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STUDIES ON MECHANICAL PROPERTIES OF Al - BASED CAST COMPOSITES

Rakesh Kumar Yadav[1], Nabi Hasan[2] , Ashu Yadav[3]

[1]M.Tech. Scholar,Al-Falah School of Engineering & Technology
Dhauj,Faridabad,Haryana,India
rkymech@gmail.com
[2]Asst. Prof.(Mechanical Deptt.), Al-Falah School of Engineering & Technology
Dhauj,Faridabad,Haryana,India
[3]Lecturer (Mechanical Deptt.),Laxmi Devi Institute of Engineering & Technology
Chikkani,Alwar,Rajasthan,India
ashuyadav3@gmail.com

Abstract

The economy is very important feature nowadays in the market. The researches are playing an important role in engineering field to increase the life of machine parts / components and decrease the cost. The composite materials have the potential to replace widely used steel and aluminium due to their good characteristics with better performance. The Al-based composites have found extensive applications in automobile industries and aerospace industries due to their increased stiffness, strength, thermal conductivity and wear resistance properties. A number of particulate phases have been employed in the Al-alloy matrix. The cast aluminium-ceramic particulate composites are finding applications in pistons, connecting rods, cylinder liner, engine cylinder block, electrical contacts etc.The present investigation is based on study of the effect of particulate phase on the SEM study, micro-hardness, elastic modulus, tensile strength and the wear behaviour of Al-5 % SiC-7 % Fe, Al-10 % SiC-6 % Fe and Al-15 % SiC-5 % Fe composites.

Key words: *Al-Si-Fe alloys, Micro-hardness, Tensile Strength, Wear*

1 Introduction

Aluminium is extracted from its ores by expending a lot of energy and money. In pure state, its usefulness and applications are very limited. However by alloying, the physical and mechanical properties are improved for wider applications. Aluminium when formed quickly develops a thin protective oxide layer. Aluminium and its alloys are widely used in services such as transportation, armory, and marine industries due to their high strength to weight ratio. They relatively resist corrosion when exposed to various aggressive environments. These environments may include water vapour, acid and base solutions [1]. Most of these environments degrade the quality of the aluminium and its alloys and affects the mechanical properties of the system thereby reducing their life-span. For example, aggressive ions of sulphate, chloride, fluoride and other impurity elements such as tin and lead incorporated in the alloy may destabilize the alloy [2]. Particularly sulphate species have been found to be most abundant indoor constituents of the corrosion layers for aluminium products [3].

Wear is one of the prime causes of secondary failure. It was conducting the experiment by Pin on disk test for calculating the wear. Wear classification depends on the mechanism responsible for removal of material from the surface [4,5]. It was found that sliding wear and slurry erosive wear resistance improved considerably with addition of SiC particulates in Al-matrix. The wear mechanism was primarily microcutting in base alloy whereas the same consisted of microcutting oxidation, plastic deformation and thermal softening in the MMC [6]. Similarly in another investigation [7] the volumetric wear rate is proposed to depend on applied load, particulate volume fraction and relative hardness in Al- Al_2O_3composite.

2. EXPERIMENTAL DESIGN

2.1. Composite Casting

2.2. For the present investigation three materials have been selected as follows

(a) Al-alloy -5 % SiC (wt%), and 7 % Fe (wt %)

(b) Al-alloy – 10% SiC (wt%) and 6 % Fe (wt %)

(c) Al-alloy – 15% SiC (wt%) and 5 % Fe (wt %)

The chemical composition of Aluminum base alloy & silicon carbide used is shown in Table. 1 & Table 2 respectively.The alloys were casted in the form of a plate, having a size: diameter- θ 125 mm and thickness - 19 mm. The tensile specimens were also separately casted having the dimensions of θ 17 mm and 200 mm length.

UTM machine. At least three samples were tested in each case and stress – strain curves were obtained to determine the tensile properties. At least four samples were tested in each case and stress-strain curves were obtained to determine the tensile properties.

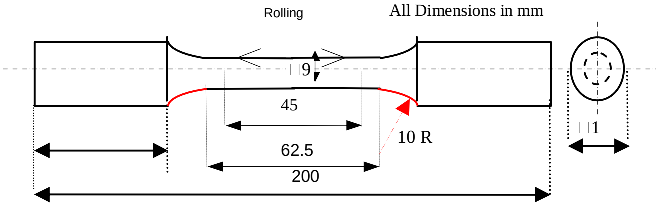

Fig. 1 Typical ASTM Standard Tensile Specimen

2.4. Wear Characterization

2.4.1. Specimen Preparation

The specimens for wear studies were cut from the composite plate. The specimen size used was diameter

Table 1 Chemical composition of Al-Alloy

Element	Fe	Cu	Si	Mn	Mg	Zn	Al
Wt	0.17	0.00159	0.1313	0.0023	0.0016	0.0053	Rest

Table 2: Chemical Composition of Black Silicon Carbide

Element	SiC	SiO_2	Si	Fe	Al	C
Wt	98.5	0.5	0.3	0.08	0.1	0.3

2.3. Tensile Testing

2.3.1. Specimen preparation

The tensile properties of the alloys were determined by performing the tension test on standard cylindrical tensile specimens. The specimens were machined with gauge diameter (D) = 9 mm, the corresponding gauge length (G) = 45 mm, the fillet radius R = 8 mm, parallel length (A) = 54 mm and total length = 200 mm [39]. A typical tensile specimen is shown in Fig.1. The tensile test was conducted on a 450 kN

-10 mm and 40 mm length. The top and bottom specimen surfaces were made planer by polishing against emery papers of appropriate grits. For the preparation of the surface to be used for wear studies, the final grit size of the emery paper was the same as the one to be used for the wear studies. In the above materials the wear studies were conducted against emery paper having the grit size 600.

2.4.2. Wear Testing Macnine

The wear machine used for evaluating wear properties was designed [8] and fabricated by me. A pin on disc wear test technique was adopted to test the wear behaviour of specimens. Wear rate and wear volume were evaluated in single path. The tests were conducted 60 mm from the center of grinding disc. Wear volumes of above said specimens were evaluated at four different applied loads i.e. 2.5N to 10 N with a variation of 2.5 N.

3. RESULTS AND DISCUSSION

3.1. Scanning Electron Microscopic

Scanning Electron Microscopy (SEM) was conducted of different powders used for the present study namely Base alloy, Silicon carbide (SiC) and Ferrous (Fe). The SEM was conducted at different magnification namely 400X, 1000X and 2000X. The Base alloy, Silicon carbide (SiC) and Ferrous (Fe) SEM, figures of powders are illustrated in Fig. 2(a-c).

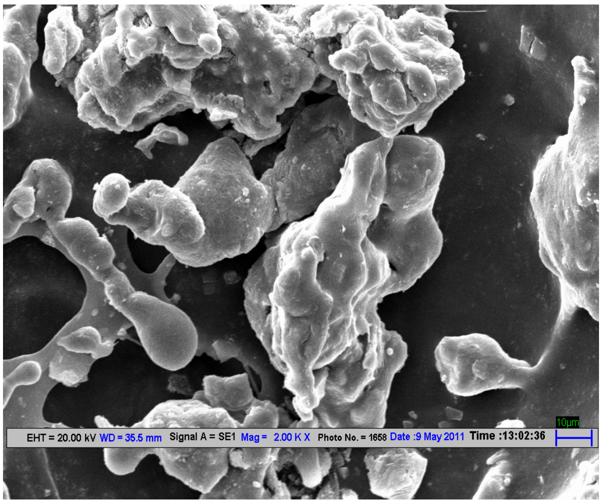

Figure 2(a)-Al-alloy (SEM) magnification 2.00KX

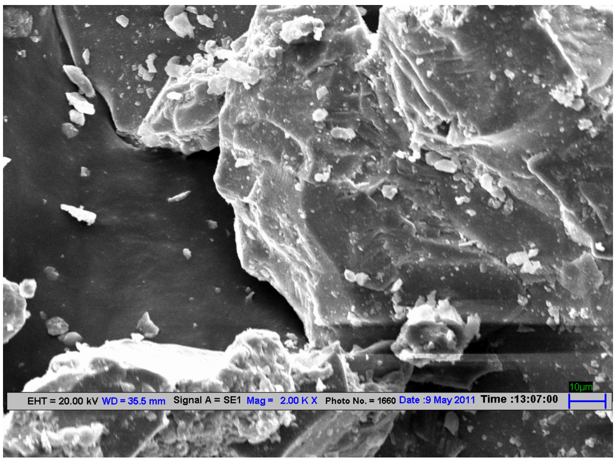

Figure 2(b)- SiC (SEM) magnification 2.00KX

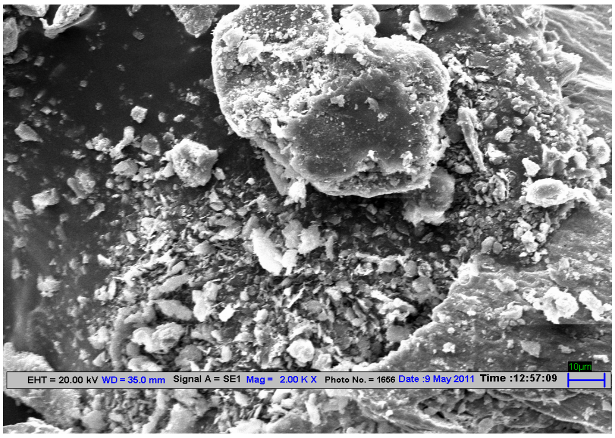

Figure 2(c)-Fe (SEM) magnification 2.00KX

Figure 2(a) shows that every particle having irregular shape and increasing the magnification the exact morphology of the particles which is clearly visible and having cavities in some particles.

Figure 2(b) shows that every particle having irregular shape and sharp edges and big in size. some particles show their glazing which means the symptoms of fracture of SiC particles.

Figure 2(c) shows that every particle has irregular as well as flat shape, the size of the particle is also clearly visible.

3.2. Microhardness Measurements

The average micro hardness of Sample No –1, Sample No –2 and Sample NO.–3 are finding as 63, 68 and 71 HV1 respectively. Thus the hardness is found to increase with increasing volume fraction of SiC phase and decreasing volume fraction of Fe phase.

3.3. Evaluation of Tensile Properties

Typical stress-strain diagrams for the Sample No.-1, Sample No.-2 and Sample No.-3 respectively. The stress-strain diagrams were to evaluate various tensile properties such as elastic modulus, tensile strength, percentage elongation etc. The elastic modulus, ultimate tensile strength and true stress are presented in table 3.

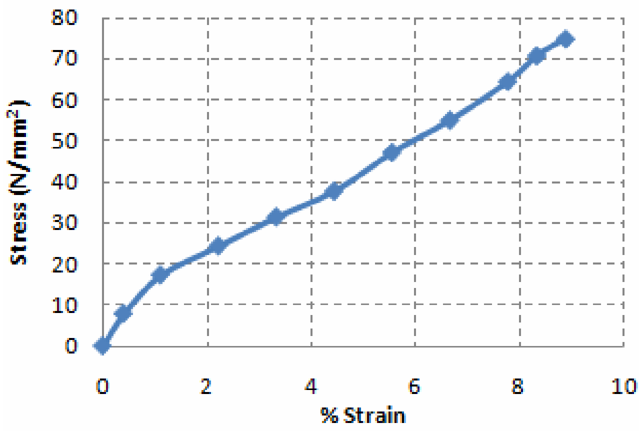

Fig. 3(c) Stress vs Strain of Sample 3

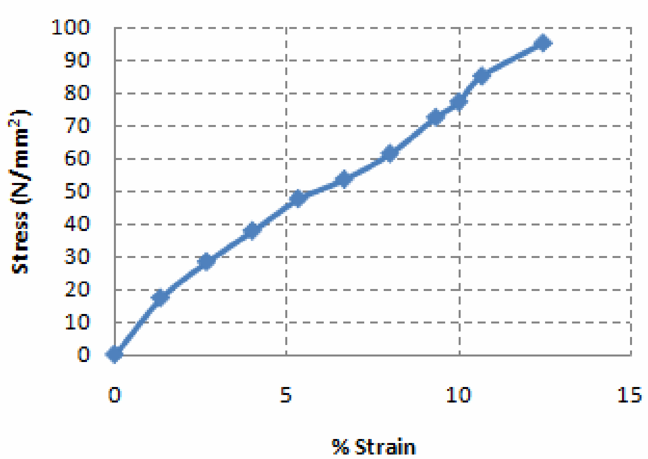

Fig. 3(a) Stress vs Strain of Sample 1

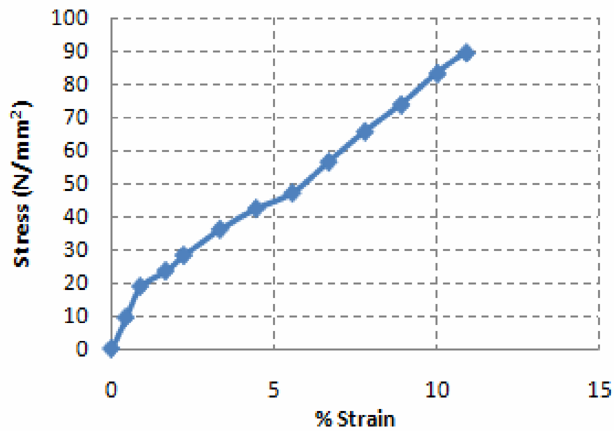

Fig. 3(b) Stress vs Strain of Sample 2

The Stress vs Strain graph are drawn for sample No. 1. Figure 3(a) shows sample No. 1 has more ultimate tensile strength as compared to other. Sample No. 1ultimate tensile strength is 91.43 MPa and strain 0.12.

The Stress vs % Strain graph are drawn for sample No.-2, figure 3(b) shows sample No. 2 has more ultimate tensile strength as compared to sample No. 3 but less in sample No.1. Sample No. 2 ultimate tensile strength is 89.7 N/mm^2 and strain is 0.09.

The Stress vs % Strain graph are drawn for sample No. 3, figure 3(c) showes less Ultimate tensile strength as compared to others but this composition specimen showed more modulus of elasticity as compared to other. Sample no 3 ultimate tensile strength is 73.16 N/mm^2 and strain is 0.10.

TABLE 3 Elastic Modulus and Strength Properties of Materials

Material	Elastic modulus (MPa)	Ultimate Tensile strength (MPa)	True stress (MPa)
Sample No.-1	686.84	91.43	102
Sample No.-2	700.91	89.7	99.09
Sample No.-3	718.65	73.16	80.35

3.4. Wear

Wear rate of the sample No.1, 2 and 3 has been evaluation. A pin-on-disc method was used. A circular specimen having the diameter of 10 mm with 40 mm length was cut from the casted plate. A polishing machine self designed and fabricated was used. A wear test rig was attached on the polishing machine. A digital venires calliper was used to measure the length of the specimen after wear. The weight of the specimen was weighed with precaution and tries to get the exact weight loss after each reading. A mark was choosing on the emery paper for the sliding distance. The sliding distance 60 mm from the centre, after that this distance converted into linear distance. Three applied load was used to measure the wear rate, i.e. 2.5 N, 5 N and 7.5 N. The specimen was tested at least five times for 10minute. The emery paper was changed after every five reading. The graphs of wear rate have been illustrated in Fig. 4.

Figure 4 shows the comparison of specimen was put together. The nature of graph was found that as applied load increased wear rate is also increased but, the sample No.-2 was found much better wear resistance.

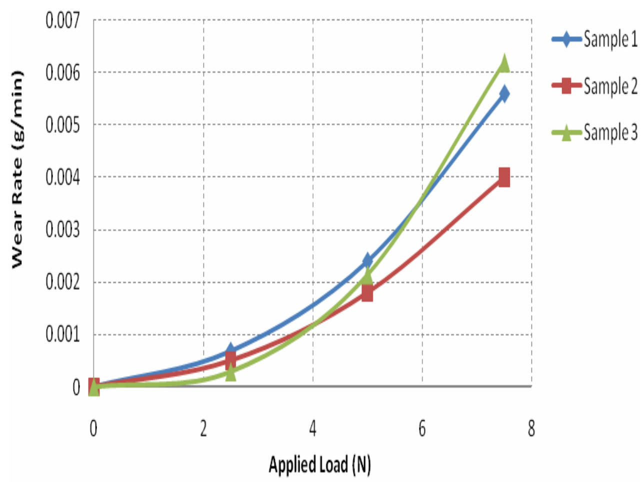

Fig. 4 Effect of Wear Rate Vs Applied Load of Sample 1,2 & 3

4. CONCLUSIONS

On the basis of experimental work the following conclusions can be drawn

1.The SEM of Aluminium alloy shows irregular shape and shows cavities in some particles.

2.The SEM of SiC shows irregular shape with sharp edges and some particles show their glazing which means the symptoms of fracture of SiC particle. At some places segregation of SiC particles are also observed.

3.The SEM of Fe shows irregular as well as flat shape. The size of the particles is also clearly visible and shows a rectangular shape in some particles.

4.The average micro hardness of Sample No.–1, Sample No.–2 and Sample NO.–3 are finding as 63, 68 and 71 HV1 respectively. Thus the microhardness is found to increase with increasing volume fraction of SiC phase and decreasing the volume fraction of Fe phase.

5. The Elastic modulus is increased from 686.84 MPa to 718.65 MPa with increasing of SiC.

6. The average Ultimate Tensile Strength of Sample No.-1, Sample No.-2 and Sample No.-3 are finding as 91.43, 89.7 and 73.16 MPa respectively. The Ultimate tensile strength is to decrases increases with increasing of SiC.

7.The wear rate of specimen No 2 was found less. It means the composition Al-10%SiC-6%Fe was found good for the manufacturing parts.

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