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Investigation on Compressive Properties 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). The developed composites are tested for their compressive properties and the results so obtained are compared with pure Al 3102 casted specimen.

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 FOR MANUFACTURING OF COMPOSITES

A. ALUMINIUM 3102

Fig 1: Al 3102 billet

Aluminium 3102 is commercially pure aluminium with the addition of manganese, iron, silicon, zinc etc, 3102 is the most widely used aluminium alloy due to its 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.

B. E-GLASS

Fig 2: E-Glass Fibres

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

C. SILICON CARBIDE(SiC)

Fig 3: SiC

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.

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.

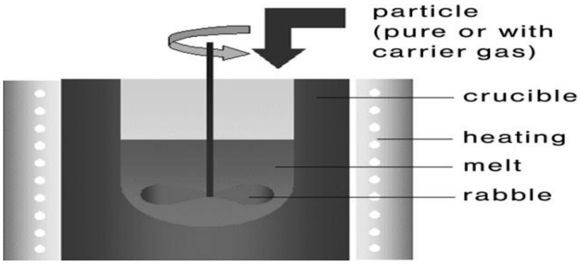

Fig 4: Stir Casting Process

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.

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Fig 5:Final Casted Product

B. PROPORTIONS OF THE REINFORCMENTS USED

Table 1: Proportions of the Reinforcements Used

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

C. TESTS CONDUCTED

Compression test: Universal Testing Machine

PROCEDURE:

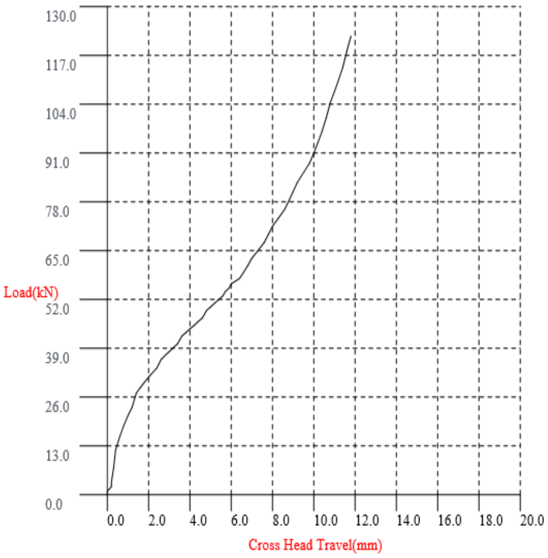
1. The specimen of standard dimensions is located between the compression grips that are adjusted manually
2. Constantly increasing load is applied to the specimen which is being constantly monitored
3. The load at which fracture occurs is noted down
4. Calculate percentage increase in area
5. Calculate percentage decrease in length.

IV RESULTS AND DISCUSSIONS

A. COMPRESSIVE STRENGTH OF 100% AL 3102

Table 2: Compressive Strength of 100% AL 3102

Compressive Strength(N/mm^2)	Peak Load (KN)	% of Al 3102	% of E-Glass	%SiC
388.54	122.08	100	0	0



Graph 1: Compressive Strength for 100 % Al 3102

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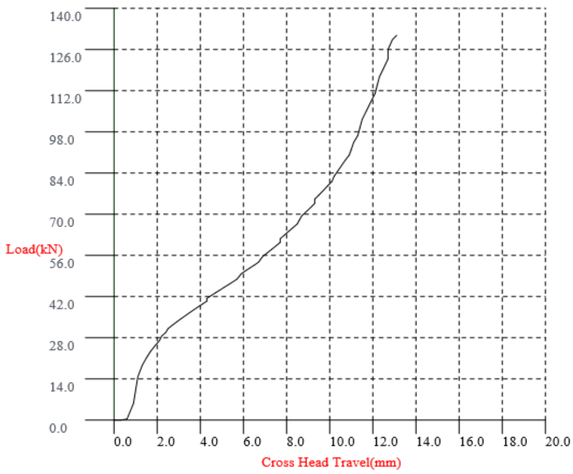
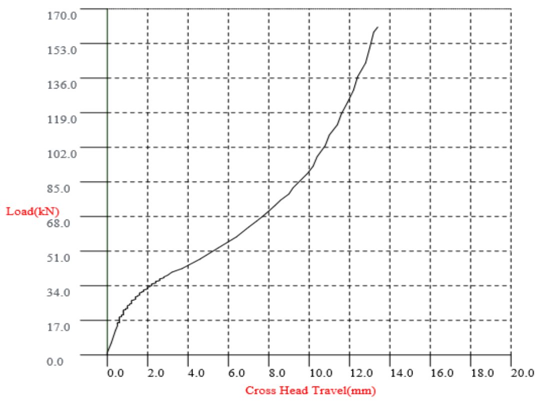
B. COMPRESSIVE STRENGTH OF AL 3102 + VARYING % E-GLASS+ 1 % OF SILICON CARBIDE (SIC)

Table 3: Compression Results for varying % of E-glass

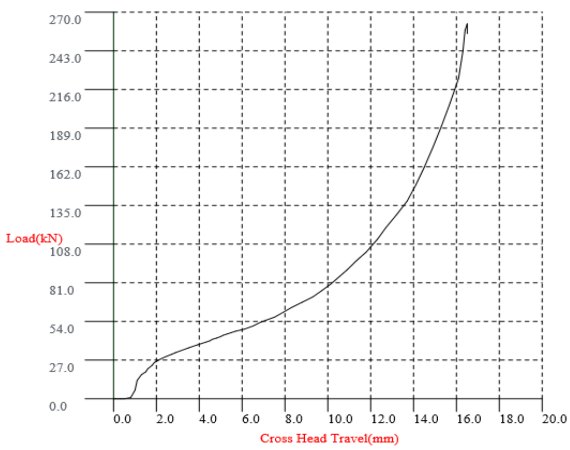
Compressive Strength(N/mm^2)	% of Al 3102	% of E-Glass	% of SiC
416.30	98	1	1
512.54	96	3	1
833.35	94	5	1
759.52	92	7	1



Graph 2: Compressive Strength for 1% SiC with 1% E-Glass



Graph 3: Compressive Strength for 1% SiC with 3% E-Glass



Graph 4: Compressive Strength for 1% SiC with 5% E-Glass

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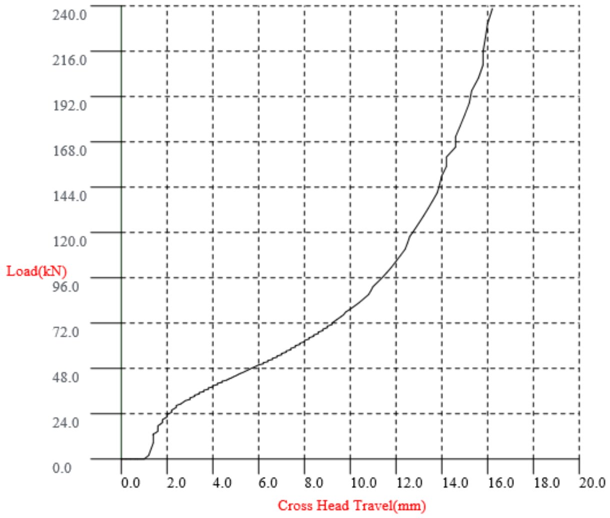
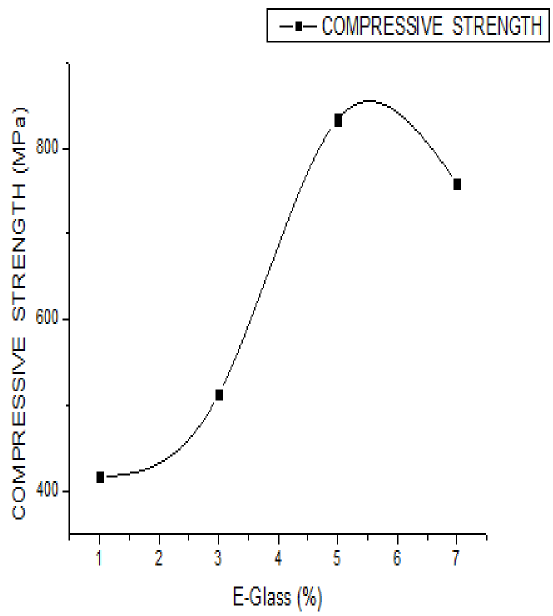


Graph 5: Compressive Strength for 1% SiC with 7% E-Glass



Graph 6: Compressive Strength v/s E-Glass with 1% SiC

1. From the above results, we see that increasing in the % of E-Glass from 1% to 5%, Compressive Strength increases from 416.30MPa to 833.35MPa, for 7% E-Glass Compressive Strength decreases to 759.52MPa.(for 1% SiC).
2. The increase in compressive strength is mainly due to the decrease in the inter-particle spacing between the particulates since Silicon Carbide(SiC) powder and E-glass fibre are much harder than Al 3102 alloy. The presence of E-glass fibre and Silicon Carbide(SiC) resists deforming stresses and thus enhancing the compressive strength of the composite material.

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.

1. Composite material of Al 3102 reinforced with E-glass fibre and Silicon Carbide particulate was successfully casted.

2. Tests conducted to determine the compressive strength revealed very encouraging results as the reinforced composite was able to take more compressive load due to presence of E-glass fibre and SiC Particulate the compressive strength increased.
3. The increase in compressive strength is mainly due to the decrease in the inter-particle spacing between the particulates since Silicon Carbide(SiC) powder and E-glass fibre are much harder than Al3102 alloy. The presence of E-glass fibre and Silicon Carbide(SiC) resists deforming stresses and thus enhancing the compressive strength of the composite material.

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