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Fabrication And Investigation Of Metal Matrix Composites Of Aluminium Al7075 Alloy - Sic/Al_2o_3

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ABSTRACT
Aluminum based metal matrix composites find varied applications in aerospace, defense, automobile, sports equipment and electronics due to their favorable properties viz. light weight, high strength and coefficient of thermal expansion. Al 7075 is a low strength cast able alloy with moderate hardness and strength and finds application in truck wheels and rail road cars. The addition of refractory reinforcement generally improves the hardness, tensile strength and high temperature properties of the material. The present investigation focuses on characterization of metal matrix composites based on Al7075 matrix reinforced with different percentages of SiC and Al_2O_3 particles. Accordingly, Al7075 -Al_2O_3-SiC composite of (0,0),(5,0),(0,5)&(5,5) wt% Al_2O_3-SiC as reinforcement are manufactured using conventional stir casting technique. Specimens are prepared as per the ASTM standards and microstructure investigation, tensile, impact and hardness Measurements have been correlated with the percentage of SiC particles.
Keywords: *Metal matrix composite (MMC), Stir Casting, Aluminum, Silicon carbide, Aluminum oxide & ASTM.*

INTRODUCTION

In this chapter general introduction to composite materials with classifications, constituents and applications are given. A brief note about various tests performed are also introduced along with the fabrication technique.

The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. The advantage of composite material is that, if well designed, they usually exhibit the best qualities of their components and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are strength, stiffness, corrosion resistance, wear resistance, attractiveness, weight, fatigue life, temperature dependent behavior, thermal insulation, thermal conductivity and acoustical insulation. Composites are formed by combining materials together to form an overall structure with properties that differ from sum of individual components.

TESTING PROCEDURE

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TESTING PROCEDURE

Stir-casting was used here in preparing composite samples. Stir casting improved the mechanical and physical properties of the aluminium matrix in the process of silicon carbide particles and aluminium oxide particles pull through molten metallic & dispersed them homogenously.

The specimens are prepared based on ASTM standards.

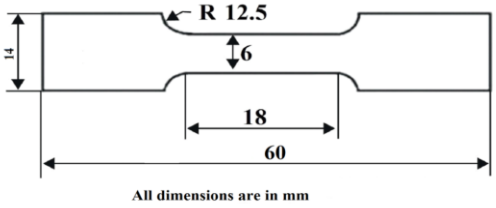

Fig:Specimen

The specimens are cooled to room temperature and then machined according to the standards specified for conducting the desired tests i.e., Ultimate Tensile Strength, Brinell Hardness Number, Charpy Impact Strength and Microstructure.

The composition of AL7075 alloy and with weight percentage reinforcement of SiC and Al_2O_3 are mentioned in following table.

SPECIMEN NO.	Al7075 (%)	Al_2O_3 (%)	SiC (%)
1	100	0	0
2	95	5	0
3	95	0	5
4	90	5	5

Table:composition of MMC of AL7075alloy-SiC & AL_2O_3

Fig:Specimens beofre machining

For performing the Ultimate Tensile strength, the specimen is machined and test is performed on UTM machine.

TENSILE TEST

Material strength testing, using the tensile or tension test method, involves applying an ever-increasing load to a test sample up to the point of failure. The process creates a stress/strain curve showing how the material reacts throughout the tensile test. The data generated during tensile testing is used to determine mechanical properties of materials and provides the following quantitative measurements

- Tensile strength, also known as Ultimate Tensile Strength (UTS), is the maximum tensile stress carried by the specimen, defined as the maximum load divided by the original cross-sectional area of the test sample.

- Yield strength is the stress at which time permanent (plastic) deformation or yielding is observed to begin.

- Ductility measurements are typically elongation, defined as the strain at, or after, the point of fracture, and reduction of area after the fracture of the test sample.

BRINELL HARDNESSTEST

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The Brinell hardness number is a function of the test force divided by the surface area of the indent. The average of the two diagonals is used in the following formula to calculate the Brinell hardness. HV = Constant X test force / (indent diagonal) 2. The constant is a function of the indenter geometry and the units of force and diagonal. The Brinell number will increase as the sample gets harder.

CHARPY IMPACT TEST

Impact strength of the hybrid MMC is determined on Charpy impact tester. Here used Charpy-V Type of impact and noth depth is 2mm at angle of $45^{0.}$

MICRO STRUCTURE STUDY

Microscopic method used to study the composite microstructure is an optical microscope (OM). The composite specimens are polished with six different emery papers of 100 to 600 grit in the steps of 100 grit. To obtain mirror like smooth surface, super finishing is carried out on double disc polisher using emulsion of alumina and water. It will expose the grain boundary, secondary phases visible in the microscope at higher magnification.

RESULTS AND DISCUSSION

In this chapter the final outcomes of various tests that are performed on the specimens fabricated are discussed along with the variation of properties with varying percentages of secondary reinforcement.

ULTIMATE TENSILE TEST

Tensile tests are performed on a Universal Testing Machine for Al7075,SiC, Al_2O_3 composites. The following table deals the information about ultimate strength and elongation of the specimen samples.

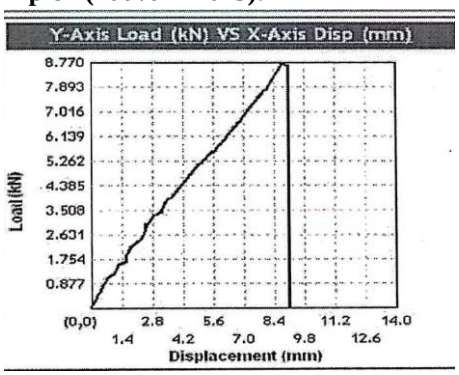
S.NO	Identification	Ultimate load (KN)	Ultimate tensile strength (N/mm^2)	Elongation %
1	AL7075	8.720	144.347	0.690
2	AL7075+ 5%SiC	10.680	176.005	1.970
3	AL7075+ 5%AL_2O_3	7.480	124.397	1.290
4	AL7075+ 5%AL_2O_3+ 5%SiC	8.040	132.783	2.230

Table:Tensile test values

. It was observed that the tensile srength is higher for 5% SiC composites than other compositions.

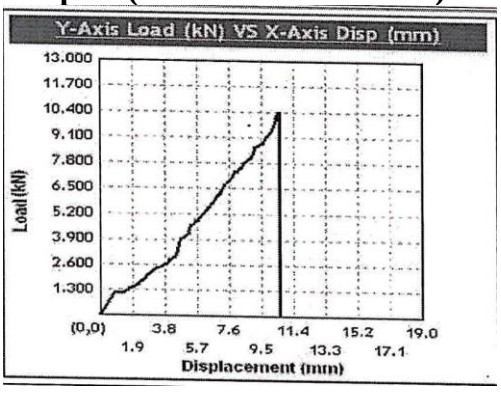
The variation of tensile strength w.r.t % SiC is shown in below figures.

Sample-1(100% Al7075):



Graph1 Tensile Strength Al7075 100%

Sample-2(95%AL7075+5% SiC):



Graph 2 Tensile Strength Al7075 95% + SiC 5%

Sample 3(95% Al7075 + 5% Al_2O_3):

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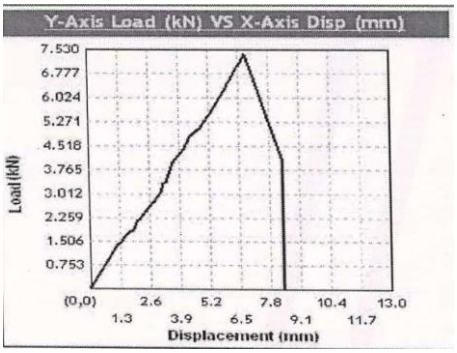
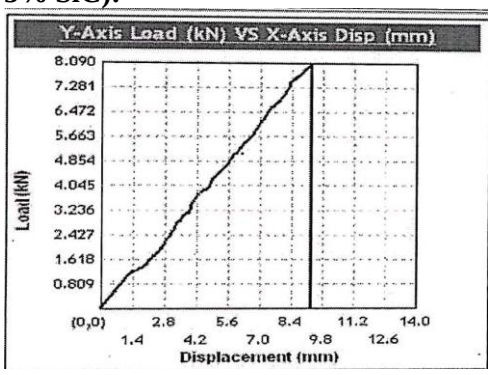


Graph 3 Tensile Strength Al7075 95% + Al_2O_3 5%

Sample- 4 (90% Al7075 + 5% Al_2O_3+ 5% SiC):



Graph 4 Tensile Strength Al7075 90% + SiC 5% + Al_2O_3 5%

BRINELL HARDNESS TEST

The theory and practice of the method are presented in the most complete way in the current Standard: ASTM E 10, Standard Test Method for Brinell Hardness of Metallic Materials. This Standard is prepared and maintained by the American Society for Testing and Materials.

BHN = P/ π * D/2 *(D-SQRT (**D**2 - d2))

ASTM Standard E 10 the following ratios should be used for the materials indicated:

For hard Silicon carbide and aluminum alloys: F/D2 = 1

For soft Silicon carbide and aluminum alloys: F/D2 = 5

Sample No	Identification	Observed average values in HV5
1	AL7075	132.33
2	AL7075+5%SiC	100.33
3	AL7075+5%AL_2O_3	93.33
4	AL7075+5%AL_2O_3+5%SiC	118.67

Table:Hardness test results

Above shows the hardness distribution in the composites for different wt% of SiC reinforcement. Hardness increases with increase in wt% of SiC in the composite. From the trend obtained, we can say that increase in % of SiC causes a small increase in the value of Hardness.

CHARPY IMPACT TEST

Impact resistance is the measure of toughness. Even though the increase in hardness is marginal, the impact strength is reducing at higher % level of reinforcement i.e, 5wt% of SiC composite. It implies that the increase in reinforcement reduces the toughness of the material.

Sample No	Identification	Observed values (Joules)
1	AL7075	10
2	AL7075+5%SiC	4
3	AL7075+5%AL_2O_3	6
4	AL7075+5%AL_2O_3+5%SiC	4

Table:Impact test result

STUDY OF MICROSTRUCTURE

Sample-1(100% Al7075):

Micro stricture consist of coarse interdendritic network of undissolved eutectic $CuAl_2$ in the matrix of aluminium solid solution.

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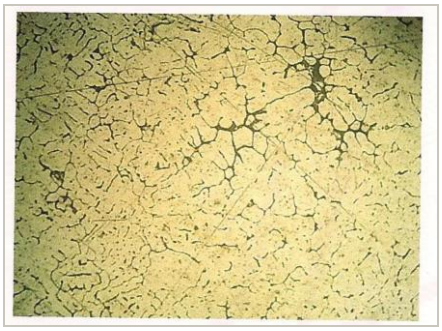

Fig: 100% Al7075 and magnification:200x

Sample-2(95% AL7075+5% SiC):

Micro stricture consists of coarse interdendritic network of undissolved eutectic $CuAl_2$ with uniformly distributed SiC particles in the matrix of aluminium solid solution.

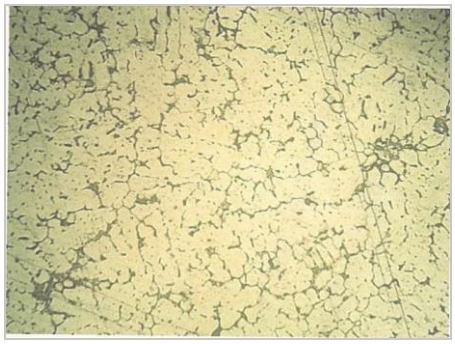

Fig:95% AL7075+5% SiC and magnification:200X

Sample 3(95% Al7075 + 5% Al_2O_3):

Micro stricture consists of coarse interdendritic network of undissolved eutectic $CuAl_2$ with Al_2O_3 particles precipiteated at grain boundaries of aluminium solid solution.

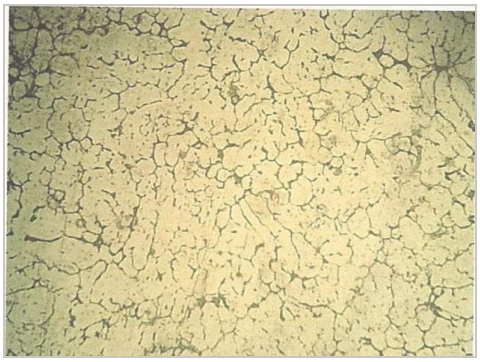

Fig: 95% Al7075 + 5% Al_2O_3 and maginification:200X

Sample- 4 (90% Al7075 + 5% Al_2O_3+ 5% SiC):

Micro stricture consists of coarse interdendritic network of undissolved eutectic $CuAl_2$ with randomly distributed SiC particles and Al_2O_3 particles precipitated at grain boundaries of aluminium solid solution.

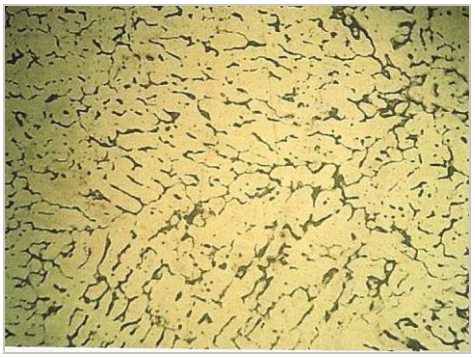

fig: 90% Al7075 + 5% Al_2O_3+ 5% SiC and magnification:100X

CONCLUSION AND SCOPE FOR FUTURE WORK

CONCLUSION

In this experimental study, MMCs of varying (0,0),(5,0),(0,5)&(5,5) wt% Al_2O_3-SiC were prepared using stir casting fabrication technique. Microstructural aspects, hardness, tensile strength and impact strength of the prepared composites were studied. Based on the experimental evaluation, following conclusions were drawn.

- Marginal improvement in hardness is observed in the composites with increase in weight percentage of SiC reinforcement.
- Tensile strength of the composite material increases with increase in weight percentage of SiC. Maximum tensile strength of 176.005 MPa is found for Al 7075-SiC 5% composite.

- Impact strength of the material decreases with the addition of SiC reinforcement. Maximum impact strength " 6J " is observed for Al 7075-5% Al_2O_3 composite.
- Elongation is high upto 2.23 in the composite of Al7075 90%+SiC 5%+Al_2O_3 5% which increases the ductility of matrail while it is low 1.97 in the composite of Al7075 90%+ SiC 5%
- The microstructure shows better dispersion of reinforcement in the matrix and there is no indication of agglomeration of reinforcement in the matrix.

SCOPE FOR FUTURE WORK

- Composites have prominent role to play in shaping the aerospace structures during coming years particularly due to their high specific properties. They are used in missiles, rockets and space satellites.
- Aircrafts, Antenna structures, Solar reflectors, Satellite structures, Radar, Rocket engines, etc.
- Jet engines, Turbine blades, Turbine shafts, Compressor blades, Airfoil surfaces, Wing box structures, Fan Blades, Flywheels, Engine bay doors, Rotor shafts in helicopters, Helicopter transmission structures, etc.
- Automobile: Engines, bodies, Piston, cylinder, connecting rod, crankshafts, bearing materials, etc.,

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