in Group-1,2 while Group-3 contains fiber glass with these particles.Wear rate behavior differents from group to another.Group-1 showed that the wear rate is clear (variation with %W sand for all its peresantage)-see Fig 5- while in Group-2 is constant approximately until up to 50% sand(see Fig 6).In figure 7, wear rate is very low compared with Group-1,2 and the maximum value for its is 0.3 g/cm.

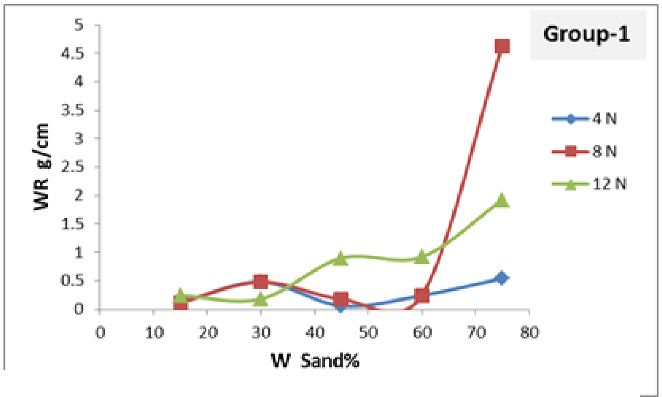

Fig 5 : Variation of W.R Vs %W of sand aggregate for Group-1.

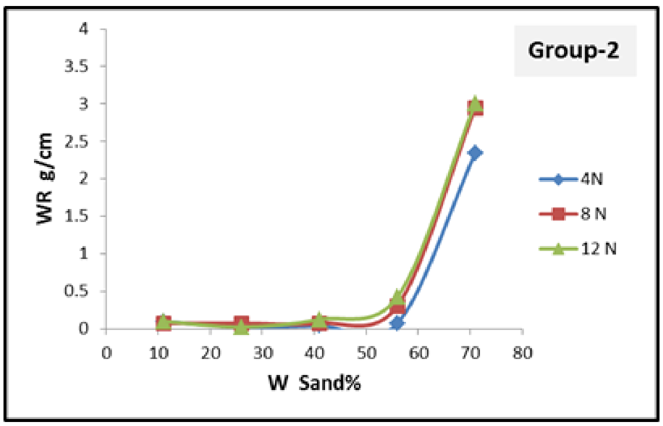

Fig 6 : Variation of W.R Vs %W of sand aggregate for Group-2.

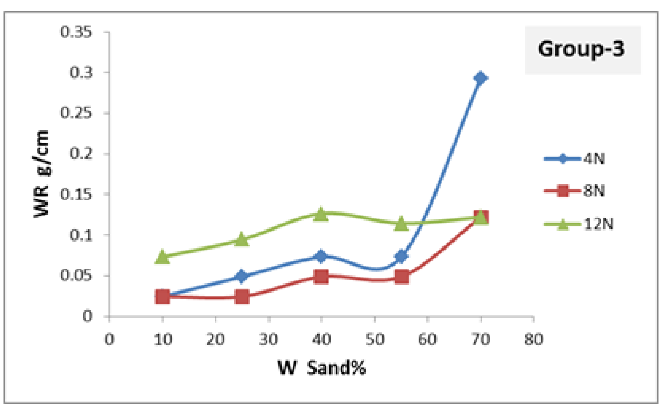

Fig 7 : Variation of W.R Vs %W of sand aggregate for Group-2.

Figure 8 shows the variation of W.R Vs time of sample No.5 for all groups.The sample Group-2/No-5 showed highly wear rate with time compared another samples because lower adhesion force among matrix and strengthening phase due to from added silica foam which is increase brittle matrix. Adding fiber glass decreases wear rate with time highly.

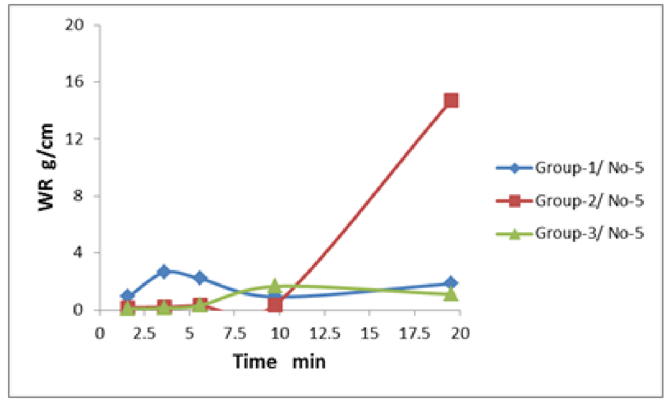

Fig 8 : Variation of W.R Vs Time of sample No.5 for all groups .

5.CONCLUSIONS

The following points can be concluded from the present study: It can be noticed that the Group-2 has lower wear rates compared with Group-1 and Group-2. The wear rates increases for all groups with increase of the applied load, The Group-2/No-5 showed highly wear rate with time while Group-1/No-5 and Group-3/No-5 showed lower wear rates with time. The wear rates increases for all groups with increase of the percentage of sand aggregate (%W).

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