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Synthesis of Al- Sic Composite Prepared By Mechanical Alloying

*Charanjit Singh[1]& *Jagteshwar Singh[2]
[1]Assistant Professor, Department of Mechanical Engineering, Surya School of Engineering and Technology,Bapror, NH-1, Shambhu, Punjab,
[2]Assistant Professor, Department of Mechanical Engineering, Surya School of Engineering and Technology, Bapror, NH-1, Shambhu, Punjab,

Abstract: *Aluminium matrix composites (AMCs) refer to the class of light weighthigh performance aluminium centric material systems. Properties of AMCs can bepersonalized to the demands of special industrial applications by appropriate combinationsof matrix, reinforcement and processing technique.*
The widespread acceptance of particulate metal matrixcomposites for engineering applications has been hindered by the high cost of producingcomponents. Although several technical challenges exist with casting technology yet it can beused to overcome this problem. Achieving a uniform distribution of reinforcement within thematrix is one such challenge, which affects directly on the properties and quality of compositematerial. In the present reading a modest effort has been made to develop aluminium basedsilicon carbide particulate MMCs with an objective to develop a conventional low cost technique ofproducing MMCs and to obtain homogenous dispersion of ceramic material. To achieve theseobjectives Mechanical alloying method of powder metallurgy has been adopted and consequentproperty analysis has been made. Experiments have been conducted by varyingweight fraction of SiC (4%, 6%, 8% and10%), while keeping all other parametersconstant. Friction and wear characteristics of Al–SiC composites have been investigated under dry sliding conditions. Dry sliding wear tests have been carried out using pin-on-disk wear test rate normal loads of 10, 20, 30, 40 and 50N and at constant sliding velocity of 1.6m/s.
The results show that the 'developed method' is moderately successful to attain uniformdispersion of reinforcement in the matrix. An increasing trend of hardness with increase in weight percentage of SiC has been observed. It was found from the testing that the wear rate decreases linearly with increasing weight fraction of silicon carbide.
Keywords: *AMCs, MMCs, MA, Al, SiC*

I. Introduction

Scientific investigations by materials scientists have been continuously directed towards improving the properties and performance of materials. Significant improvements in mechanical, chemical, and physical properties have been achieved through chemistry modifications and conventional thermal, mechanical, and thermo-mechanical processing methods. However, the ever-increasing demands for ``hotter, stronger, stiffer, and lighter'' than traditional materials have led to the design and development of advanced materials. The high-technology industries have given an added stimulus to these efforts.[2]

Aluminium alloy materials or simply composites are combinations of materials. They aremade up of combining two or more materials in such a way that the resulting materials havecertain design properties on improved properties .The Aluminium alloy composite materialsconsist of high specific strength, high specific stiffness, more thermal stability, morecorrosion and wear resistance, high fatigue life.[1]

MMC's are either in use or prototyping for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and a variety of other applications.Aluminium based composite materials are leading ones in this area; they are fabricated using many methods, including powder metallurgy processes.[3]

Mechanical alloying (MA) is a solid-state powder processing technique involving repeated welding, fracturing, and rewelding of powder particles in a high-energy ball mill. Mechanical alloying is a unique process for fabrication of several alloys and advanced materials at room temperature**.** The Mechanical alloying process was developed in 1966 at The International Nickel Company (INCO) as part of a program to produce a material combining oxide dispersion strengthening with gamma prime precipitation hardening in a nickel-based super alloy intended for gas turbine applications. In fact, the original Mechanical alloying process was the by-product of research into different subjects. [2]

In the present work, an effort has been made to study hardness and wear properties with varying weight fraction of SiC in particle reinforced MMCs developed with the help of mechanical alloying method of powder metallurgy technique. The behavior of the composite was studied by using a Pin on Disk machine.

II. Experimental Procedure

Under the following parameters the present experimentation was performed [2]:

- Type of mill: **High-energy mill (*Attrition Ball Mill)***
- The material of milling tool: **Stainless steel**
- Type of milling media: **Balls**
- Milling atmosphere: **Air**
- Milling environment: **Dry milling**
- Milling media-to-powder weight ratio: **10:1**
- Milling time: **7 hr per sample**

1. Raw Materials

The aluminium and silicon carbidepure powders were acquired from Nice Chemical Pvt. Ltd. (Cochin) India that has particle sizes in the range of 200 Mesh. . But, the powder particle size is not very serious, except that it should be smaller than the grinding ball size. This is because the powder particle size decreases exponentially with time and reaches a small value of a few microns only after a few minutes of milling.

2. Sample Preparation

Equivalent quantities of the metal powders were taken by weight. The weighing was done in a very precise weighing balance. 200 gm batches were prepared for each sample.

Sample A (Al – 96%, SiC 4%)
The quantities of the metal powder as:
Al= 192 gm, SiC = 8 gm

Sample B (Al – 94%, SiC 6%)
The quantities of the metal powder as:
Al = 188 gm, SiC= 12 gm

Sample C (Al – 92%, SiC 8%)
The quantities of the metal powder as:
Al = 184 gm, SiC=16 gm

Sample D (Al – 88%, SiC 10%)
The quantities of the metal powder as:
Al = 180 gm, Al_2O_3 = 20 gm

3. Ball Milling

The milling procedure takes place by the stirring action of an agitator which has a vertical rotating central shaft with horizontal impellers of Attritor used for the Mechanical alloying process. The rotation speed of the central shaft is about 100 rpm (4.2 Hz).

The morphology of the powders is tailored when they are subjected to ball collisions. The initial ball-powder-ball collision causes the ductile metal powders to flatten and work harder when they are cold welded and heavily mechanically deformed. Milling results in cold welding and deformation of the layered particles and a refined microstructure is obtained. It also helps in making the powder uniform.

4. Sieving Of Powder

Sieve analysis was done on each powder and general fineness number was calculated. Grain particles ranging from 0 to 100 µm were to be used reinforcement. So 100 µm was used to sieve both the powders. After sieving, Aluminium and silicon carbide powder was of the range of 50 to 100 µm.

5. Preparation Of Compact

Die Design & Fabrication

As abrasion wear rate test was to be performed on compacts, sodie of circular cross-section was prepared. The die is shown in Fig. 1. Material used for manufacturing of die is hot die steel.

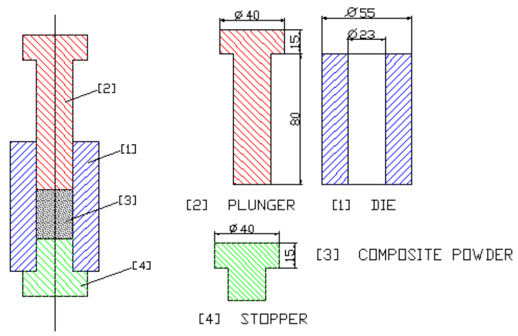

Fig. 1 Die [8]

Compaction of Metal Matrix Composite

Compaction of the samples was done on a manually operated hydraulic press & floating circular cross-section die as shown in Fig. 2. The specimens were hard-pressed using pressure of 2 MPa & at room temperature for 2 min.

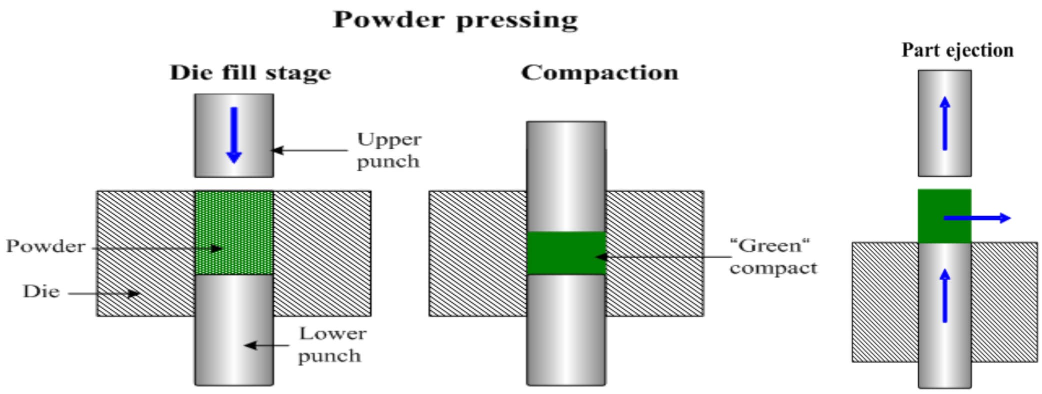

Fig. 2Powder Pressing [8]

6. Sintering

Sintering was donein a horizontal tube electric furnace with a high purity hydrogen (inert) environment for 1 hr. The hydrogen flow rate was 1.5 l/min. The sintering temperature was kept at 530^0 C.All the samples were sintered simultaneously.

Specimen Before Machining Specimen After Machining

Fig. -3 SPECIMEN

7. Samples Testing

A) Wear Testing of Al-SiC Composite

Dry sliding wear tests for the Al-SiC have been conducted using pin-on-discmachine. The tests have beenconducted in air. The specimen is held stationary against the counter face of a 60mm diameter rotating disc made of En-32 steel. The wear tests have been conducted under the fivenormal loads 10, 20, 30, 40&50 N and at fixed sliding speed of 1.6m/s. Each wear test has beencarried out for a 30 min. Thepin is removed from the holder after each run, properly cleaned using acetone.

B) Hardness Testing of Al-SiC Composite

Specimens of size Φ12 mm*3 mm were prepared and polishing operation was done. The specimens were rubbed by emery paper of grade 100,200,500, and 650 in increasing order. When mirror like surface was obtained,etching was done on the specimens using 10% NaOH solution. Then hardness test was performed on all the specimens.

III. Results And Discussion

1. Wear strength testing results of Al-SiC Composite

The results of all the fourspecimens are shown in Fig.4 to 7. The results show that with increase of SiC content, the wear strength increases.

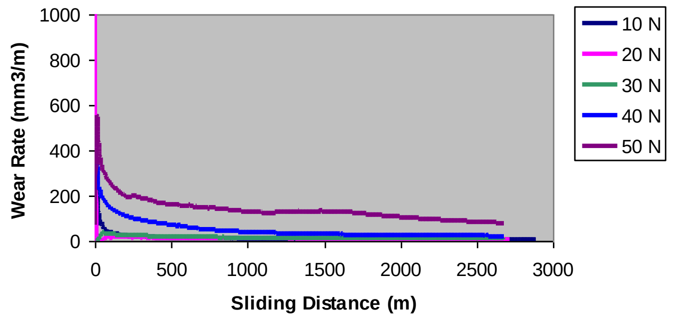

Fig. 4 : Wear Rate (4% SiC) V/s Sliding Distance

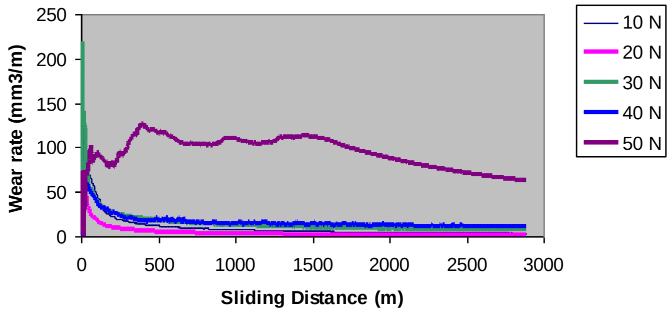

Fig. 5 : Wear Rate (6% SiC) V/s Sliding Distance

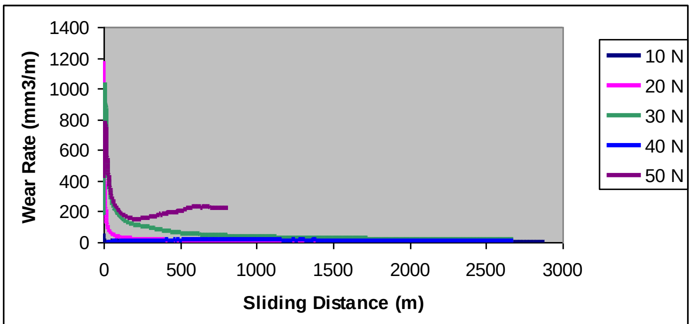

Fig. 6: Wear Rate (8% SiC) V/s Sliding Distance

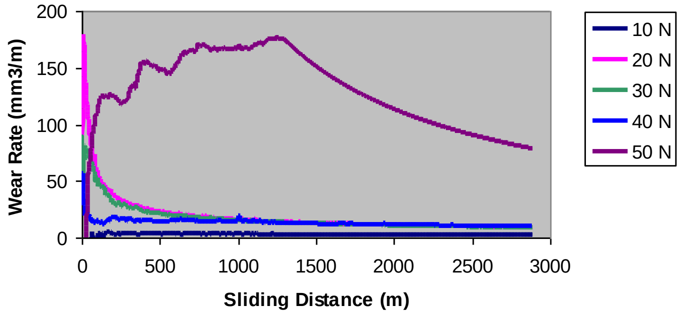

Fig. 7 : Wear Rate (10% SiC) V/s Sliding distance

From the Figures4 to 7exhibiting wear rate v/s sliding distance for different % of SiC, and various curves obtained it is clear that as the % of SiC increases wear rate decreases. All the curves for different % of SiC show immediate rise in wear behaviour at the starting. The reason for this may be the contact stresses due to which unsteadiness of the foam of samples occurred. For more than 6% of SiC the wear behaviour shows the identical variations, however 4% of SiC, the wear behaviour is slightly different that may be due to some extraneous factors in experimentations.

2. Hardness

In Table 1, Fig.8the hardness shows the variation with % of SiC. It is clear from the picture (Fig.8) that as the % of SiC increases in aluminium, hardness of the sample's increases on HRB scale.

SiC (%)	HARDNESS (HRB)
4	46.0
6	58.1
8	59.3
10	62.5

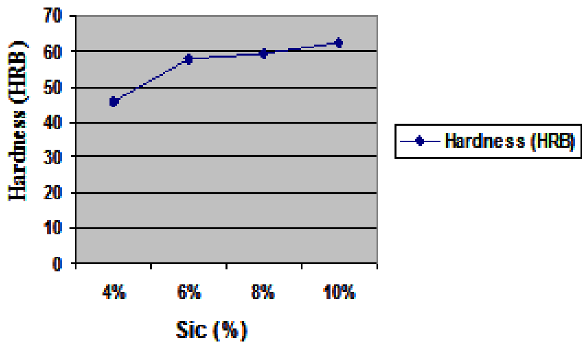

Table.1 Value of Hardness &SiC (%)Figure 8: Hardness (HRB) V/s SiC (%)

IV. Conclusion

Knowing the advantageous influence of mechanical alloying on the tribological properties of aluminum matrix composites, we produced Al – SiC composites, by powder metallurgy using mechanical alloying.

During the present examination it was found that the SiCcontents were able to improve the wear rate (Fig. 4–7), hardness (Fig. 8) of aluminum composite produced by powder metallurgy using mechanical alloying by Attritor mill.

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