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Mechanical Behaviour Analysis of Al6061, Al-SiC and Al-SiC-Gr Metal Matrix Composites

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Abstract - This study reflects on the the potential use of aluminium metal matrix composite with reference to the aerospace and automobile industries. The desired mechanical properties are initially identified. Then this study explores the importance and limitations of pure Al6061. In order to overcome these limitations metal matrix composites were preferred as a replacement of aluminium. Aim of this paper is to study about the increase in mechanical properties of metal Matrix composite when compared to its pure material. Here Al6061 is composited with silicon carbide and combination of silicon carbide and graphite as Al-SiC and Al-SiC-Gr respectively. Here composition of Al-SiC is 90% of Al and 10% of SiC. Composition of Al-SiC-Gr is 90% of Al, 7.5% of SiC and 2.5% of Gr. Metal matrix of aluminium is manufactured by Sir casting. Tests like hardness, tensile and charpy impact are used in analysis of mechanical behaviour.

***Key Words*:** MMC, Al6061, SiC, Graphite, Stir casting

1.INTRODUCTION

Metal matrix composites are made up of two or more different types of of materials. MMCs have found increase range of applications in our day to day life. There are advantages in substituting MMC instead of non reinforced materials. They processes improved properties such as high strength, young's modulus, wear resistance, damping capacity when compared to its pure alloys. In present day the reinforced aluminium metal matrix composites are highly preferred due to their low cost with several advantages.

Two distinct phases are seen in composites, they are dispersed phase and matrix phase which results in difference in bulk properties. Composites can be aptly defined as two or more different materials which have different chemical and physical properties. In composite each constituent materials remain distinct and separate in finished metal matrix.

Continuous fibre, discontinuous fibre and particulates are three forms by which reinforcement basically formed. Fibre reinforcement considerably presents propagation of crack and adds rigidity to composites mixture of both continuous and short fibre are uni-directional in nature. Some of the reinforcements of such fibres are cellulose, glass fibres, polymers and carbon fibres. In particulate reinforcement prevention of crack propagation and dislocation movement. Often metals are reinforced with mixture of sand and gravel to attain increase in strength at a cost of ductility. When the constituent materials present were at least three then they are called hybrid composites.

2. Fabrication of Composites

In this study, Tested materials were pure Al6061, Al-SiC metal matrix composite and Al-SiC-Gr metl matrix composite. Here pure Al6061 was melted using die casting to desired shape which for mechanical testing like hardness, tensile and impact test. Furthermore no dimensional machining is needed for microstructural analysis. Both composites were fabricated using Stir Casting. Composition of Al-SiC composite were Al-90%, SiC-10% of total volume of the composite. Al-SiC-Gr composite composition were Al-90%, SiC-7.5% and Gr-2.5% of total volume of composites.

2.1 Stir Casting

Stir casting is the among the many casting process in which stirrer is employed to create vortex in order to thoroughly mix reinforcement in the matrix. It ishighly suited for metal matrix composite production. Reasons are mass production, simple, low cost and easily controllable. Major components of stir casting are reinforcement feeder, furnace and stirrer. Heating and melting of materials is performed in furnace. Bottom pouring furnace is highly suitable because after mixing instant pouring is required to eliminate solid setting ion the crucible. Mechanical stirrer is used to achieve vortex which inturn mix the particles thoroughly in all possible directions. Feeder feeds the reinforcement particulates into the melt mold is used for pouring the molten mixture.

Hence the Al-SiC metal matrix composite is obtained by melting 90% of Al in the furnace and 10% of SiC is introduced to melt by feeder. Thorough mixing is done by the stirrer. Pouring is in mold and solidified to form cylindrical rod of Al-SiC metal matrix composite. Again same procedure is repeated by melting 90% of Al and introducing 7.5% of SiC- 2.5% of Graphite into the melt via feeder and solidification is done to obtain cylindrical rod of Al-SiC-Gr metal matrix composite. Experimental setup of stir casting machine is shown in Fig -1.

Fig -1: Stir Casting Setup

3. Mechanical Testing

Mechanical testing is crucial part of manufacturing process. Primary purpose of testing is for safety assurance mechanical properties of a material is obtained from mechanical testing different properties of materials can be obtained from different testing types the tensile strength of a material is worked out from the tensile test. Toughness of the material can be determined from a charpy v-notch test. Hardness of the material can be obtained from brinell hardness test.

3.1 Tensile Test

Strength is one of the important property of the material. Information about the strength or its behaviour can be determined by the tensile test. Basic procedure is to place specimen in between grips. It holds the specimen tight. Dimensions of specimen is known (length and cross sectional area). Weight is applied on one end and opposite end is fixed. Apply load until it finally breaks. Ultimate tensile strength of three specimen is calculated by performing above procedures. The dimensions of tensile specimen is shown in fig -2.

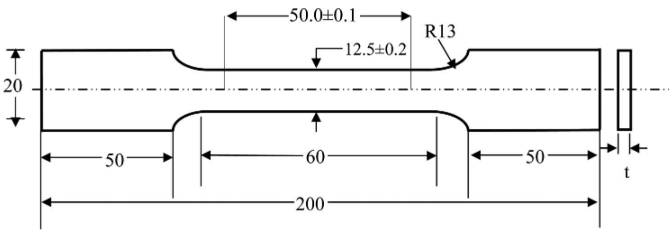

Fig -2: Tensile Test Specimen Dimensions

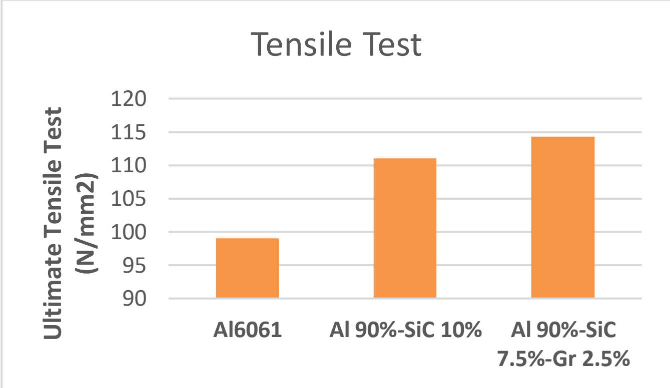

Chart -1: Tensile Test

Chart -1 shows the ultimate tensile strength of each specimens. conclusion drawn from tensile test is Al-SiC-Gr metal matrix composite records higher Ultimate tensile strength than other specimens.

3.2 Hardness Test

Indentation hardness of the materials are characterized through brinell scale. By loading on a test piece penetration of an indenter is measured. This test measures the hardness of the material in brinell scale. Generally this test is preferred for specimen that are forged or casted. Indenter is hardened steel ball of diameter Generally 10mm, 5mm or 2.5mm. Load is applied and removed with the help of hand lever works on hydraulic power. By using load, diameter of Indentation and diameter of hardened steel ball brinell hardness number is calculated. Above procedure were repeated for the specimens.

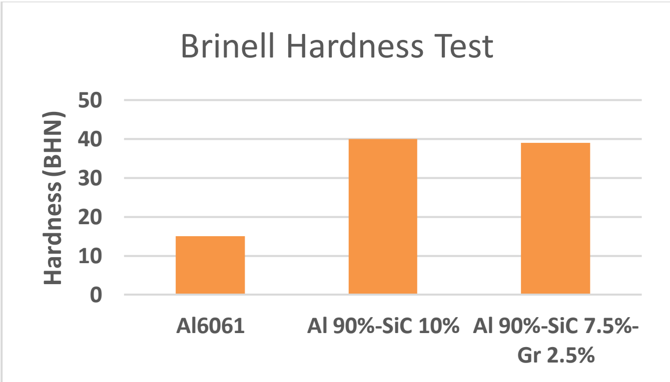

Chart -2: Brinell Hardness Test

From the chart -2 shows the hardness values of each specimens. Thus hardness values Al-SiC metal matrix composite exhibits higher BHN than other specimens.

3.3 Impact Test

Impact test can be performed by two test. In this investigation the Charpy Impact test was done to evaluate the resisting capability of the metal matrix composite to breakage by Impact load. Charpy Test determines the amount of energy absorbed by the specimens. Energy absorbed is a measure of specimen toughness. Across the parallel jaws v-notch specimen is placed. Pointer set to maximum and the Hammer is released from the initial point to downwards. Energy absorbed are tabulated by repeating same procedures for these specimens. Fig -3 shows the dimensions of specimen subjected to impact test.

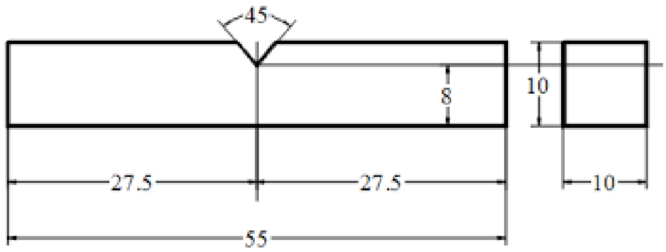

Fig -3: Impact Test Specimen Dimensions

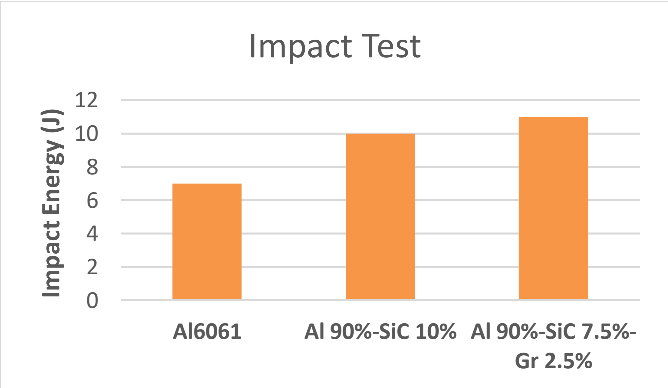

Chart -3: Impact Test

From the chart -3 impact test experimental values it is clear that Al-SiC-Gr metal matrix composite absorbs higher energy than the remaining specimen.

3.4 Tabulation of Test Result

Experimental values obtained from the respective tensile test, impact test and Brinell hardness test are shown in the table -1 given below

SPECIMEN	ULTIMATE TENSILE STRENGTH (N/mm^2)	HARDNESS (BHN)	IMPACT ENERGY (J)
Al6061	99	15	7
Al 90%-SiC 10%	111	40	10
Al 90%-SiC 7.5%-Gr 2.5%	114.33	39	11

Table -1: Test Results

4. Microstructure Analysis

Material structure is the result of processing and the composition of respective material. Structural changes have Impact on the material properties. Thus affect the material performance. It helps us to attain information on how material was made and its quality. Magnification plays a huge role in failure analysis.

Metallurgical microscope is a high resolution microscope employed for viewing non transparent bodies. It works on the principle of reflected light microscopy. This is ideal for viewing materials in metallurgical field.

To obtain more accurate interpretation and observation of the microstructure the respective specimens were prepared in appropriate manner. Preparation of specimen is done by grinding and repolishing. Specimen is mounted in an acrylic type medium according to standard practice. Examination were done in the etched condition and magnification were done upto 500x. Microstructural images obtained from metallurgical microscope of Al6061, Al-SiC MMC and Al-SiC-Gr MMC are shown in Fig-4, Fig-5 and Fig-6 respectively.

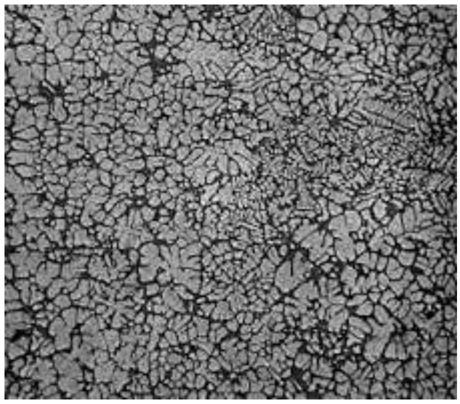

Fig -4: Microstructural Image of AL6061

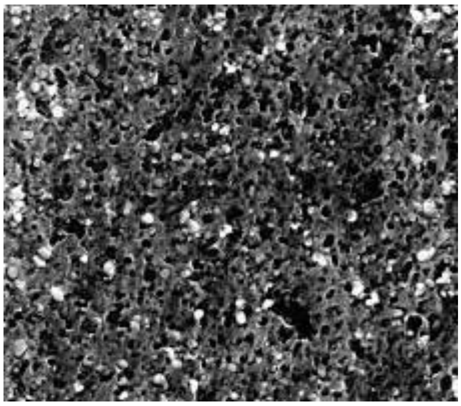

Fig -5: Microstructural Image of Al-SiC MMC

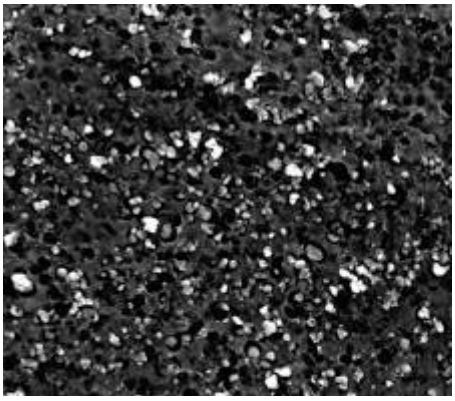

Fig -6: Microstructural Image of Al-SiC-Gr MMC.

Above images helps us to understand the materials structure in microscopic level. Pure Al6061 image shows the homogeneity of the material. Microstructural image of Al-SiC MMC and Al-SiC-Gr MMC shows the particulate distribution of silicon carbide and SiC-Gr respectively.

5. CONCLUSION

Mechanical properties and Microstructure analysis of pure Al6061, Al-SiC and Al-SiC-Gr metal matrix composites were investigated in this study. The results obtained are as follows

- Tensile strength of pure Al6061 is very low compared to Al-SiC and Al-SiC-Gr metal matrix composites. Al-SiC-Gr MMC records high ultimate tensile strength. This shows us strength of the aluminium increases by adding SiC and Graphite.
- Hardness test clearly shows tremendous increase of hardness from pure Al6061. This test results shows Al-SiC metal matrix composites records high hardness number. Test concludes graphite addition slightly reduces hardness.
- Impact strength of Al6061 shows significant increase by addition of SiC and Graphite. Toughness of the aluminium is increased.
- Microstructure analysis helps us to understand the basic structural difference between Al6061 and its composites (Al-SiC & Al-SiC-Gr) in microscopic level. Furthermore it shows us the distribution of particulates within the structure.

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