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"Investigation on Tensile Strength of SiC Particulate and e-Glass Fibres Reinforced Al 3102 Hybrid Metal Matrix Composites"

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Abstract: Metal Matrix Composites (MMC's) consist of either pure metal or an alloy as the matrix material, while the reinforcement generally a ceramic material. Now a day these materials are widely used in space shuttle, commercial airlines, electronic substrates, bicycles, automobiles, etc., Among the MMC's aluminium composites are predominant in use due to their low weight and high strength. The key features of MMC's are specific strength and stiffness, excellent wear resistance, high electrical and thermal conductivity. Hence, it is proposed to form a new class of composite. Al 3102 alloy reinforced with E-glass and SiC particulates to form MMC using stir casting. The MMC is obtained for different composition of E-glass and SiC particulates (varying E-glass with constant SiC and varying SiC with constant E-glass percentage).

Keywords: Aluminium 3102, E-Glass fibre, SiC Particulate, Stir casting.

I. INTRODUCTION

Composite materials are important engineering materials due to their outstanding mechanical properties. Metal matrix composite (MMC) materials are one of the widely known composites because of their superior properties such as high strength, hardness, stiffness, wear and corrosion resistances. Silicon carbide particle (SiC-p) reinforced aluminium-based MMCs are among the most common MMC and commercially available ones due to their economical production. With the rapid progress in material processing and manufacturing technology, it is therefore desired to develop a new generation of composite materials having low density, light weight, high strength, stiffness and hardness. The Aluminium Metal matrix composites are one such option which can yield us the desired properties. Composite materials in general are materials which are engineered combinations of two or more materials tailored to get the desired properties. The matrix phase and reinforcement phase with significantly different physical or chemical properties, which are constituents of any composite material when combined produce a material with characteristics different from the individual components. Various types of engineered composites are prevalent in industry, which include polymer matrix, ceramic matrix and metal matrix composites.

II. MATERIALS USED TO PREPARE COMPOSITES

A. Aluminium

Aluminum 3102 is a commercially pure aluminum with the addition of manganese, iron, silicon, zinc etc,. 3102 is the most widely used aluminum alloy due to it's excellent characteristics. The addition of manganese increases the strength and 3102 is 20% stronger than 1100. As with 1100, 3102 has excellent corrosion resistance and workability. It is commonly used in Chemical equipment, Cooking and Kitchen equipment, and decorative trim and storage tanks.

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COMPOSITION OF Al 3102

Element	Content (percentage)
Aluminium, Al	<97.8
Iron, Fe	<0.70
Silicon, Si	<0.40
Zinc, Zn	<0.30
Copper, Cu	<0.10
Titanium, Ti	<0.10
Manganese, Mn	<0.050-0.40
Remainder(each)	<0.050
Remainder(total)	<0.15

B. E-Glass

E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiberglass.

COMPOSITION OF E-GLASS

Constituent	Quantity in %
SiO_2	55.2
Al_2O_3	14.8
CaO	18.7
MgO	3.3
B_2O_3	7.3
Na_2O	0.2
K_2O	0.2
Fe_2O_3	0.2
F_2	0.1

C. Silicon Carbide

Silicon carbide is a compound of silicon and carbon with a chemical formula SiC. Silicon carbide was originally produced by a high temperature electrochemical reaction of sand and carbon. Any acids or alkalis or molten salts up to 800°C do not attack silicon carbide. In air, SiC forms a protective silicon oxide coating at 1200^{o}C and is able to be used up to 1600°C. The high thermal conductivity coupled with low thermal expansion and high strength gives this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600°C with no strength loss.

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III.EXPERIMENTAL METHODOLOGY

A. Fabrication of Test Specimen

The alloy ingots are placed in the crucible, and then the crucible is heated to the required temperature. The heating of the crucible may be done by means of electric furnace, coal furnace etc. the temperature inside the furnace was recorded using a temperature recorded. The crucible was taken out when the temperature was 660 degree Celsius. Here we have made use of a Induction furnace. Degasifier is added to molten metal to remove soluble gases present in liquid state metal, in the amount of 2 to 3 percent of molten metal weight.

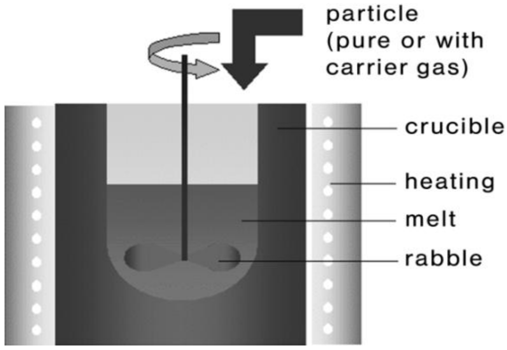

Fig 1: Stir Casting Process

Molten metal at about 660^{0}c is taken in a crucible from the furnace. The temperature is recorded using a thermo couple. Then the reinforcements namely E-Glass, and SiC are added to the molten metal and with the help of a mechanical stirrer the reinforcements are easily mixed with the matrix. Then after few minutes of stirring, the liquid metal with reinforcements is poured into the dies to get the required castings.

Fig 2: Removing Casting After Cooling Final Casted Products

B. Proportions Of The Reinforcments Used

SET 1

Composition Name	E-Glass Fiber(%)	Silicon Carbide(%)
A	1	1
B	1	3
C	1	5
D	1	7

SET 2

Composition Name	E-Glass Fiber (%)	Silicon Carbide (%)
E	3	1
F	5	1
G	7	1

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C. Tensile Test Conducted

Apparatus used: UTM

Specifications of UTM

- Hydraulic Pump Motor 2HP
- Maximum Load 400kN

Procedure:

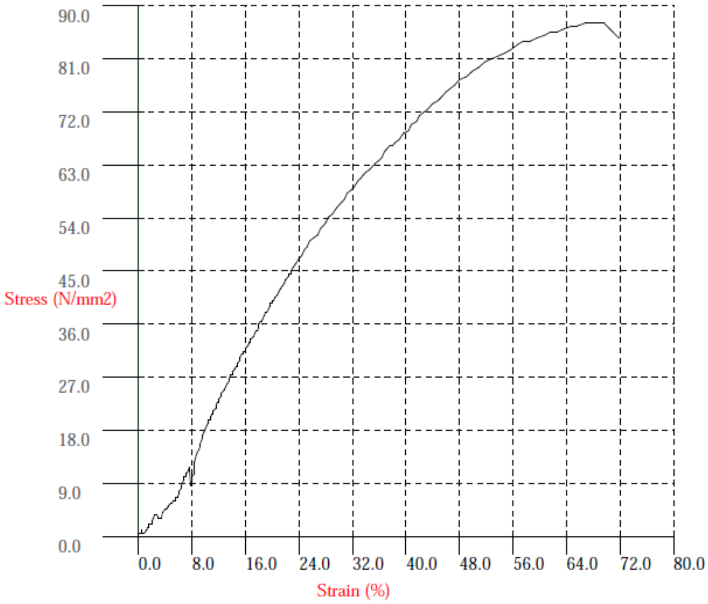
1. The load pointer is set at zero by adjusting the initial setting knob.
2. The dial gauge is fixed and the specimen for measuring elongation of small amounts.
3. Measuring the diameter of the test piece by vernier caliper at least at three places and determine mean value also mark the gauge length.
3. Now the specimen is gripped between upper and middle cross head jaws of the m/c.
4. Set the automatic graph recording system.
5. Start the m/c and take the reading.
6. The specimen is loaded gradually and the elongation is noted until the specimen breaks.

IV. RESULTS AND DISCUSSIONS

A. Tensile Strength of 100 % Al 3102

Table 1: Tensile Results for 100 % Al 3102

Tensile Strength (N/mm^2)	% of Al 3102	% of E-Glass	% of SiC
87.06	100	0	0



Graph 1: Stress v/s strain for 100% Al 3102

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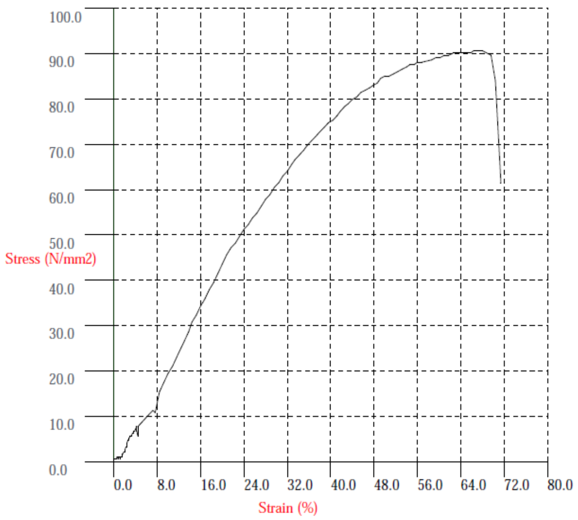
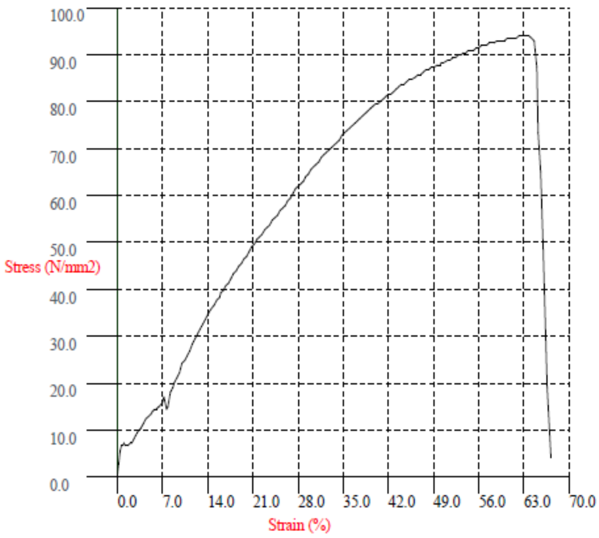
B. Tensile Strength of AL 3102 + 1% SiC particulate+ Varying % E-glass

Table 2: Tensile Results for varying % of E-glass

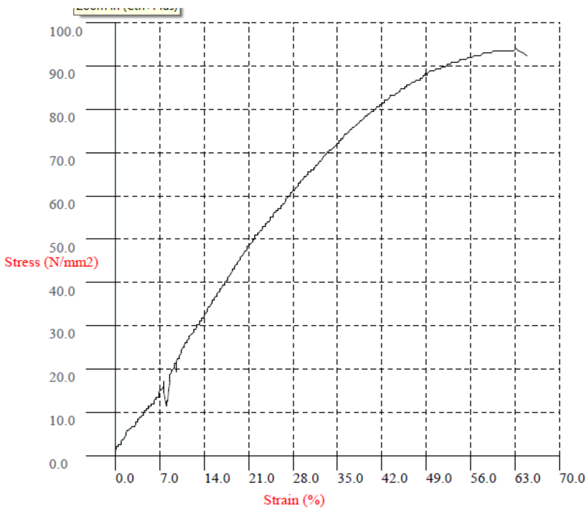
Tensile Strength (N/mm^2)	% of Al 3102	% of E-Glass	% of SiC
90.68	98	1	1
93.99	96	3	1
94.04	94	5	1
91.30	92	7	1



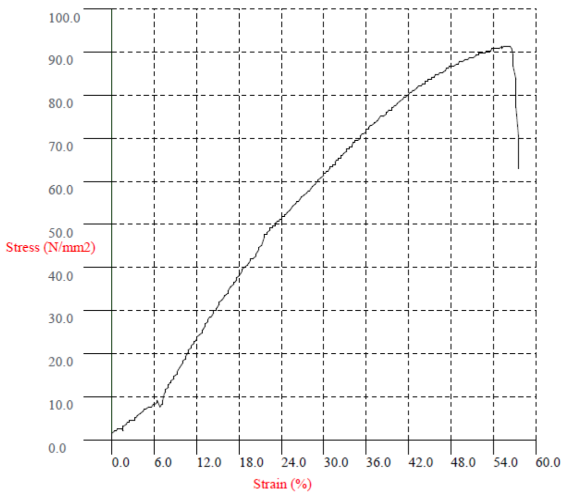
Graph 2: Stress v/s strain for 1% E-Glass, 1% SIC and 98% Al



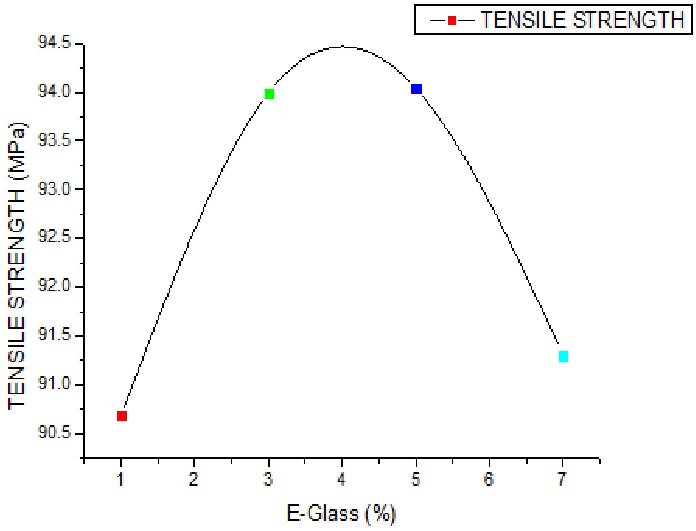
Graph 3: Stress v/s strain for 3% E-Glass, 1% SIC and 96% Al



Graph 4: Stress v/s strain for 5% E-Glass, 1% SIC and 94% Al



Graph 5: Stress v/s strain for 7% E-Glass, 1% SIC and 92% Al 3102



Graph 6: Comparison of Tensile Test results for varying % of E-Glass

➢ From the above results, we see that increasing in the % of E-Glass from 1% to 5%, Tensile Strength increases from 90.68MPa to 94.04MPa, for 7% E-Glass Tensile Strength decreases to 91.30MPa.(for 1% SiC).

➢ This is because ultimate tensile strength increases with increase in percentage composition of constituent material with Al 3102. The increases in ultimate tensile strength is due to the addition of E-Glass fibre which gives strength to the matrix alloy there by enhanced resistance to tensile stresses, there is reduction in the inter-spatial distances between the particles this leads to restriction to plastic flow due to random distribution of the particulate in the matrix. And strength decreased as E-Glass being fibre it won't mix properly and its melting point is more so it spills out from the mixture of molten Al 3102 and SiC.

V. CONCLUSION

From the experiments conducted to study the effect of adding various volumes fractions of E-glass and Silicon Carbide on the mechanical properties such has ultimate Tensile strength, Compression strength and Hardness of the following conclusions can be drawn

- ➢ Composite material of Al 3102 reinforced with E-glass fibre and Silicon Carbide particulate was successfully casted.
- ➢ Tests conducted to determine Ultimate tensile strength indicated no exact trends; however there has been an increase in UTS due to presence of E-glass fibre and SiC Particulate as compared to base metal.
- ➢ The increase in ultimate tensile strength is due to the addition of E-glass fibre which gives strength to the matrix alloy there by enhanced resistance to tensile stresses, there is a reduction in the inter-spatial distance between the particles this leads to restriction to plastic flow due to the random distribution of the particulate in the matrix.

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