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Studying of Mechanical Properties for AlSiC Composites

Abstract*-This search include to produce Al-SiC composites, containing two different weight percentages 25%, 50%, of SiC and sintering at three different temperatures (300,400,600) °C have been fabricated by powder metallurgy method. Wear,Vickers microhardness characteristics of Al–SiC composites have been tested, in Wear test has been investigated under sliding conditions and compared with those observed in pure aluminum. Wear sliding tests have been carried out using pin-on-disk wear test rate normal loads of 500 g and at constant sliding velocity of 500 rpm. While in Vickers test the load that are used 50 g, 0.49N for 15 sec.,Weight loss of samples was measured and the variation of cumulative Wear loss with increasing temperature and with SiC additives has been found for both pure aluminum and the composites. It was also observed that the Wear rate varies with normal load and found that a better values in addition 1g in SiC composites at 600°C but lower in composites of 25% and in pure Al at other sintering temperature, on the other hands it's found a fluctuation in (600,400,300)°C, at 25 % at 5min, 3min.this return to the same reason of adhesive wear and its type. in Vickers micro hardness has high values for 600°C , for both pure Al and Al SiC composite, and this fluctuation also seen in time of wear rates that be lower value in 1min., 5 min. while in 3 min. has a high value,*

Keywords*- Al SiC composites, Wear test, Vickers microhardness*

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1.Introduction:

Composites materialsare the multiphase materials, it can be explain as any multiphase material that are made artificially and have a suitable proportion of the properties of the materials phases. These phases are formed in a macro sized, and differ in form, chemical composition and essentially in soluble in each other [1] [2].

The composite properties are been to meet the required purpose. The composites materialsare be formed to meet the required purpose. These materialsare made by combining two different materials in most cases; one of these materials called matrix while the other phase is a dispersed phase. The properties of composites depend on the properties of the constituent phases like amounts, size and shape of dispersed phase. composite materials can be classified to: (1) type of matrix material-metal matrix composites (MMC), polymer matrix composites (PMC) and ceramic matrix composites (CMC) (2) in size–and shape- of dispersed phase –particle – reinforced composites, fiber-reinforced composites and structural composites [3][4][5].

In particle-reinforced composites they are two kinds of strength mechanisms:

First, dispersion–strengthened, secondly, particulate-reinforced composites. in second type of strengthened composites, the particle is smaller , and this size between (0.01-0.1) µm in size .this strengthening can be explain that occur atomic/ molecular level i.e. its similar to the precipitation hardening in metals where matrix part has the major portion of an applied load, while dispersoids hinder/impede the motion of dislocations. Inparticulate composites is other class of particle-reinforced composites where our search based on it, these contain large numbers of coarse particles. This type of composite material isformedto produce unusual combinations of properties rather than to improve the strength. Such as some Mechanical properties, is representing by: [3]

$$E_c(u) = E_mV_m+E_pV_p$$

2. Experimental Procedure:

In this workused Al fine grey powder (220µm) purity 99.0% as matrix material to prepared composite material, and atomic weight 26.98, and 500g, the source is Central Drug House (P) Ltd.7/28 Varadaan House, Daryaganj, New Delhi-110002 (India) the composition as show in table (1):

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Table (1) Chemical Composition for Al powder:

Impurities	Percentage
Iron(Fe)	0.5%
Heavy metals(pb)	0.03%
Arsenic(AS)	0.0005%

Silicon carbide powder (SiC) that added with weight ratio (25%-50%) hasparticle size (220μm), m.w (40.1) SP. 99.51%, the source is RIEDEL-DE HEAN AG-Hannover-Germany. Areenforced material. Al and Sic compressed at (3 tone) after mixingprocess this procedure was used for every all samples. The final sample hasweight (2g) with diameter (10mm), height (15mm), the die has adimensionslength to diameter (120mm*40mm) from stainless steel. The product sample sintered at (300, 400, 600)℃ for soaking time (2 hr) in electricalfurnace.

3. Testing:

I.Wear test

The pin on disk instrument is popular Wear testing apparatusFig. (1) Where the pin is loaded normally. This instrument consists of electrical motor which rotates at angular velocity; the motion is transferred from the electrical motor to the disc. The disc has angular velocity (500 rpm). Wear disc has manufactured from toolset with (55 HRC) hardness, manufacturedby Middle-Forat Comp./Iraq and ASTM-G99, Standard Specification (ASTM-G99).

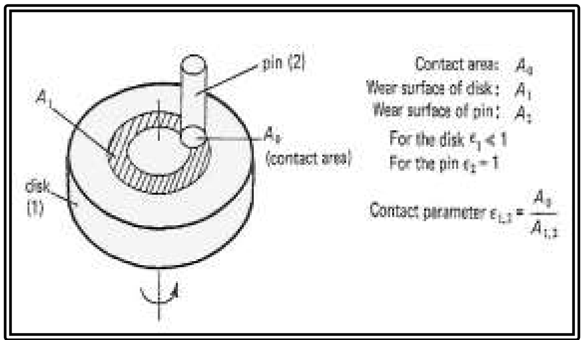

Figure. (1) Pin-on-Disc

The weight method was used to calculate the wear rate by using the following equations [6]:

$$W_R = \frac{\Delta W}{S_D} \quad (1)$$

$$\Delta W = W_1 - W_2 \quad (2)$$

$$S_D = 2\pi rnt \quad (3)$$

Where, WR is wear rate in (g/cm), W1, W2 are the weight of specimens before and after wear test in (g), SD is sliding distance in (cm), r is disc radius in (cm), n is number of disc cycles (500 rpm),and t is time of test in (10 min).

Sliding velocity can be calculated from the following:

$$V = \frac{\pi N D}{60} \quad (4)$$

Where V is sliding velocity in (m/sec), D is sliding diameter in (m), and N is disc's velocity (rpm).

II.Vickersmicrohardness Test:

Vickers micro-hardness test was carried out on the cross-section of the (Al-Sic) composite material (25%SiC), (50%SiC) by using digital Vickers microhardness type (HVS-1000, Laryree technology Co.Ltd), CHINA). This test was done by using load (50 g- 0.49 N). For dwell time(15 Sec). One reading was taken for each sample of Al-SiC composite materials. The indenter of Vickers micro- hardness is diamond indenter which was pressed on to prepared metal surface to cause asqure-based pyramid indentation.

4. Result and Discussion:

This section presents the results of (25% SiC, 50%SiC) samples which performed by using powder metallurgy technique, this samples was studied under the following parameters; sintering temperatures (300,400,600)℃, and SiC percentage. The results show the effect of these parameters on Wear,Vickers microhardness tests and can be seen in tables (2,3,4) below :

Table (2) resultofweight lossinwear test

Samples	Weight loss (g)		
	1 min.	3min.	5min.
Al pure at 300℃	0.0179	0.0389	0.0923
25%SiCat 300℃	0.0025	0.0098	0.0238
50%SiC 300℃	0.0123	0.0138	0.0186
Al pure at 400℃	0.1825	0.9395	0.9716
25%SiC at 400℃	0.0015	0.0037	0.0076
50%SiCat 400℃	0.1106	0.1215	0.1252
Al pure at 600℃	0.0242	0.0524	0.0699
25%SiC at 600℃	0.0881	0.1196	0.1475
50%SiC at 600℃	0.0014	0.0031	0.0075

Table (3) show wear rate for samples

Samples	Wear rate gm/cm.min		
	1min.	3min.	5min.
Al pure 300℃	7.1*10-4	5*10-4	7.3*10-4
25%Sic 300℃	0.9*10-4	1.3*10-4	1.8*10-4
50% Sic 300℃	4.9*10-4	1.8*10-4	1.4*10-4
Al pure 400℃	7.2*10-4	12.4*10-4	7.7*10-4
25% Sic 400℃	0.597 *10-4	0.491*10-4	1.7*10-4
50% Sic 400℃	4.4*10-4	1.6*10-4	0.9*10-4
AI pure 600℃	9.63*10-4	6.95*10-4	5.57*10-4
25%Sic 600℃	3.51*10-4	15.9*10-4	0.605*10-4
50% Sic 600℃	0.59*10-4	0.41*10-4	0.56*10-4

Table(4) show Vickers micro hardness

Samples	HV result
Al pure 300℃	44
25%Sic 300℃	52
50% Sic 300℃	98.9
Al pure 400℃	38.2
25% Sic 400℃	42.2
50% Sic 400℃	69.6
AI pure 600℃	77.9
25%Sic 600℃	105.7
50% Sic 600℃	282.3

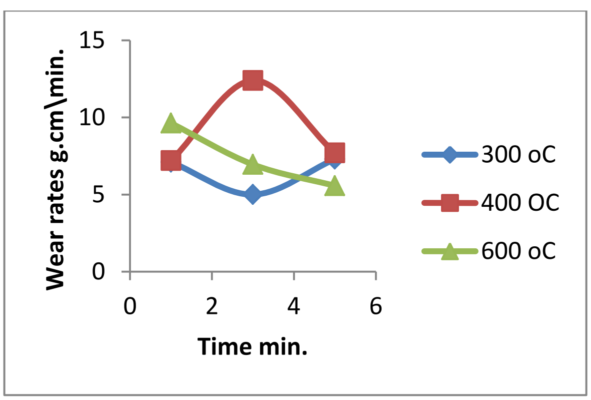

Figure.(2) show wear rate for Al pure for (300,400,600)℃

From fig(2) show that The wear rate for Al pure decreasing by increased sintering temperature due to increasing fraction force especially at 600℃, on the other hand increasing of loading time there is a fluctuation in (1 min,3min)at (300,400)℃.From the fig.(2) in Al pure Wear rate higher compared with the reinforced sample with Sic at different addition, that because applied stress on sample surface is uniformed, there is a large contact area between the disc and sample surface, so that, there is a high value for both stress and wear, further more in wear process increasing temperature cause rotational motion leads to soften unreinforced sample. In Vickersmicro hardness has a high value at 600℃ because of effect of sintering temperature on structure by join the atoms between each other so this reveal in high strength of structure.[6][7]

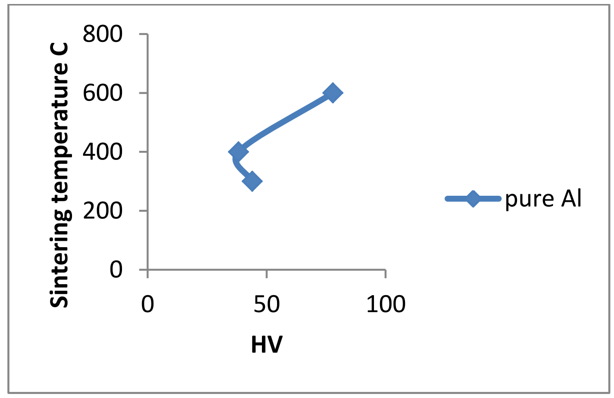

Figure.(3) HV for Al pure for 300-400-600℃

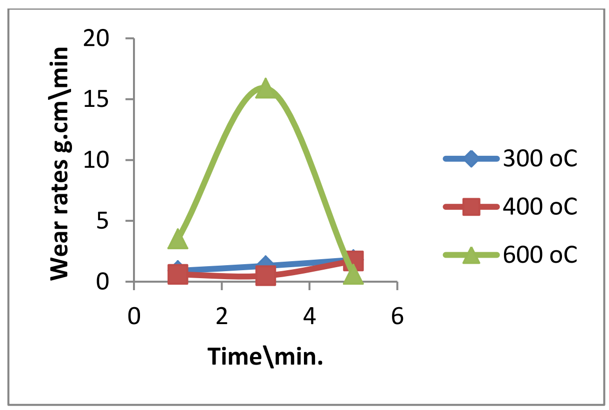

Figure.(4) Show the Wear rate result for 25%SiC

From fig(4) show the Wear rate for 25% SiC a higher Wear rate at 400℃ for (5) min and at 600 ℃ for (3 min), and at 300℃ (5min). while a lower Wear rate at 300℃ for (1,3 min), and for (1,3) at 400℃, at 600 ℃ for (1,3,5) min. especially at 600 ℃, also in Vickers microhardness show high value at 600C because of adding SiC particle as a reinforced material the composites material is product to made unusual combination of properties less than to improve the strength, and SiC has a high strength, hardness, this values for all samples in hardness test, as shown in table (4), and in fig. (5):

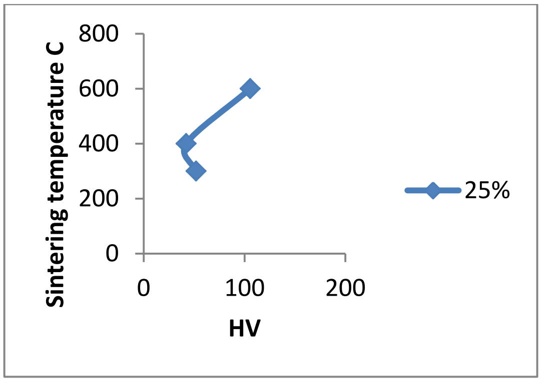

Figure.(5) show HV for 25% of SiC

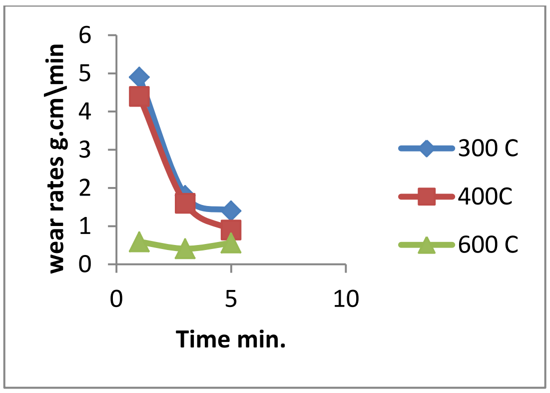

Figure. (6) show the Wear rate for 50% of SiC

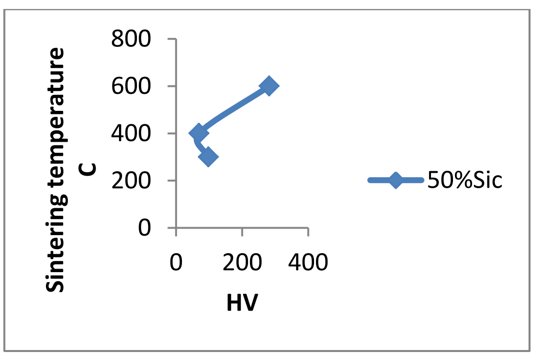

Figure. (7) show HV for 50% SiC

The observation of the Wear test, Vickers microhardness test, figures (6,7) show a lower value for Wear result found in 600℃ for (1,3,5) meanwhile higher value found at (300,400)℃ for (1,3) min. that also related to sintering temperature that made a coherence and coalescence between atoms than other temperature, also the presence of SiC particles as a homogeneous distribution in Al matrix . in wear test for a initial stage for (1,3) min the wear rate increase with wear times for both Al pure and reinforcement samples than for higher wear times because of continuous sliding under applied load .in increasing wear times lead to increase in flatten contact knops in both surfaces the related surface has a low knops rates ,although that a continuous sliding related a stress hardening for a sample surface cause a decreasing in wear rates for a higher wear times. in Al pure which the more sample effect by wear times than reinforcement samples where the wear rate have a low rates with addition of SiC. The 50% SiC has a low wear rate than a 25% SiC because of SiC particles which has high hardness that lead to decrease of contact touching surfaces [8][9].

Also, the reason for fluctuation of wear rates for (25%-50%) SiC result return to an adhesive wear when the materials enters into plastic deformation region either due to the increased load or due to increase sliding times or velocity then cracks grow via atomic bond rupture and therefore wear loss become significant. [10][11] when the material in the elastic deformation range the bond breakage and subsequent crack propagation doesnot occur and thus the wear rate is negligible the adhesive wear can be divided to three groups :

Firstly, severe wear happened at little or no lubricant and high loads and speeds. The size of wear crush between (20-200) µm, more ever these crush grain has high volume; secondly mild wear happened at suitable lubricant and the pressure between the contact surfaces has ability to form oxide layer and the crush size be (2-20) µm and be more soften .thirdly, the burnishing wear happened at slip surface has a hexagonal structure and a suitable lubricant, the wear crush is a small plates .this type form a polishing surface with small parts, this type found in metals[8]. And this fluctuation also seen in time of wear rates that be lower value in 1min., 5 min. while in 3 min. has a high value, this return to the same reason of adhesive wear and its types, as shown in figure below (8) ,[12][13][14]:

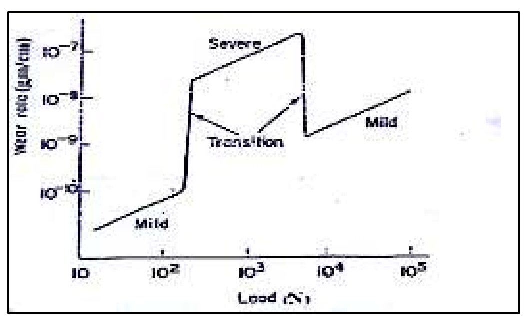

Figure (8) show types ofadhesivewear[8]

As well as in Vickers microhardness test also has a high value in 600℃also at (400,300)℃ for 50% SiC has high valuesthat's returned addition value of sic will raised wear resistance because of high hardness particles, whenever addition rate increased hardness sample ,further more particles make as element for stress and loaded inside matrix materials[6].

Sintering temperature has effect on wear rate and hardness value reveal to particle contact with matrix material that depend on diffusion mechanism and will be form necks cause growth and increasing size follow by constricting pours process. This reason appears samples sintered at(300,400℃) happened in lower value contracting pours process that sample sintered (600℃) as seen in Fig.(9). The matrix alloy is observed on the surface of the specimens as show the metal flow around the spherical particles.

As the flow stress of the matrix alloy is very low and its ductility is very high at high temperature in wear test, the stress can flow around the particles and be sheared strongly at the interface. Therefore the matrix alloy could be more strongly bonded to the surfaces of the particles. This improvement in interfacial bonding induces an increase in the strength of composites pre-strained in compression at high temperature, Because of the increased capacity to transfer external load.[14]

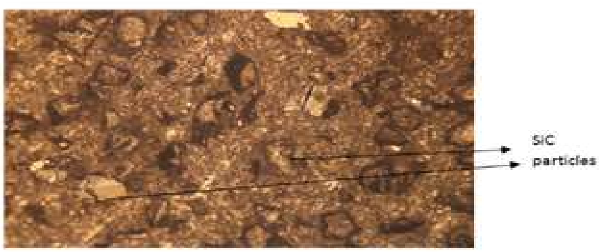

Figure.(9) show the microstructure of 50% SiC at 600℃

5. Conclusion:

1. For a given load, wear rates of composites and pure aluminum pins Decrees with increasing of Sic particles and at increasing of sintering temperature.
2. The wear rate has a fluctuation in some temperature at 300, 400, 600C° for different times.
3. The times effect reveals that the wear rate will be fluctuation for different temperature.
4. In Vickers micro hardness has a high values in 600C°, and for pure Al especially

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