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Tensile and Impact behaviour of Al-Sic-Zn-Cu Metal Matrix Composite

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Abstract

Aluminium is one of the lightest available commercial metals with a density approximately one third that of steel or copper. Its high strength to weight ratio makes it particularly important to transportation industries allowing increased pay loads and fuel savings. The Aluminum-Silicon Carbide-Zinc and Copper alloys are the primary alloys used in airframe structural applications, automobile and recreational industries. In this paper, Al-SiC-Zn-Cu are varied by different proportions mainly Zn (2%, 4%, 6%, 8%) and Cu (2%, 4%, 6%, 8%), tensile test and impact tests are performed to evaluate the mechanical properties like tensile strength, % elongation, yield stress on computerized UTM and impact strength by using Izod and Charpy tests. The variation of mechanical properties with the increasing percentage composition of Zinc and Copper are evaluated. The results are quantified and analyzed by graphical analysis.

Keywords: Aluminium, casting; metal matrix composites, tensile strength, impact strength, materials.

Introduction

Aluminium is the world's most abundant metal and is the third most common element, comprising 8% of the earth's crust. The versatility of aluminium makes it the most widely used metal after steel. After iron, aluminium is now the second most widely used metal in the world. This is because aluminium has a unique combination of attractive properties. Low weight, high strength, superior malleability, easy machining, excellent corrosion resistance and good thermal and electrical conductivity are amongst aluminum's most important properties[1]. Aluminium is also very easy to recycle. A unique combination of properties makes aluminium and its alloys one of the most versatile engineering and construction material available today[2,3]. A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal[4]. MMCs are made by dispersing a reinforcing material into a metal matrix[5]. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. Aluminum MMCs are the combination of aluminum and its alloys as principal matrix materials and a reinforcing material generally silicon carbide or carbon fibers, zinc and copper are used as reinforcing material.

Methodology

Preparation of Samples: Aluminum MMCs are the combination of aluminum and its alloys as principal matrix materials and a reinforcing material. Generally silicon carbide, zinc and copper are used as reinforcing material. The present Al-SiC-Zn-Cu composite is made by considering mass basis ratio as per the dimensions of the required sample to be produced in the die. Al- 70%, SiC- 10%, Zn-10%, Cu-10% is considered as the basic sample or reference sample. First heating the Aluminium 6061, Silicon Carbide of grit size 60, Zinc and Copper powders to molten states. Thorough mixing of Aluminum, Silicon Carbide, Copper and Zinc by stirring[6]. Pouring the molten metal composition in to the mould, solidifying and air cooling is done[7,8]. Figure 1 shows the Photograph of the induction furnace for making the samples. Figure 2 shows the Pouring the molten metal into the die of 25 mm diameter square rod. Figure 3 shows the Photograph of obtained Al-SiC-Zn-Cu Sample. Al-SiC-Zn-Cu are varied by different proportions mainly Zn (2%, 4%, 6%, 8%) and Cu (2%, 4%, 6%, 8%).

Figure-1
Induction furnace for making the samples

Figure-2
Pouring the molten metal into the die

Figure-3
Photograph of Al-SiC-Zn-Cu Sample

Tension Test: The tension test is conducted on a universal testing machine TUE-600(C) at room temperature and Figure 4 shows samples for tensile test and the obtained results are tabulated in Table 1.

Figure-4
Samples for Tensile test

Impact Test: The impact test is used to determine the behavior of material when subjected to high rates of loading usually in bending, torsion and tension. In the impact test, the impact strength i.e., resistance to shock loads and the toughness of material under dynamic load is determined. The principle employed in non impact testing procedures is that a material absorbs a certain amount of energy before it breaks or fractures. The quantity of energy thus absorbed is characteristic of the physical nature of the materials[9, 10]. If it is brittle it breaks more readily, i.e., absorbs a lesser quantity of energy and if it is ductile, it needs more energy for fracture. The two important standard impact tests are Izod impact test and Charpy impact test. Figure 5 and Figure 6 show the Izod and Charpy samples. The charpy specimen is placed in the vice so that it is simple supported beam at the ends. The Izod specimen is placed in the vice like a cantilever beam[11, 12].

Results and Discussion

Following Graphs in Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11 are plotted against the percentage of composition with tensile strength, yield strength, percentage elongation, Youngs modulus and impact strength of Zn and Cu respectively.

Table-1
List of experimental results obtained by conducting different tests

S.No	Specifications	70:10:10:10 Basic Sample 1	78:10:10:2 Zn2% Sample 2	76:10:10:4 Zn4% Sample 3	74:10:10:6 Zn6% Sample 4	72:10:10:8 Zn8% Sample 5	78:10:10:2 Cu2% Sample 6	76:10:10:4 Cu4% Sample 7	74:10:10:6 Cu6% Sample8	72:10:10:8 Cu8% Sample 9
1.	% of elongation	0.8	0.48	0.42	0.36	0.40	1.68	1.46	1.24	0.84
2.	Tensile strength (MPa)	135.66	124.5	157.77	164.95	92.64	144.96	127.63	110.34	159.14
3.	Yield stress (MPa)	110.65	95.30	120.28	129.37	72.14	110.45	97.66	84.88	130.42
4.	Impact strength For Izod (J/ m^2)	10000	20000	10000	20000	10000	20000	20000	20000	30000
5.	Impact strength for Charpy(J/ m^2)	40000	30000	40000	40000	20000	40000	50000	60000	50000
6	Youngs Modulus (MPa)	16.95	25.93	37.56	45.82	23.16	86.29	87.60	88.99	18.94

Figure-5
Samples for Izod Test

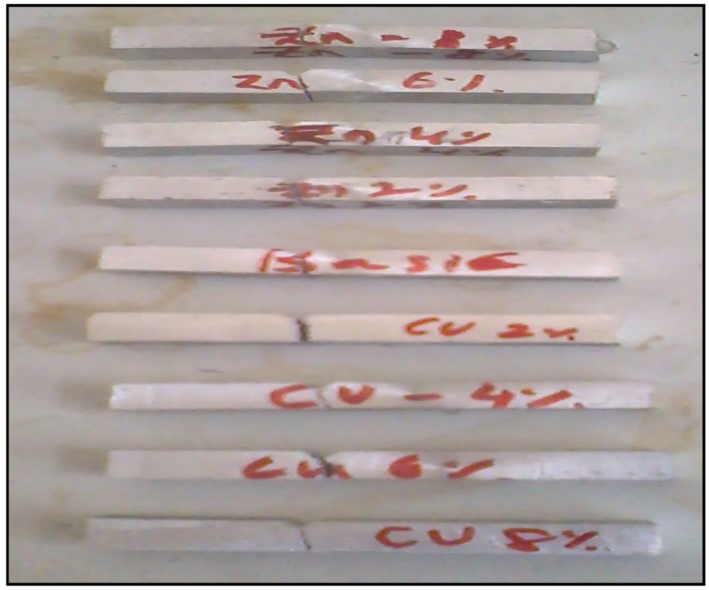


Figure-6
Samples for Charpy Test

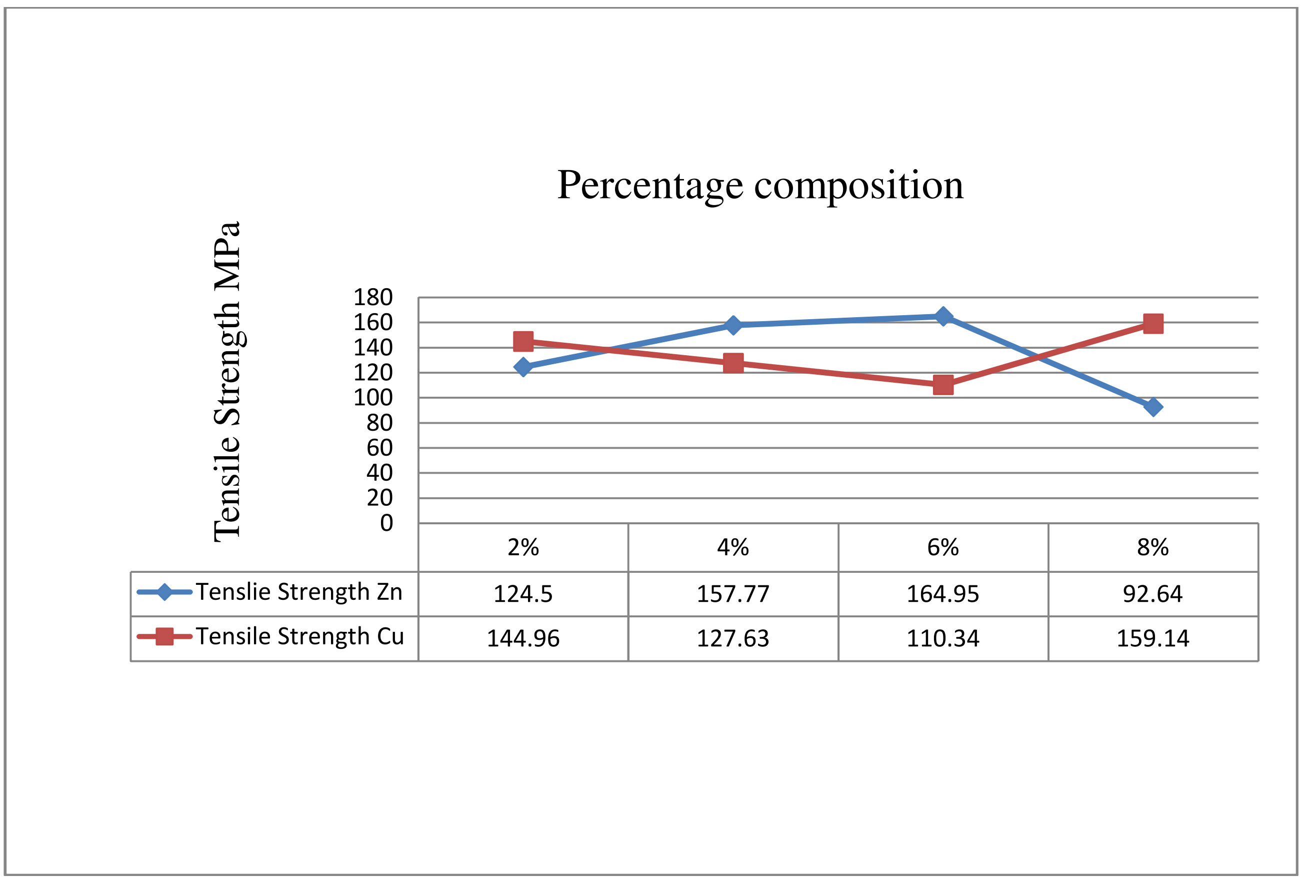


Figure-7
Composition Percentage Vs Tensile Strength of Zn and Cu

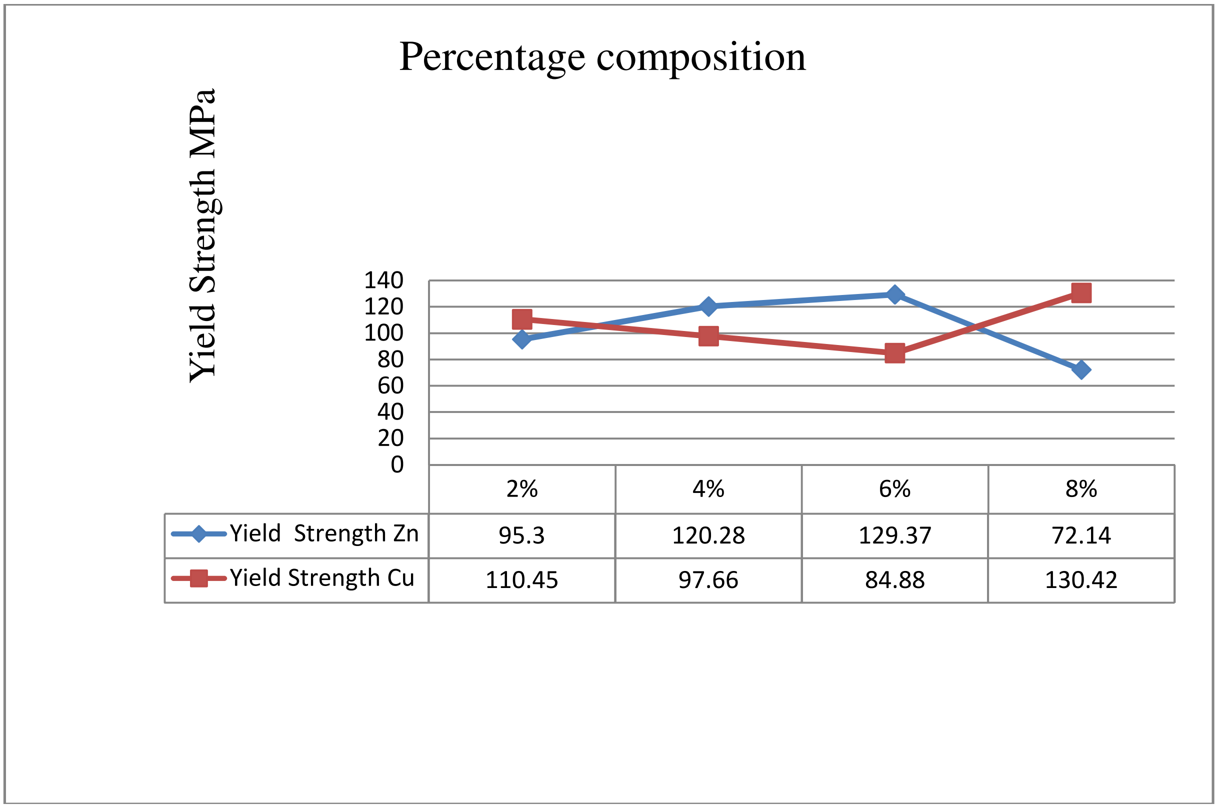


Figure-8
Composition Percentage Vs Yield Strength of Zn and Cu

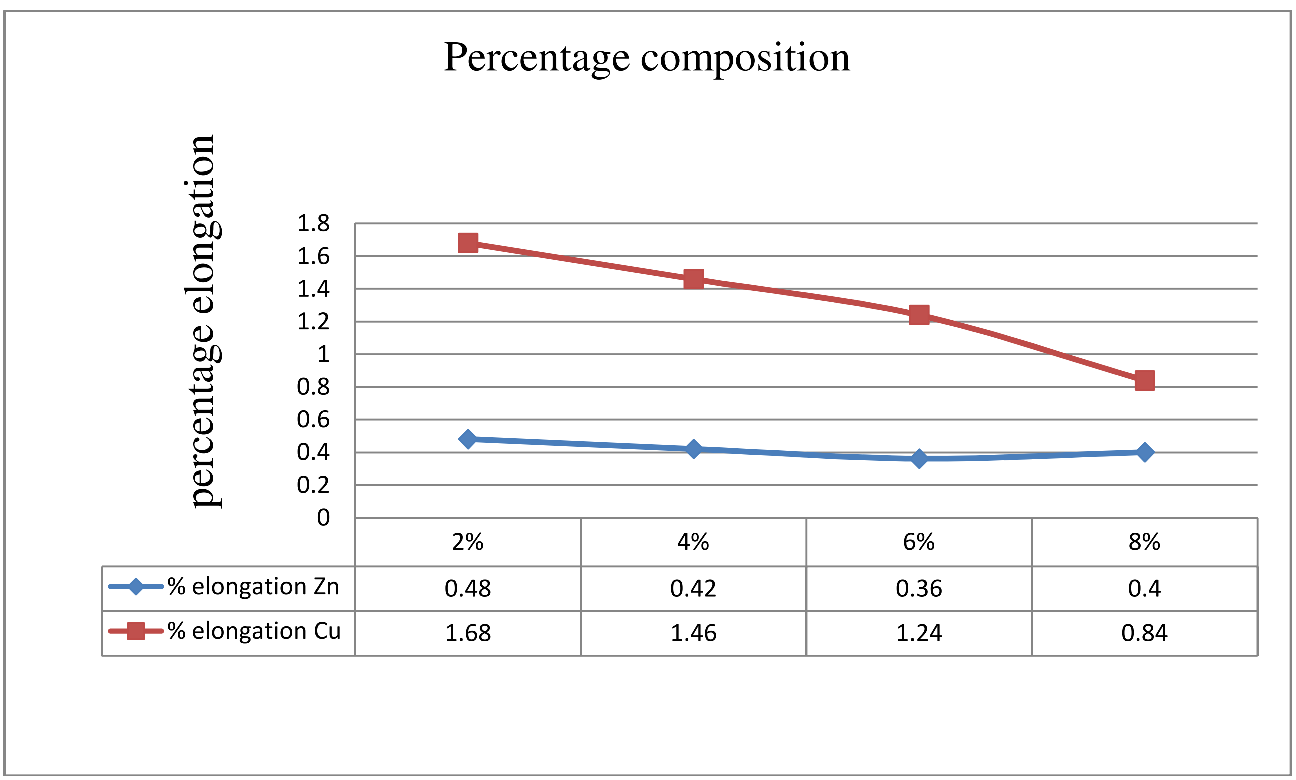
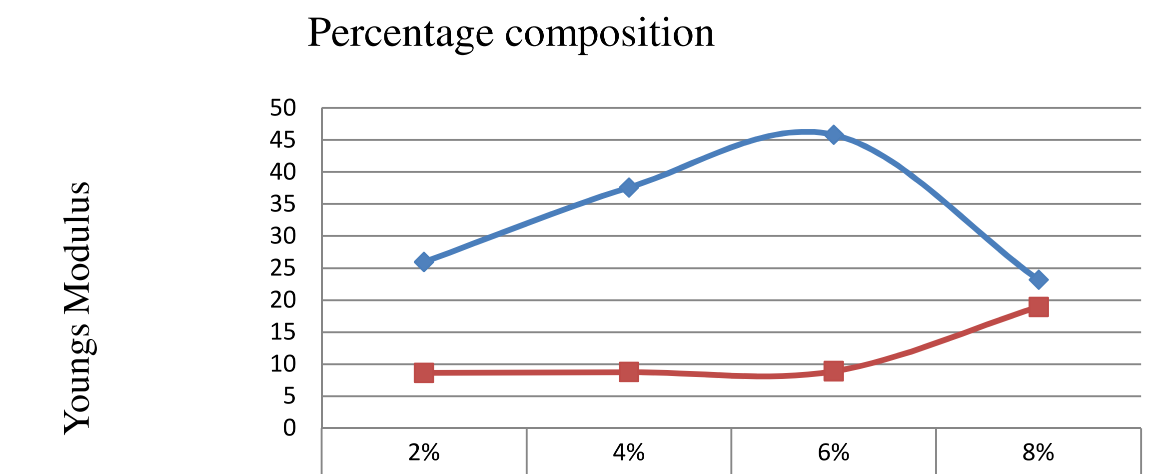
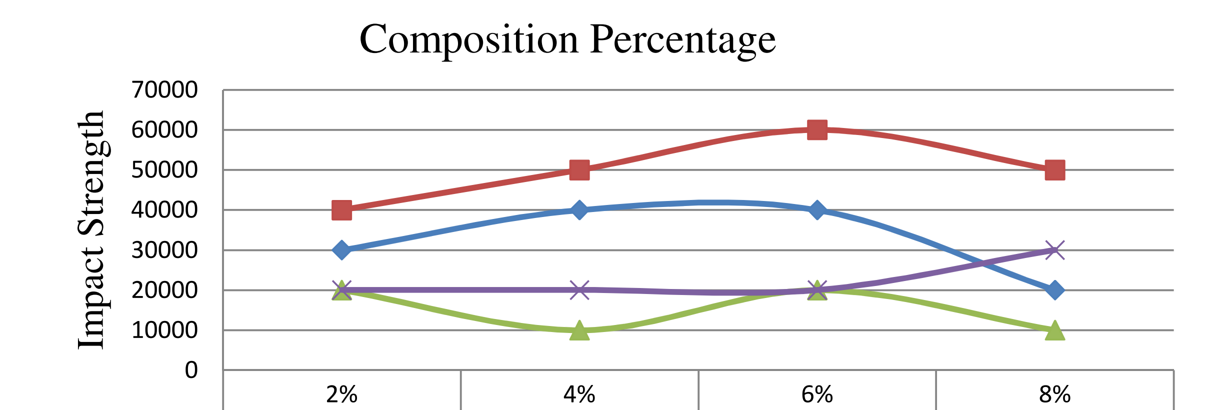


Figure-9
Composition Percentage Vs Percentage elongation of Zn and Cu



	2%	4%	6%	8%
Youngs Modulus Of Zn	25.93	37.56	45.82	23.16
Youngs Modulus of Cu	8.62	8.76	8.89	18.94

Figure-10
Composition Percentage Vs Youngs Modulus of Zn and Cu



	2%	4%	6%	8%
charpy Of Zn	30000	40000	40000	20000
Charpy of Cu	40000	50000	60000	50000
Izod of Zn	20000	10000	20000	10000
Izod of Cu	20000	20000	20000	30000

Figure-11
Composition Percentage Vs Impact Strength of Zn and Cu

Conclusion

High tensile strength of 164.95 MPa is obtained in Zinc series with composition Al- 74%, SiC- 10%, Cu-10%, Zn-6% and in copper series with composition Al- 72%, SiC- 10%,Cu-8%, Zn-10 a maximum tensile strength of 159.14 MPa is obtained. Comparing with the basic sample Al- 70%, SiC- 10%,Cu-10%, Zn-10 with Zn and Cu series, the strengths of Cu and Zn based series obtained are quite higher. For higher tensile strengths Zn 6% and Cu 8% are preferable. Tensile strength is increasing with increase in Zn composition in Zn series. The %elongation of Copper series is decreasing with increase in the composition of copper i.e. %elongation of (Cu2%> Cu4%> Cu6%> Cu8%). With increase in the percentage of Zinc the percentage of elongation is decreased for Zn 2%, Zn 4%, Zn 6%. High Yield strength of 129.37MPa is obtained in Zinc series with composition Al- 74%, SiC- 10%,Cu-10%, Zn-6% and in Copper series with composition Al- 72%, SiC- 10%,Cu-8%, Zn-10% a maximum yield strength of 130.42MPa is obtained. Comparing with the basic sample Al- 70%, SiC- 10%, Cu-10%, Zn-10 with

Zn and Cu series, the yield strengths of Cu and Zn based series obtained are quite higher. Yield strength is increasing with increase in Zn composition in Zn series. Higher impact strength found for Cu 6%. Lower impact strength found for Zn 8%. By the above properties the sample having high tensile and impact strength can be used for marine and engineering castings, condenser tubes, pump parts, motor boat shafting's etc.

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