International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-2, December, 2019

Experimental Research on the Tribological -Mechanical Properties of Al-SiC composites and EN31 Steel

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Abstract: In this research, metal matrix composites was fabricated using stir cast technique. Al 6061 alloy (Matrix) and silicon carbide (Reinforcement) were selected as particles. Tata Ace (mini truck) frame made of EN31 steel considered as a comparative material. Optimal weight % of SiC particles was selected as 30 %. Tensile, impact, hardness tests and tribological behaviour of the fabricated composites and EN31 steel was carried out. The mechanical tests such as tensile, impact and hardness are conducted according to the ASTM standards. The results shows that the fabricated composites had improved properties when compared to EN31 steel.

Keywords : SiC particles, Metal matrix composite, Stir casting, carbon steel EN31.

I. INTRODUCTION

THE Automotive chassis is a skeletal frame on which the components like engine block, axle assemblies, and steering etc, are mounted [1]. Automobile chassis is the structural element which holds the automobile rigid, stiff and unbending. A rigid chassis ensures minimal noise, vibrations and harshness for the entire automobile. The skeleton is the most vital component that invigorates and solidness to the vehicle under stacking conditions [2]. The field of composite materials are broadly characterized into polymer network, metal lattice and clay framework composites. The lattice holds the dominant part "delicate" stage (normally pliable, greater formability and high warm conductivity) to which installed the "hard" fortifications (high solidness and low warm expansion) [3]. The support stage can be utilized in nonstop or spasmodic, orientated or disorientated way as indicated by the application. Aluminum finds wide application in basic material particularly in the aeronautic trade as a result of its light weight property [4-6]. Be that as it may, the low quality and low liquefying point finds troublesome in presenting to significant applications [7-9]. A wide acknowledged technique for taking care of this issue was the utilization of support particles, for example, SiO_2, SiC, B_4C particles, carbon fiber, glass fiber/stubbles or different components or mixes as alloying component [10].

Revised Manuscript Received on December 30, 2019.
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II. MATERIALS AND METHODS

A. Al6061 alloy as matrix material

Composites were manufactured using Al 6010 alloy as shown in Fig.1 used as the matrix and SiC particles as the reinforcement. The physical and mechanical properties of Al 6061 alloy is given in the Table. I & II. Pure Aluminum has greater affinity for oxygen; this results in the creating a very thin but tenacious oxide film which covers the surface when exposed to the atmosphere [11].

Fig. 1. Aluminum alloy (Al 6061)

Table- I: Physical properties of Al 6061

Density lb/in^3	0.0975
Thermal Conductivity, Btu-in/hr-ft^2-°F	1160
Electrical Resistivity, Ω-cm	3.99e-006
Specific Gravity	2.7
Melting Point (Deg F)	1090
Modules of Elasticity in Tension	10
Modules of elasticity in Torsion	3.8

Table-II Mechanical properties of Al 6061

Ultimate Tensile Strength	45,000
Tensile Yield Strength	40,000
Elongation at Break	12%
Hardness, Rockwell B	60
Modules of Elasticity, ksi	10,000

Silicon Carbide is made out of tetrahedral of carbon and silicon particles with solid bonds in the precious stone cross section. Thickness of SiC was 3.1 g/cm^3 and normal molecule size of 20 µm. It is extremely hard and solid material [12]. SiC when heated to 1200 °C, an oxide layer is deposited on the particles and these particles can be operated up to a temperature of 1600 °C. Silicon carbide pottery with next to zero grain limit polluting influences keep up their solidarity to high temperatures, moving toward 1600 °C with no quality misfortune.

Fig. 2. Silicon carbide powder

B. Stir casting of composite

Manufacture strategies influence the microstructure, dispersion of the fortifying materials and interfacial security among network and fortification. During creation it is must to guarantee uniform circulation of the fortification in the network and arrangement of good bond among lattice and strengthening material, to accomplish ideal properties. There are a few manufacture methods, for example, mix cast, press cast [13], diffusive cast, reho cast, vacuum cast and powder metallurgy are accessible for creating MMC's. The creation strategies can be separated into three sorts, for example, (I) strong stage process, (ii) fluid stage procedure and (iii) semi-strong procedure. Among the assortment of assembling forms accessible for spasmodic metal grid composite, mix giving is commonly acknowledged a role as an especially encouraging course, as a result of minimal effort. Lie in its effortlessness, adaptability and materialness to the huge amount generation. Mix cast enables extremely enormous measured parts to be created, and can continue high efficiency rates. The expense of planning composite materials utilizing mix cast technique is around 33 % to one a large portion of that of contending strategies. Fig.3 shows the pictorial chart of the mix cast arrangement.

Fig. 3. Stir Casting Equipment

Obstruction heater with a temperature scope of 3000 °C was utilized to dissolve the grid material. The heater has a temperature controller with k type thermocouple to control and quantify the temperature. An electric engine is fixed at the top edge of the heater to give mixing movement to the stirrer. The speed of the stirrer can be shifted as the arrangement has a speed controller connected to it.

Aluminum compound 6061 is sliced and weighed to get the right weight according to the stoichiometric figurings. The compound is then taken into a pot alongside the Kavaral. The heater is warmed to a temperature of 800 °C and is continually kept up at that temperature all through the procedure. Warming the support particles before scattering into the soften helps their exchange by causing desorption of adsorbed gases from the molecule surface. Silicon carbide particles are warmed to 1000 °C. Preheating of SiC particles expels surface polluting and modifies the surface synthesis by shaping an oxide layer superficially. The expansion of pre-warmed SiC particles in Al soften has been found to improve the wettability property. Kavaral is the creation of Potassium chloride (KCl) + Nitric corrosive (HNO_3), its capacity is to evade oxidation. The prescribed sum that will be included is 250 gm for the matrix melt of 50 kg.

C. Addition of Degasser powder

Degasser powder reduces blow holes formed during the casting process. The reasons for adding degasser powder are as below when magnesium is in the molten state, it tries to absorb hydrogen from the atmosphere. When the absorbed hydrogen is unable to escape from the molten metal, it results in the formation of blow holes. When coverall 65 is added, it forms a thin film over the molten metal and prevents contact of molten metal with the atmosphere. When degasser tablets is added to molten metal, the chlorine present in these tablets react with hydrogen in the molten metal and form hydrochloric acid which dissolves in the molten metal, thereby reducing blow holes.

D. Pouring of matrix melt

The melt is mixed at a speed of 300 rpm for thirty minutes using a mechanical operated stirrer. The mixed metal is then gradually filled the bite the dust which is preheated to a temperature of 973 °C. The pass on is permitted to cool in air for two hours and afterward the example is expelled.

E. Solution Treatment

During throwing low cooling pace of the amalgam takes into consideration the reinforcing of aluminum eliminate to accelerate of arrangement and develop into enormous incongruous stages inside the network. In the as cast structure, the enormous in cognizant nature of the Al-SiC [14] stage does little to build the quality of the compound. To get finely scattered an answer heat treatment ought to be directed on the combination.

F. Composite Preparation

The hardness of arranged composites was expanded by expanding silicon content. Expansion of graphite particles in aluminum network can prompt production of financial composites with improved hardness. These composites can discover application in car like cylinder, cylinder liners and associating bars. These composites can likewise discover application where light-weight materials are required with great hardness and quality [15].

Retrieval Number: B3897129219/2019©BEIESP
DOI: 10.35940/ijeat.B3897.129219
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

III. MECHANICAL PROPERTIES AFTER TESTING

A. Brinell hardness and wear test

Mass hardness estimations were completed on the base metal and fabricated composite specimen by utilizing standard Brinell hardness test machine. Tests utilized for the hardness tests are displayed in Fig 4. The pin-on-disc setup used for wear tests is shown in Fig.5. The test parameters and values are displayed in Table-III.

Fig. 4. Hardness Test Setup

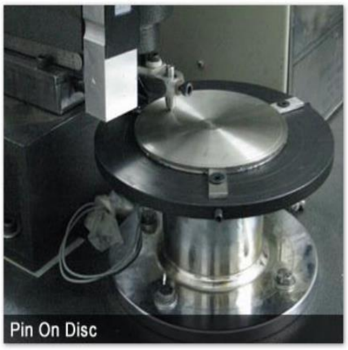


Fig. 5. Wear Test Setup

Table-III: Linear reciprocating setup for both materials

Sl. No	Test parameters	Value
1	Normal force	20 N,40 N
2	Wear track length	12 mm
3	Speed	200 cycles/min
4	Revolutions	2500
5	Pin geometry circular	Φ 6mm
6	Pin material	Al

B. Tensile test

The presence of SiO_2 composition in the Metal Matrix Composite have resulted in a slight increase in the tensile behavior of the composite. The Tensile test setup displayed in Fig. 6 and test values are shown in graph below. It is inferred that the addition of SiO_2 increases the Hardness since the moving dislocation in the Aluminium which usually would favours it being ductile in its pure form has now been occupied by the fine Silicon di-Oxide. On the other hand, the yield point also lowers considerably. It can be observed that the graph after the yield point breaks abruptly at a point lower than it leading to failure if the material. Had it been in its pure form, the Aluminium would have shown higher yield point and be less brittle. Silicon di-Oxide has increased the hardness of the composite which favours its utilization in the heat affected zones of the automotive equipment's.

Fig. 6. Universal testing machine - Tinius Olsen H10KS

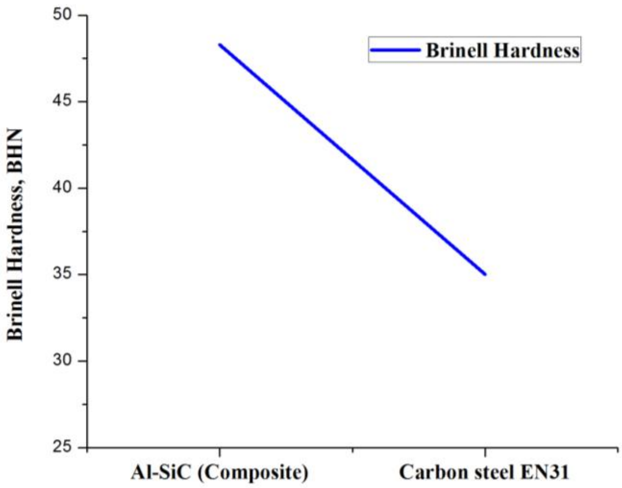
IV. RESULT AND COMPARISON

A. Brinell Hardness

The Hardness Test value comparison between Al-SiC [1] (Composite material) and Carbon steel (Existing material) is tabled and graphed below.

Table-I: IV Hardness test results

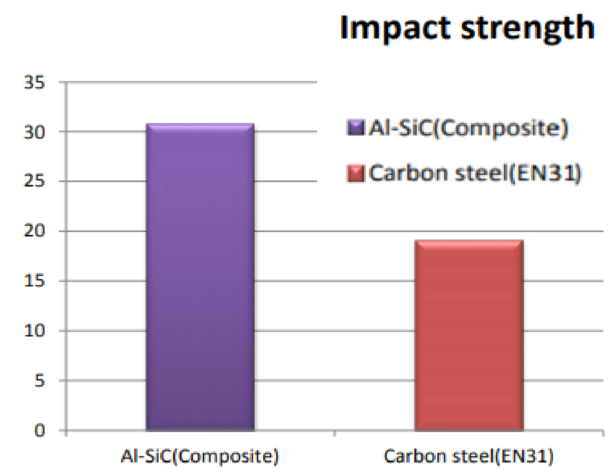
SI. No	Material	Indenter dia in (mm)	Load in kgf	Hardnes s (BHN)
1	Al-SiC[1] (Composite)	Steel sphere 5 mm	100	48.3
2	Carbon steel EN31[2]	Steel sphere 5 mm	100	35



Graph -1 hardness test results

B. Impact strength

The Impact strength value comparison between Al-SiC (Composite material) and Carbon steel.



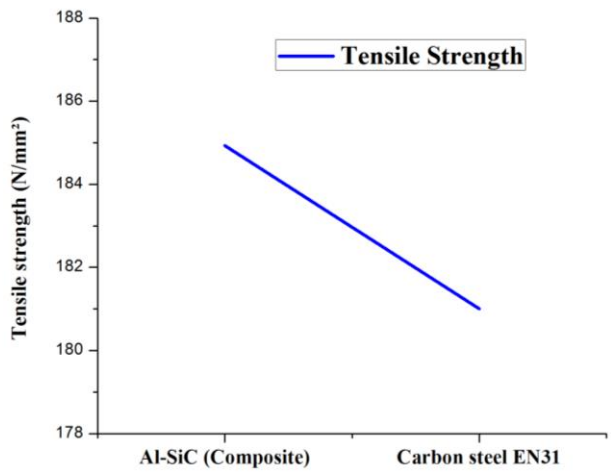
Graph -2 impact strength test results

C. Tensile test

The Tensile test value comparison between Al-SiC (Composite) and Carbon steel (Existing material) is tabled and graphed below.

Table-V: Tensile test results

SI. No	Material	Cross section of area (mm²)	Ultimate load in (KN)	Tensile strength (N/mm²)
1	Al-SiC[1] (Composite)	490.87	13.360	184.93
2	Carbon steel (EN31[2])	490.87	22.5	181



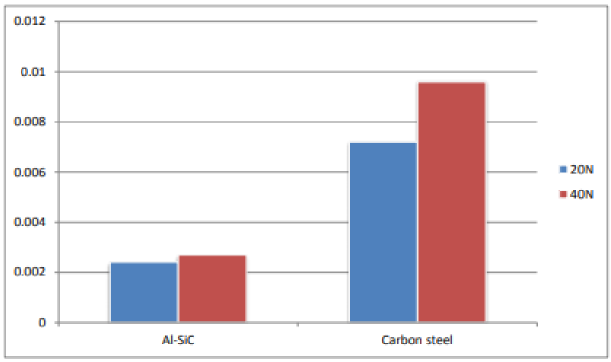
Graph-3 Tensile test results

D. Wear Test

The wear test value comparison between Al-SiC (Composite material) and Carbon steel (Existing material) is tabled and graphed below.

Table-VI: Wear test results

SI. No	Material	Sliding speed (m/s)	Load (N)	Wear rate (mm³/m)
1	Al-SiC[1] (composite)	2	20	0.0024
	Al-SiC[1] (composite)	2	40	0.0027
2	Carbon steel (EN31[2])	2	20	0.0072
	Carbon steel (EN31[2])	2	40	0.0096



Graph -4 Wear test results

V. CONCLUSION

This investigation and analysis of the frame made up Al-SiC is providing better results comparatively. The outcome delineates that the hardness and rigidity of Al-SiC is higher contrasted with EN31.we can utilize aluminum silicon carbide for outline because of its light weight and high quality. In this manner it is a light weight it builds the eco-friendliness of the vehicle than the current carbon steel EN31 material casing.

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