Experimental Characterization of Mechanical Properties of Aluminium 6061 Metal Matrix Composite

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Abstract— Automobiles and aerospace applications require materials that have modified mechanical and tribological properties. It is very difficult to achieve these modified properties in any monolithic material. Aluminum alloys are the most exploited materials in various fields of applications including Automobiles and aerospace due to some of its basic properties. The core objective of present research work is to investigate the mechanical properties (hardness, and flexural strength) of SiC and Co powder filled Al 6061 Composites and to identify the best combination regarding wt% of matrix, and reinforcement regarding mechanical properties. It was revealed that MMC with 3%wt of SiC, 3%wt of Co exhibited excellent mechanical properties among the all fabricated metal matrix composites. The hardness and flexural strength of all fabricated MMCs increases with increase in % wt of SiC and Co particulates.

Key words: Aluminum, Metal Matrix Composites, SiC, Cobalt

I. INTRODUCTION

Metal matrix composites (MMCs) materials has been noted to offer such tailored property combinations due to their unique mechanical and physical properties such as high specific strength, low coefficient thermal expansion and high thermal resistance, good damping capacities, superior wear resistance, high specific stiffness and satisfactory levels of corrosion resistance

The aluminium based metal matrix composites are commonly used for certain applications like high speed vehicles, aircraft operating in desert environment, helicopter rotor blades, aircraft engine blades, water turbines etc.

In the present work, the aluminium based metal matrix composites have been fabricated. The Al 6061 alloy has been used as matrix material while SiC and Co in different percentage have been used as reinforcement materials. The composites have been fabricated using stir casting method. To examine the effect of different percentage of SiC and Co on mechanical properties of developed MMCs, different mechanical test (hardness and flexural) have been conducted.

II. LITERATURE SURVEY

A. Mechanical Characterization of Al 6061 Alloys/Composites

Ahmed, et al [1] fabricated aluminum silicon alloy-silicon carbide particulate MMCs with various volume fractions to investigate the effect of porosity on the tensile properties of composites.. The porosity content of the composites were measured using an image analyzer. The tensile tests were carried out according to the ASTM B557 test method. It was revealed that the porosity content increases with increase in silicon carbide particles in MMCs. It was also conclude that the use of modified stair casting method significantly reduce porosity.

Sevik, et al. [2] studied the impact of % wt and size of Al_2O_3 particles on mechanical properties of MMCs of an aluminum–silicon. The different composites were fabricated using pressure die-casting technique. The hardness of the composites increased with increase in % wt of Al_2O_3

Mahendra. et al. [3]studied the effect of fly ash on the mechanical and tribological properties of Al-4.5% Cu/ fly ash MMCs. The MMCs were fabricated using stir casting technique. The results revealed that hardness, tensile strength, compression strength, impact strength, and resistance to dry wear, slurry erosive wear and corrosion rate increases with increase in % wt if fly ash content. On the other hand, it was also found that density decreases with increase in fly ash content.

Sudarshan, et al. [4]investigated the impact of % wt of fly ash on the macro and micro hardness of aluminium based MMCs with fly ash. The composites were produced using stir cast technique. The results indicated that the narrow size range fly ash particles demonstrate superior mechanical properties over wide size range fly ash particles.

Yusoff, et al. [5]used powder metallurgy technique for the manufacturing of aluminum composites reinforced with 20 wt % slag powder with various particle sizes. An attempt has also been made to investigate the effect of compaction pressure and slag particle size on surface hardness of aluminum composites. The results revealed that different slag particle size and compaction pressure significantly influence the surface hardness of aluminum composites.

Shanmughasundaram, et al. [6]studied the microstructure, mechanical, wear and corrosion behavior of Al - Fly Ash composites fabricated using stir casting method. The results revealed that the hardness, tensile strength and wear resistance increases and corrosion resistance and density decreases with increase in fly ash content.

Nguyen et al. [7] Investigated the mechanical behavior of the oxidation behavior of the magnesium alloy AZ 31 B and weave the sample by a solidification process. They found that the presence of nano-sized alumina (Al 2 O 3) fine particles increased and the oxidation resistance of the AZ 31 B alloy gradually increased. The presence of nano-Al_2O_3 particulates tended to retard the transient phase of oxidation.

III. MATERIALS & METHODS

In the present work, Aluminium 6061 alloy was used as a matrix material (chemical composition of aluminium 6061 alloy is presented in table 1) while silicon Carbide and cobalt in different weight percentage were used as reinforcement material for the fabrication of MMCs.

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
Wt %	0.5	0.5	3.8-4.9	0.3-0.9	1.2-1.8	0.25	0.15	0.1	Remaining

Table 1: Chemical composition of Al6061alloy in % wt

To fabricate the MMCs, initially Al 6061 alloy pieces putted in the graphite crucible according to required weight and heated up to 800 ˚C using an induction furnace and then mixed reinforced material SiC and Co up to homogeneous distribution. Then poured into the dies. After that solidification, the MMC was taken out from the mould. The MMCs having different percentage of SiC and Co were fabricated using same procedure.

Mechanical testing such as hardness and flexural strength were carried out for all the fabricated metal matrix composite samples to identify the best % wt combination of SiC and Co in fabricated aluminium 6061 alloy based MMCs.

A. Hardness

The Rockwell hardness of all the fabricated samples was measured using Rockwell cum Brinell hardness tester, manufactured by Engineering models and equipment, Roorkee, India. The hardness measurement was repeated on four samples for each composition. Finally, average of all four hardness was considered for the particular composition. In this work, all the hardness tests were conducted with diamond indenter and a load 150 kg.
Following are the test parameters:

- Minor load = 10 kgf
- Major load = 150 kgf
- Indenter = 120 degree diamond cone indenter
- Size of test samples (EA-1 to EA-4) = 15 mm*15 mm*

B. Flexural Strength

Flexural tests on all fabricated MMCs were conducted on universal testing machine. The machine meets the accuracy requirements of IS 1828-1975. Flat specimens were used for the all flexural test having size (60 x 10 x 10) mm respectively. The test were carried out at constant crosshead speed of 1 mm/min. for the flexural strength, load and cross-head displacements were recorded. Then flexural strength is calculated as
Where,
P = Maximum load,
b= Width of specimen,
t= Thickness of the specimen
L = Span length of the sample.

1) Test parameters

- Size of composite samples = 60 mm*10 mm*
- Crosshead speed = 10 mm/min
- Span length = 60 mm

IV. RESULT & DISCUSSION

A. Effect of hardness on SiC & Co powder filled Al 6061 Composites

The hardness measurement was repeated on four samples for each composition. Finally, average of all four hardness was considered for the particular composition. Table 2 shows the hardness of the different fabricated composites. The figure 1 shows the bar chart for the average value of hardness for all the fabricated MMCs.

Composite Designation	Sample 1 (HRB)	Sample 2 (HRB)	Sample 3 (HRB)	Sample 4 (HRB)	Average (HRB)
Al/SiC/Co MMC (3SAl0C)	76	78	80	78	78
Al/SiC/Co MMC (3SAl1C)	77	82	81	80	80
Al/SiC/Co MMC (3SAl2C)	84	83	84	81	83
Al/SiC/Co MMC (3SAl3C)	85	86	84	85	85
Al/SiC/Co MMC (0SAl3C)	61	64	63	64	63
Al/SiC/Co MMC (1SAl3C)	70	67	67	68	68
Al/SiC/Co MMC (2SAl3C)	75	75	74	72	74

Table 2: Hardness of the Fabricated MMCs

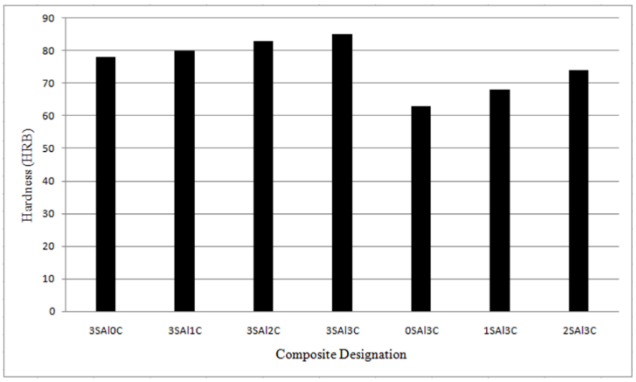

Fig. 1: Effect of hardness on SiC and Co powder filled Al 6061 Composites

From figure 1 it was revealed that the variation in hardness exhibited more with variation in SiC content as compare to variation in Co content because SiC particles have high hardness as compare to Co particles. It is also visible from the table 2 and figure 1that hardness of MMCs increases with increase in percentage weight of SiC and Co content. It is due to uniform distribution of SiC and Co particulates in the MMCs, which further increase the density of composite [8] [9]. Also, increase in the hardness of composites indicates better bonding of matrix with the reinforcement materials [10]. The maximum hardness is achieved with 3SAl3C MMC i.e MMC with 3%wt of SiC, 3%wt of Co.

B. Effect of Flexural Strength on on SiC and Co powder filled Al 6061 Composites

The flexural test is employed to evaluate the load at which material starts to bend. In the present work, the flexural test is conducted on the universal testing machine using three-point bending method.

Composite Designation	Sample1(MPa)	Sample 2 (MPa)	Average Flexural strength(MPa)
Al/SiC/Co MMC (3SAl0C)	163	183	173
Al/SiC/Co MMC (3SAl1C)	192	172	182
Al/SiC/Co MMC (3SAl2C)	231	205	218
Al/SiC/Co MMC (3SAl3C)	292	304	298
Al/SiC/Co MMC (0SAl3C)	198	216	207
Al/SiC/Co MMC (1SAl3C)	238	210	224
Al/SiC/Co MMC (2SAl3C)	265	281	273

Table 3: Flexural Strength of the Fabricated MMCs

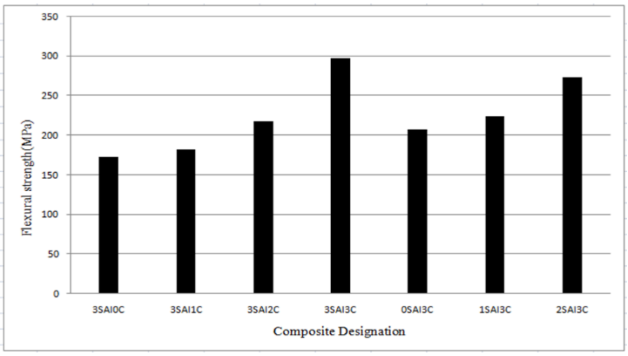

Fig. 2: Effect of flexural strength on SiC and Co powder filled Al 6061 Composites

V. CONCLUSION

The following conclusion have been drawn from present research work

- Among the all fabricated metal matrix composites i.e 0SAl3C, 1SAl3C, 2SAl3C, 3SAl0C, 3SAl1C, 3SAl2C and 3SAl3C, the 3SAl3C MMC (MMC with 3%wt of SiC, 3%wt of Co) exhibited excellent mechanical properties (hardness and flexural strength).
- The maximum hardness is achieved with 3SAl3C MMC i.e MMC with 3%wt of SiC, 3%wt of Co. so by the increasing wt. % of SiC and Co in the aluminium 6061 hardness has to be increase.
- For the weight wt. % of SiC-Co in aluminum 6061 matrix the flexural Strength of the MMC is increase with the increasing of the SiC-Co reinforcement maximum at 3%wt of SiC, 3%wt of Co.

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