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Mechanical Characterization of Hybrid Aluminium Metal Matrix Composite (*Al 6061 with SiC and B_4C*)

Mechanical Characterization Hybrid Aluminium Metal Matrix Composite (Al 6061 with SiC and B4C)

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Abstract—*The Manufacturing of Lighter metal composites with High strength, Hardness, Stiffness and Wear resistance, The application of particle reinforced metal matrix composites have their unique importance in the field of Aerospace and Automobile. The Mechanical properties of metal matrix enhances with particle reinforcements. The effect of two particles reinforced metal matrix as greater impact than single particle reinforced metal matrix, in acquiring desired material properties. The Aluminium alloys reinforced with particulates got more unique importance in light weight material constructions in the field of Aerospace and automobiles. Also two particle reinforced aluminium alloys got more significant importance to get very desired properties. The combined effect of the particle reinforcements made metal matrix to get desired properties.*

The work is carried out to manufacture Hybrid Aluminium Metal Matrix composite, Aluminium 6061 alloy is reinforced with two carbide particulate reinforcements of 90µm, i,e Silicon carbide and Boron carbide, through Liquid metallurgical process. The combined effect of these two carbide reinforcement particles on mechanical properties is evaluated. Also the individual effect of these two reinforcement particles at different weight percentages is studied. Concentrating towards B_4C particles, it's effect on Aluminium metal matrix is analyzed.

Keywords: *Desired, Unique, Significant, Concentrating.*

1. INTRODUCTION

Manufacturing particulate aluminium matrix composites (PAMCs), based on liquid metallurgical route, because they can be used to produce components by casting processes. The fabrication of PAMCs using casting techniques is very adoptable because it permits a low-cost and easy design fabrication, casting processes to current production process are requisites for flexibility in designing the component is through controlled solidification process[1].

PAMCs applications mainly in manufacturing light weight constructions in the field of automotive, aerospace, because of the high strength and wear resistance that these materials have. In generally, stiffness and strength, two controlled parameter affected by additional reinforcements and obtained properties have their importance. Further the importance given to the hardness and friction characteristics and wear resistance. Due to these supportive properties and characteristics, application of these hybrid materials are vastly distributed, So that development of hybrid materials being well adopted to this field of automotive and aerospace research. Therefore it is necessary to evaluate the mechanical properties of the hybrid composite and characteristics in development process[1].

Concentrating towards wettability of reinforcement particles, the limited drawbacks can be neglected. Though the carbide particles presents, the effect of these carbide particles have made the aluminium metal matrix to stand for the desired mechanical properties. Just pointed towards combined effect and individual effect of each carbide particle reinforcements[1,2].

2. MANUFACTURING OF HYBRID ALUMINIUM METAL MATRIX COMPOSITE"

Manufacturing of a product is a typical example of a group of products coming from Automotive field, which can take advantages of the light weight constructions and high wear resistance of PAMCs along with its strength and hardness[1,2].

Firstly we obtaining a PAMC by stir casting method is done. Two carbide particles, silicon carbide (SiC) and boron carbide (B_4C), is used, it's known indeed, PAMCs based on SiC are largely described in literature, because the easy availability and low cost of SiC carbides[1,2].

The Studies based on the B_4C particles is very rare, though it has positive effect on the aluminium metal matrix. TheB_4C particle, despite of its high wear resistance property, the combined effect is to be noted, which need in developing good wear resistance products applicable in different areas of automotive and aerospace industries[1,2].

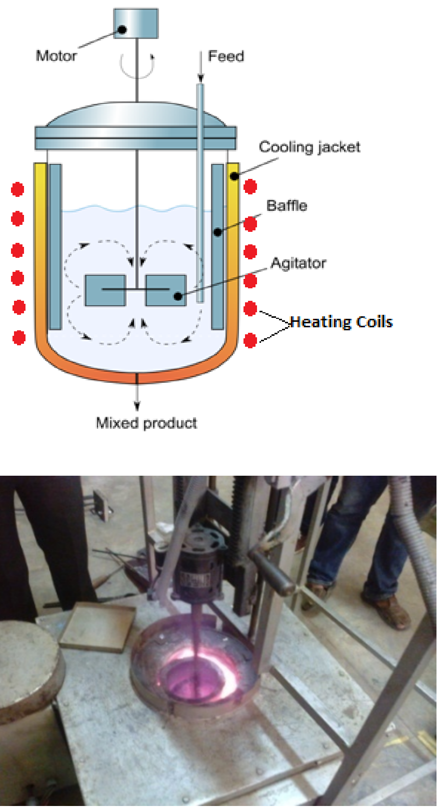

Fig. 1: Stir-Casting Process

The particle distribution of carbide reinforcements and the presence of weak compounds mainly affect the mechanical and wear resistance properties of the component, the reinforcements distribution of SiC or B_4C carbide particles is measured by image analysis technique. Moreover, the developed product on the interface is known by using optical and/or scanning electron microscope. After the process the Hardness test is conducted to check its hardness[1,2,3].

The manufacturing process is done in Liquid metallurgical route i.e Stir casting process. A Known quantity of Al 6061alloy was completely melted to around 825^0C in a graphite crucible with the help of furnace. The molten metal is stirred with the help of mechanical stirrer. About 2 wt.% of SiC is preheated to near 800^0C is added to the molten melt and which is stirred further to disperse the ceramic particles in the medium, further around 4wt.% of B_4C particles preheated to 800^0C is added to this and double stirred with the mechanical stirrer along with 0.25 to 0.40 wt.% of K_2TiF_6.Degassing tablet is added within the intervals to the crucible and slag is removed from the molten melt, Further the molten metal is stirred and carefully poured to the preheated die or to the mould and left to solidify. Further By keeping SiC constant , the addition of B_4C is varied (say up to 8 wt %) the hybrid composite material can be manufactured by repeating above same procedure for different wt.% of SiC and B_4C.

Silicon carbide, in general a transition form non wetting to wetting occurs at high temperature because of dissociation of surface oxides. At higher temperature of particles before dispersion into the molten aluminium aids their transfer by causing oxide formation I,e. SiO .Here the combination effect of both carbide reinforcement particles were determined, Basically Silicon carbide(SiC) along with in addition of Boron carbide(B_4C).Both the reinforcement particles are characterized by high hardness and wear resistance along with good thermal stability[3,4,5].

The main effect of B_4C shows good wet-ability property when combined with molten aluminium alloy, by forming a layer of liquid B_2O_3 on the B_4C particles. Due to its low melting point, B_2O_3 exits above 450^0C as a liquid on the surface of B_4C and enhances wetability through a liquid phase reaction by forming B_2O_3-Al_2O_3 oxide compound. Also small percentage additional K_2TiF_6 to liquid aluminium helps in wetting, which can be found particularly successful. Therefore additional percentage of K_2TiF_6 added during the processing and at the end process a small pinch of Mg , say around 1g to 2g is added[6,7].

Below table shows the tested and used aluminium 6061 alloy chemical composition.

Table 1: Chemical Composition of Al 6061alloy

Element	Wt. % Present
Magnesium (Mg)	0.93
Silicon (Si)	0.41
Iron (Fe)	0.50
Copper (Cu)	0.18
Chromium (Cr)	0.04
Zinc (Zn)	0.20
Titanium (Ti)	0.13
Manganese (Mn)	0.08
Traces	0.05
Aluminium (Al)	95.8 – 98.6

Below table shows the General Properties of Individual Materials I,e. Al 6061alloy(Heat treated) ,SiC and B_4C.

Table 2 : Properties of Individual Materials (Al 6061, SiC and B_4C)

Properties	Al 6061 alloy	SiC	B4C
Density (g/cc)	2.7	3.21	2.52
Hardness(Vicker's)	107(500g)	2800(500g)	3000–3800 (500g)
Ultimate Tensile Strength (MPa)	310	450 - 560	300 - 500
Modulus of Elasticity(GPa)	68.9	430	360 - 460
Melting Point 0C	582 - 852	1370	1763

3. TEST AND ANALYSIS

After manufacturing the Hybrid Aluminium Metal Matrix Composite(HAMMC) firstly micro structure test is done to check the presence and distribution of both the reinforcement particles. Further Tensile test , Compression test , Hardness test(Brinell hardness test) and Wear test(Pin-on-disc Test) is carried out for non heat treated i,e. for as-casted HAMMC for different weight percentage of reinforcement particles of SiC and B_4C.

3.1 Image Analysis

The small pieces of cut specimens as per standard metallograph, were taken and the surfaces are grinding through 400 and 200 mesh size grind wheel, later final mirrored polishing is done to get fine surface finish. Further the specimens are etched by with Keller's reagent , then observed through Nikon Microscope LV150 with Clemex Image Analyser. Later for different wt.% , the PAMCs specimens are observed, and a image at equal Wt.% of SiC and B_4C is as shown in figures,

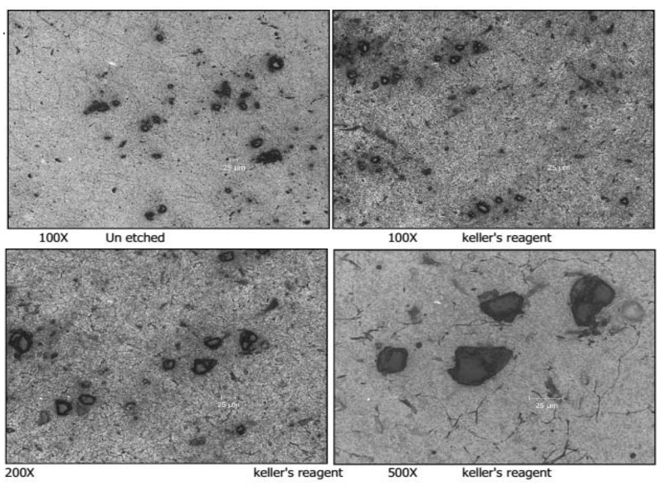

Fig. 2: Microstructure

Microstructure top shows the Un etched and etched(keller's reagent) at 100X and the below shows the etched(keller's reagent) microstructure at 200X and at 500X. Microstructure consists of fine precipitates of alloying elements dispersed along the grain boundary in the matrix of aluminium solid solution. Particles are dispersed in the matrix.

3.2 Hardness test

As per the standard hardness test (Brinell Hardness test) The specimen is prepared and tested through MRB 250 Brinell hardness tester. For different varying wt % of SiC and B4C the hardness is shown in below graph. Maximum BHN is found is 115.02 at equal wt. % of SiC and B_4C.

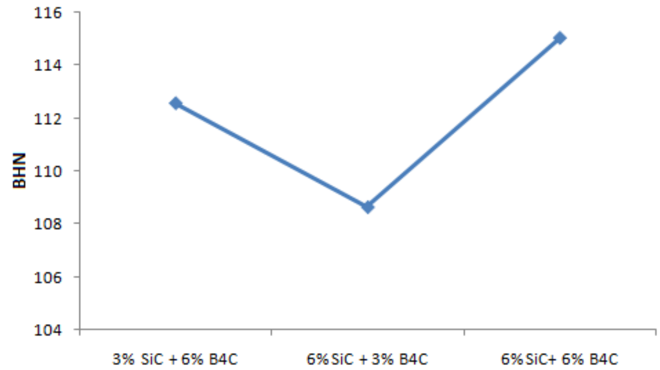

Fig. 3: Brinell hardness number

3.3 Tensile Test

To test for tensile strength, the specimens are prepared as per the ASTM E8M standard.For different Wt. % of reinforcements the specimens are tested. The graphs shows the tensile property of prepared specimens.Below graph shows the tensile ness at 6% SiC and 6%B_4C (!59 N/mm^2)

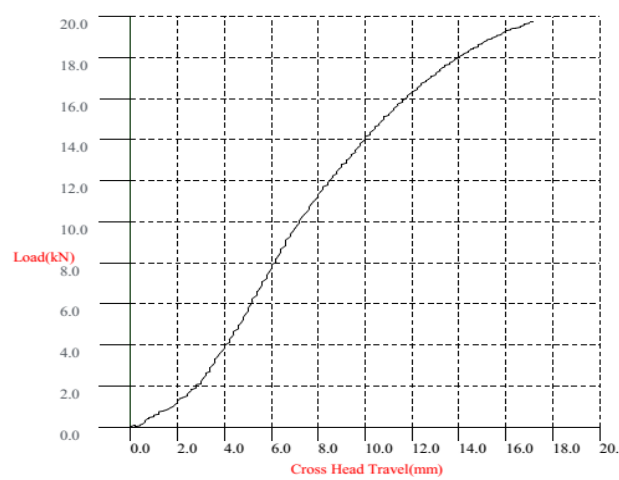

Fig. 4: Tensile ness at equal Wt. %

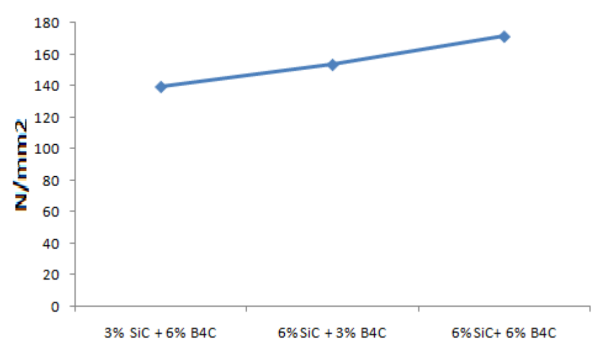

Fig. 5: Tensile strength at different Wt. %

3.4 Compression Test

To test for compressive strength, the specimens are prepared as per the ASTM E9 standard.For different Wt. % of reinforcements the specimens are tested. The graphs shows the comp. strength of prepared specimens.Below graph shows the tensile ness at 6% SiC and 6%B_4C(939.72 N/mm^2)

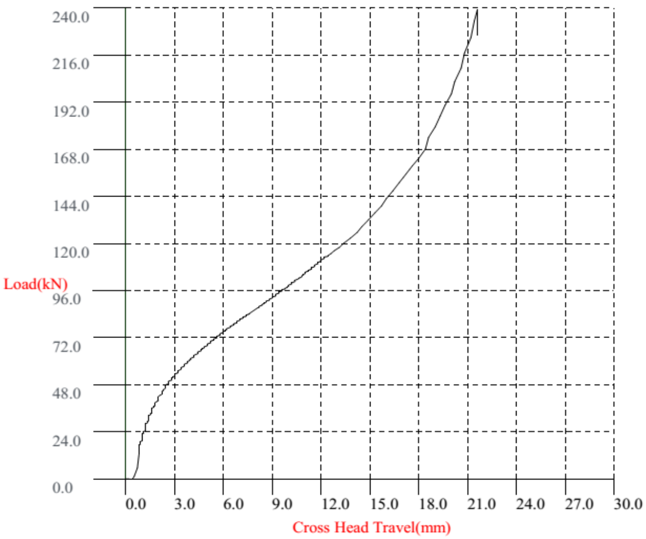

Fig. 6: Comp. Strength at equal wt.%

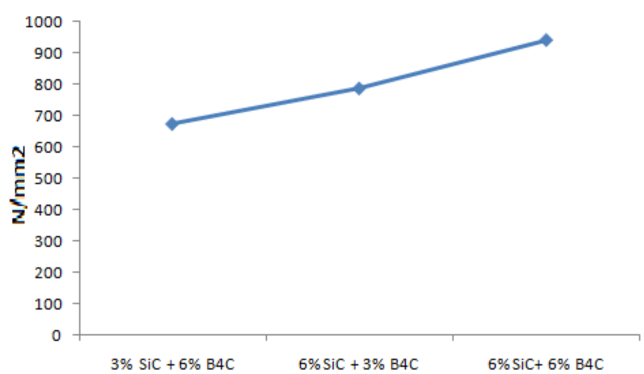

Fig. 7: Comp. strength at different Wt. %

3.5 Wear Test (Pin-on-disc Test)

Wear resistance of the composites sample were measured using Pin-on-Disk Tribology testing. The counterpart was rotated at 600 rpm, corresponding to linear speed of 50 ms^{-1}. The sliding distance was 500 m with a normal 1500 g load applied for Al 6061 alloy along with different wt. % of SiC and B_4C , which is plotted in graph

The effect of B_4C particles is greater effect than the SiC particles, Also when in combination effect the wear rate is less and the HAMMC got increases wear resistance property. Thus the effect of B_4C particles is more.

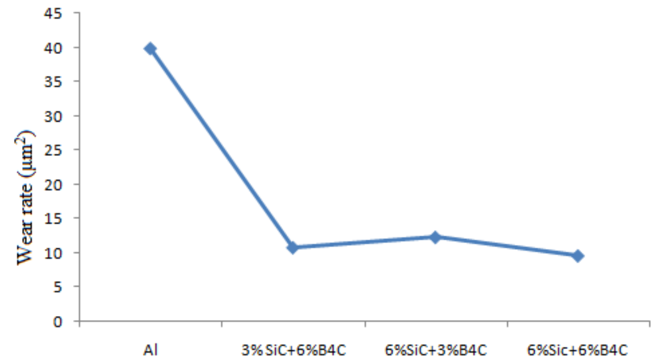

Fig. 8: Wear rate at different wt.%

4. DISCUSSION

From tests it's clears that the effect of B_4C reinforcement particles is more than SiC reinforcement particles in HAMMC. The increased wt. % of the B_4C reinforcement particles made the metal matrix to become brittle, though the britility is normalized by presence of SiC.The combined effect is very much unique support to the overall increased properties of HAMMC.

When seen results of hardness test, the hardness is slightly lowers at wt. % of 6% SiC and 3%B_4C and it maximum at 6% SiC and 6% B_4C.Here it is justified that effect of B_4C is more.

5. CONCLUSION

The Al 6061 alloy with SiC and B4C is developed through Stir casting method, for different Wt.% of reiforcements.From the work following conclusions were drawn

- Hybrid composite is developed sucessfully.
- Microstructure of composite at 6% SiC and 6% B_4C was shown
- Comparing with the hardness result, the Wt.% of B_4C plays very important role,found tobe maximum at 6% SiC and 6% B_4C.
- The further increase in Wt.% of B_4C results in more brittleness of hybrid composite.

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