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EVALUATION OF MECHANICAL PROPERTIES ALUMINIUM METAL MATRIX COMPOSITE FOR MARINE APPLICATIONS

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ABSTRACT

Nowadays automotive and marine industries are in need of better class of materials that need all versatile applications and also they should be environment friendly. Therefore the need of the hour is to innovate new materials namely smart materials, composites and supper alloys. In this paper aluminium metal matrix composite is prepared using stir casting process with aluminium 6061alloy as matrix metal and Silicon carbide as reinforcement with different proportions. Flexural and hardness tests are conducted and the result shows that composite specimen with high percentage of Silicon carbide has better properties than the others.

Keywords: aluminium 6061alloy, silicon carbide, stir casting process, mechanical properties.

1. INTRODUCTION

The various fabrication techniques available to manufacture the MMC are compocasting (stir casting), liquid metal infiltration, squeeze casting and spray co-deposition [1.2]. Vijaya Ramnath *et al.* [3] reviewed work done on aluminium metal matrix composites. Rajan *et al.* [4] made an attempt to compare the effect of the three different stir casting methods while making MMC with flyash as reinforcement with aluminium alloy and concluded that compocasting method is more effective. Abhishek Kumar *et al.* [5] used electromagnetic stir casting of A359/Al_2O_3 to produces MMC with smaller grain size with good particulate matrix interface bonding. Ding *et al.* [6] investigated the behaviour of the unreinforced 6061 aluminium alloy and short fiber reinforced 6061 Al alloy MMC and conclude that addition of high-strength alumina fibres in the Al6061 matrix will constrain the plastic deformation in the matrix which leads in reduction of fatigue ductility. Vijaya Ramnath *et al.* [7] investigated the mechanical properties of aluminium alloy-aluminium oxide-Boron Carbide MMCs fabricated by stir casting and concluded that aluminium with 2% alumina-3% boron carbide have better tensile strength in comparison with other compositions. Naher *et al.* [8] carried out a computational and experimental analysis to study the effect of viscosity on particulate distribution during Al-SiC MMC fabrication and concluded that stirring speed has effect on uniform distribution of reinforcement. Wang and Müller [9] conducted a study to predict the performance of array arrangement on ducted composite material marine current turbines (CMMCT) and also they suggested that the developed array can be used to optimize the existing CMMCT power generation. Mouritz *et al.* [10] reviewed the advanced composite structures for naval ships and submarines. Vijaya Ramnath *et al.* [11, 12] reviewed CNT based composites and found compression and chemical properties of aluminium CNT composites. Wear resistance is one of a important factor for various industrial applications. The friction and wear properties of several metallic alloys in unlubricated conditions are widely investigated [13]. Stiffness, hardness and wear resistance of a MMC can be enhanced by adding titanium diboride to metal matrix composites. Also it is found that various works in this field have been directed at aluminium based materials [14].

2. EXPERIMENTAL DETAILS

In this section, matrix material, reinforcement, experimental setup and details of compositions of composites are discussed.

Table-1. Properties of Al and SiC.

Properties	Aluminium (Al)	Silicon Carbide (SiC)
Density (gm/cm^3)	2.70	3.30
Tensile Strength (MPa)	185	588.0
Coefficient of thermal expansion ($10^{-6}/°C$)	23	4.6
Modulus of Elasticity (GPa)	70	345

a) Matrix and reinforcement used

In this work wrought aluminum alloy is taken as matrix metal and aluminium Oxide is taken as reinforcement. Their properties are furnished in Table-1.

b) Fabrication method

For fabricating metal matrix composites, a lot of methods are available. In this work stir casting method is used due its simple set up and cost. In stir casting process, the molten metal and reinforcement mixture is stirred, in order to distribute the reinforcement effectively in the matrix metal. Hence, the reinforcement is heated separately while Aluminium 6061alloy is melted in a crucible in an induction furnace at a temperature of 870°C. Now, the preheated reinforcement is added with the molten aluminium and vigorous mechanical stirring is

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done. Now, the composite is poured in a steel die with standard dimension. The molten composite mixture is allowed to solidify for 24 hours. It is machined into specimen for flexural and hardness test. The Composition of matrix and reinforcement is given in Table-2.

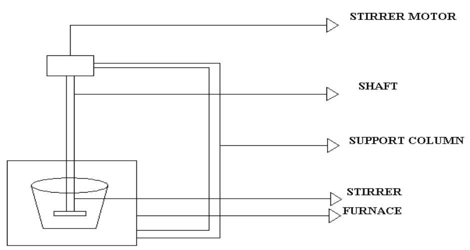

Figure-1. stir casing setup.

Table-2. Composition of matrix and reinforcement.

Samples	Al in %	SiC in %
1	99.5	0.5
2	99	1.0
3	98.5	1.5
4	98	2
5	97.5	2.5

3. TESTING

In this work flexural and hardness tests are performed as per ASTM standards. For flexural test Universal testing machine with three points bending setup is used and the test samples are prepared as per ASTM: A-370.

4. RESULTS AND DISCUSSIONS

a) Flexural test

The flexural test results are presented in Table-3. From Figure-3, it is observed that the flexural strength of sample 5 is higher than other samples due to the presence of high percentage of silicon carbide.

Table-3. Flexural properties of composites.

Sample	**Flexural break load** (kN)	**Flexural strength** (MPa)
Sample 1	1.08	211.6
Sample 2	1.15	224.9
Sample 3	1.22	233.8
Sample 4	1.30	241.6
Sample 5	1.39	248.5

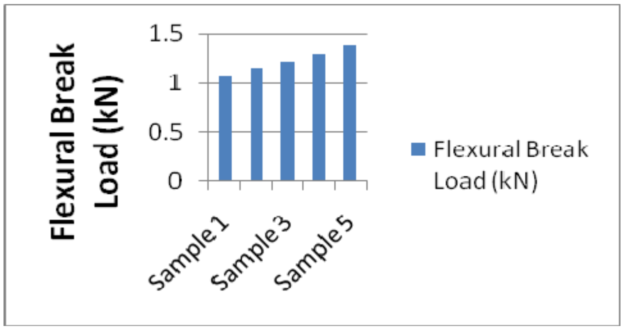

Figure-2. Break load of flexural tested samples.

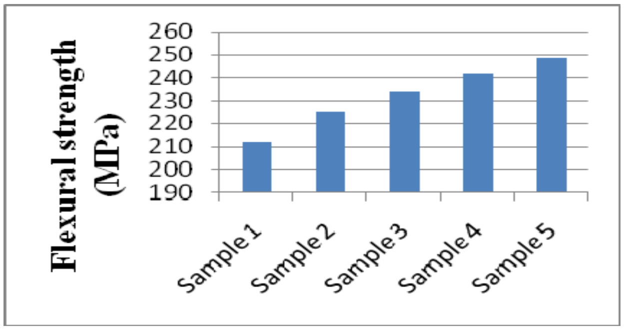

Figure-3. Flexural strength tested samples.

b) Brinell hardness test

Brinell hardness test is carried out using hardened tungsten ball indenter with diameter 10 mm on 5 samples with three trials and the results are furnished in table 3. From figure 4, it is clear that the hardness of sample 5 is greater than other samples due to the presence of high percentage of SiC.

Table-3. Hardness of composites.

Sample	**Trial 1** (BHN)	**Trial 2** (BHN)	**Trial 3** (BHN)	**Average hardness**(BHN)
Sample 1	49.8	48.8	49.2	49.3
Sample 2	52.3	51.6	52.6	52.2
Sample 3	55.4	54.9	54.2	54.8
Sample 4	59.2	59.6	58.3	50.1
Sample 5	63.6	62.1	62.5	62.7

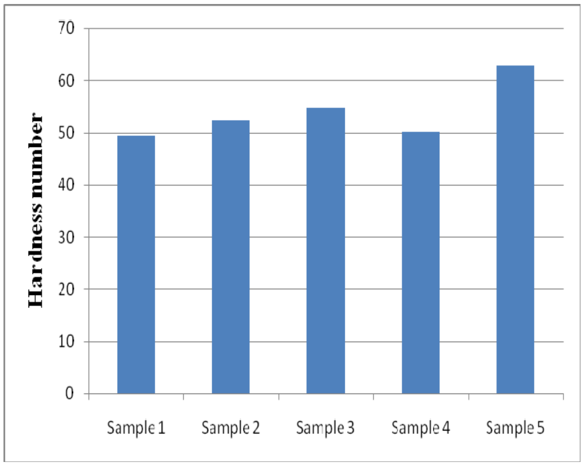

Figure-4. Brinell hardness number (hardness test).

5. CONCLUSIONS

In this paper, metal matrix composite is fabricated by stir casting process with different volume fractions of Silicon carbide with aluminium 6061 alloy. It is concluded that the flexural strength of the composite increases with the increasing weight % of the Silicon Carbide. The flexural strength of sample 5 is higher than that of the other four samples. The brinell hardness of sample 5 is greater than other samples because of the presence of silicon carbide.

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