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Characterisation Of Aluminium Metal Matrix Composites Reinforced With Sic (Carborundum) & Al_2o_3 (Corundum)

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Abstract. Aluminium alloys are widely used in aerospace and automotive industries due to their advantages of physical and mechanical properties. This paper presents a study on the performance of stir cast SiC & Al2O3 reinforced Aluminium metal matrix composite materials. The particulate reinforcement of SiC & Al2O3 is in the ration of 3:2. The mechanical characterization of AMMC indicates that the composite exhibit improved physical and mechanical properties such as low coefficient of thermal expansion, high ultimate tensile strength, high impact strength and hardness. Through scanning electron microscope, the microstructure of AMMC & distribution of SiC & Al2O3 particles in Aluminium alloy (Al 1350) is uniform. By experimental analysis, it is observed that AMMC with 15% of particulate reinforcement of SiC & Al2O3 with a ratio of 3:2 (9% of SiC & 6% of Al2O3) is the optimum mixture for AMMC to obtain better mechanical characteristics. This AMMC has good potential for the applications in automotive industry to manufacture engine components.

1. Introduction

Composites are materials in which two phases are combined with strong interfaces between the base metal & reinforcement. They usually consist of a continuous phase called the matrix and discontinuous phase in the form of fibers or particles called the reinforcement. The reinforcing component is distributed in the continuous or matrix component. When the matrix is a metal, the composite is termed as metal matrix composite (MMC). The matrix holds the reinforcement to form desired shape while the reinforcement improves overall mechanical properties of the matrix. Composite materials have high stiffness, high strength, low weight / density, high temperature stability, high electrical and thermal conductivity, corrosion resistance and improved wear resistance. In this paper, aluminium metal matrix composites with silicon carbide (SiC) and

Aluminium Oxide (Al2O3) as reinforcement particles in the ratio 3:2 are studied to evaluate their physical and mechanical properties. Aluminium 1350 alloy is used as matrix which has 99.5% aluminium, 0.4% iron, 0.1% silicon, 0.05% copper, 0.05% Zinc, 0.05% Tin and 0.01% Manganese. The mechanical properties of aluminium metal matrix composites are affected by the volume fraction of the reinforced SiC & Al2O3 particles.

2. Problem Formulation

Through the analysis of literature survey, it is hypothesized that AMMC with SiC & Al2O3 particle reinforcement could be reliable materials to replace grey cast iron in the automotive industry. To improve the mechanical properties of AMMC the volume fraction of the reinforcement particles is varied compared to previous developments.

3. Objectives of Work

To reduce the weight of AMMC & to increase the tensile and yield strength with minimum ductility and toughness.

To increase creep resistance at higher temperatures compared to other alloys.

To improve corrosion resistance property.

To increase modulus of elasticity during tensile and compressive load.

To reduce thermal elongation of the material.

4. Methodology

The methodology used for stir cast of SiC & Al2O3 reinforced Aluminium metal matrix composite materials is shown in figure 1.

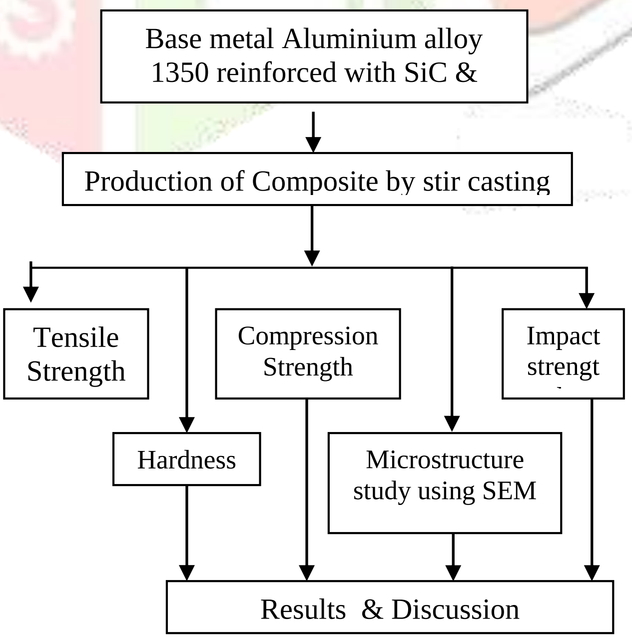

Figure 1. Flow chart of Methodology

5. Stir Casting

Stir casting is a liquid state method of composite material fabrication in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. The aluminium alloy 1350 in the form of wire,used as base metal is melted in the crucible by heating it in a muffle furnace at 7500C for 3 hours. The SiC particles and Al2O3 particles are preheated at 10000c for one hour to make their surfaces oxidized. The different specimens for tensile test, compressive test, impact test, hardness test and for microscopic study through SEM as per ASTM standards prepared with different composition and percentage of particulate reinforcement by weight in the ratio 3:2 as table 1 and shown in figure 2,3,4, 5 and 6 respectively.

Table 1. Composition and Percentage of Particulate Reinforcement

Composition	Aluminium Alloy	SiC %	Al2O3 %	Total particulate SiC&Al2O3 reinforcement %
[illegible]oy 1350	[illegible]	[illegible]	[illegible]	0
[illegible] 3 % SiC & [illegible]	[illegible]	[illegible]	[illegible]	5
[illegible] 6 % SiC & [illegible]	[illegible]	[illegible]	[illegible]	10
[illegible] 9 % SiC & [illegible]	[illegible]	[illegible]	[illegible]	15
Al.alloy 1350 with 12 % SiC & 8% Al2O3	80	12	8	20
Al.alloy 1350 with 15 % SiC [illegible]	75	15	10	25

Figure 2. Tensile Test Specimens

Figure 3. Compression Test

Figure 4. Hardness Test

Figure 5. Impact Test Specimens

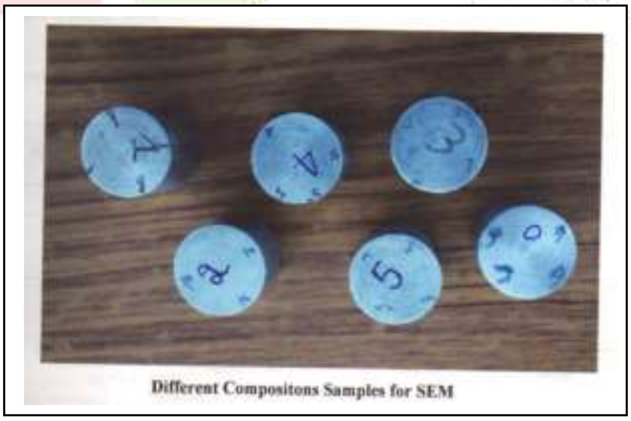

Figure 6. Diffrent Samples for SEM

6. Experimental Results

6.1 Tensile Test results

Experimentally obtained tensile test for different particulate reinforcement percentage in AMMC is carried out and results are shown in table 2.

Table 2. Tensile Test Results for Different Composition

Al.alloy 1350	Ultimate tensile strength N/mm^2 (MPa)	Percentage Elongation	Total percentage Particulate reinforcement ($SiC + Al_2O_3$) (3:2)
Pure Al. alloy 1350	83.10	16.37	0
Al. alloy 1350+ 3 % SiC + 2% Al_2O_3	94.74	27.1	5
Al. alloy 1350 +6 % SiC + 4% Al_2O_3	83.15	11.87	10
Al. alloy 1350 +9 % SiC + 6% Al_2O_3	61.01	14.8	15
Al. alloy 1350+12% SiC + 8% Al_2O_3	43.005	3.83	20
Al. alloy 1350+15% SiC + 10% Al_2O_3	49.091	5.78	25

The comparative results of UTS (MPa) for different percentage of particulate reinforcement is as shown in figure 7.

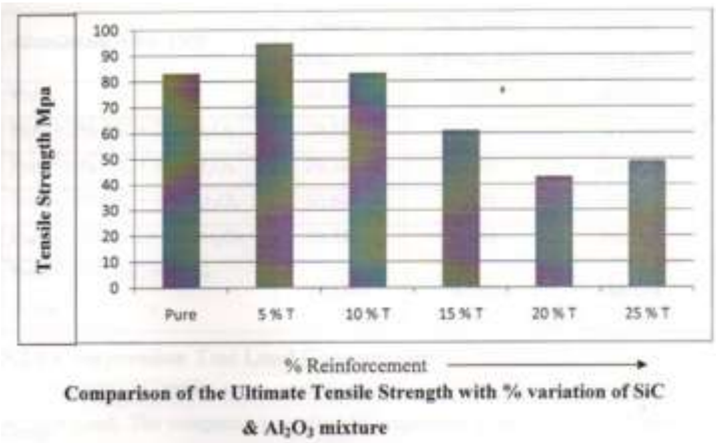

Figure 7. Comparison of Tensile Strength

6.2 Compression Test results

Experimentally obtained compression test for different particulate reinforcement percentage in AMMC is carried out and results are shown in table 3.

Table 3. Tensile Test Results for Different Composition

Al. alloy 1350	Load (KN)	Compressive Strength (N/mm^2)
Pure Al. alloy 1350	30.93	393.81
Al. alloy 1350 + 3% SiC + 2% Al_2O_3	29.18	371.53
Al. alloy 1350 + 6% SiC + 4% Al_2O_3	29.18	371.53
Al. alloy 1350 +	30.64	390.12

9% SiC + 6% Al_2O_3		
Al. alloy 1350 + 12 % SiC + 8% Al_2O_3	30.32	386.04
Al. alloy 1350 + 15% SiC + 10% Al_2O_3	30.33	386.17

The comparative results of compression test for different percentage of particulate reinforcement is as shown in figure 8.

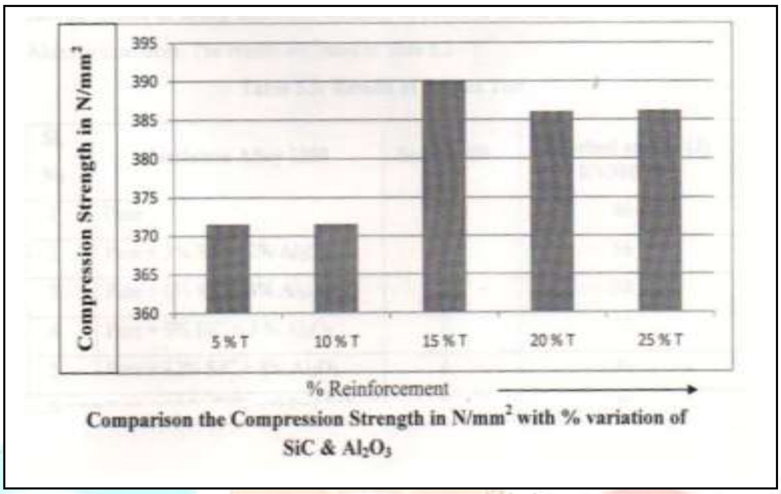

Figure 8. Comparison of Compression Strength

6.3 Impact Test results

Charpy impact test is a standardized high strain rate test which determines the amount of energy absorbed by the material during fracture. Experimentally obtained impact test for different particulate reinforcement percentage in AMMC is carried out and results are shown in table 4.

Table 4. Impact Test Results for Different Composition

Al. alloy 1350	Absorbed energy in Joules
Pure (Al. alloy 1350)	40
Al. alloy 1350 + 3 % SiC + 2% Al2O3	56
Al. alloy 1350 + 6 % SiC +4% Al2O3	38
Al. alloy 1350 + 9 % SiC +6% Al2O3	70
Al. alloy 1350 + 12 % SiC +8% Al2O3	46
Al. alloy 1350 + 15 % SiC +10% Al2O3	70

The comparative results of impact test for different percentage of particulate reinforcement is as shown in figure 9.

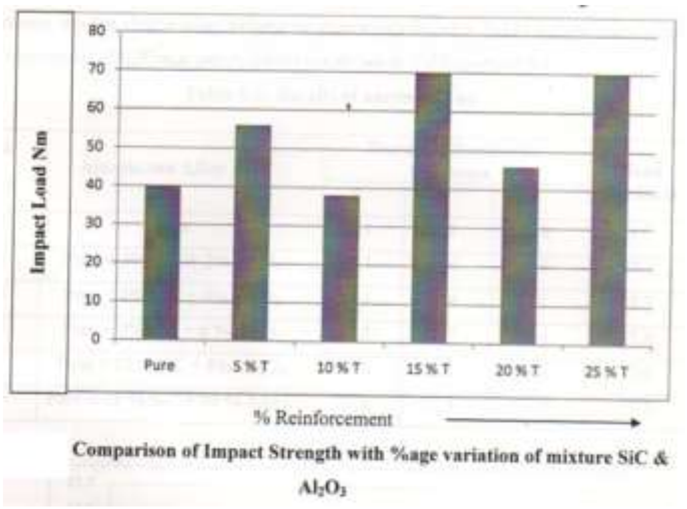

Figure 9. Comparison of Impact Strength

6.4. Hardness Test Results

Experimentally obtained Hardness test for different particulate reinforcement percentage in AMMC is carried out and results are shown in table 5.

Table 5. Hardness Test Results for Different Composition

Al. Alloy 1350	**Rockwell Hardness Number (HRB)**			**Mean hardness**
	1	2	3	
Al. alloy 1350	37.1	37.1	36.8	37
Al. alloy 1350 + 3% SiC + 2% Al_2O_3	37.4	37.4	37.1	37.3
Al. alloy 1350 + 6 % SiC + 4% Al_2O_3	37.4	37.4	37.1	37.3
Al. alloy 1350 + 9 % SiC + 6% Al_2O_3	37.7	37.7	37.4	37.6
Al. alloy 1350 + 12% SiC + 8% Al_2O_3	37.1	37.1	36.8	37
Al. alloy 1350 + 15% SiC + 10 % Al_2O_3	37.4	37.4	37.1	37.3

the result of genetic algorithm [4] for E-glass / Epoxy, HM Carbon/Epoxy and Boron / Epoxy are 44.40 % 11.27% and 14 % respectively. The Figure 11 shows the weight comparison of E-glass/epoxy, HM Carbon/Epoxy and Boron/Epoxy composite drive shafts which shows PSOA results are better than GA results. PSOA usesless number of function evaluations and has better searching capability and more computationally efficient than GA for discrete variables problem.

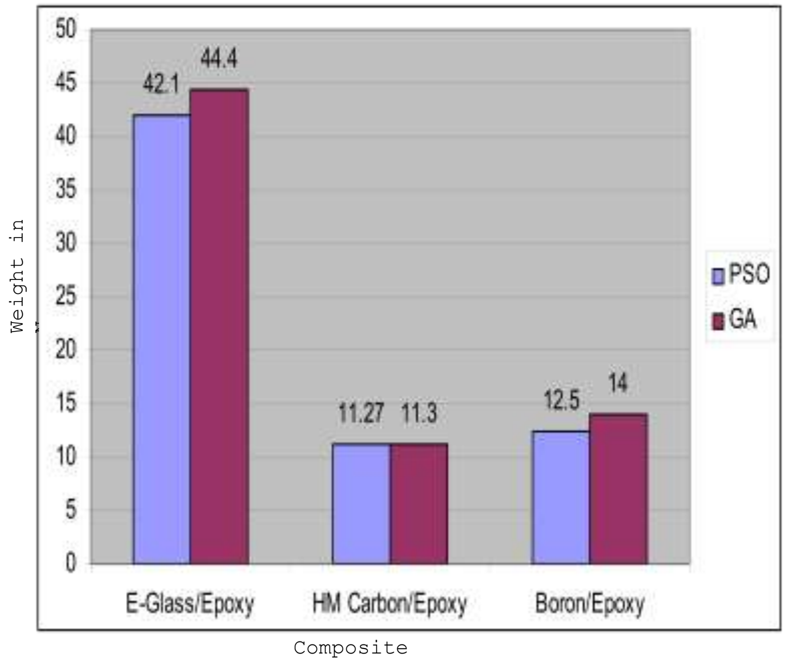

Figure 11 Comparisons of PSA Results with GA results [4]

6. Conclusions

- An optimization procedure is proposed to design a multilayered single piece composite drive shaft for a given torque, speed and length to achieve minimum weight using PSO approach.
- E-glass/Epoxy, HM Carbon/Epoxy and Boron /Epoxy materials are considered for single piece composite drive shaft.
- An optimal stacking sequence is generated using PSOA to minimize the weight to meet the functional and performance requirements.
- The weight savings of three material shafts using PSOA are compared with Genetic Algorithm results and found that the PSA have better results than GA.

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