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Research paper

Study of mechanical and wear characteristics of AL380 composite fabricated by introducing B4C using compo casting method

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Abstract

In the present work, Al380 Al alloy and B4C metal matrix composite was fabricated with different weight fractions (1%,2% and 3%) using compo-casting method. The wear properties of fabricated composite is tested by pin on disc apparatus. On different loads of 30N,60N and 90N the wear tests are performed. The mechanical properties of hardness and tensile strength are performed on brinell's hardness apparatus and Ultimate tensile machine. The study of homogeneous distribution of B4C particles were examined by scanning electron microscope (SEM) in the composites. The result shows that the Al380 Al alloy reinforced with B4C particles, that composite improves the mechanical properties and wear rate. Increasing of wear rate with the increase in B4C particles in composites. Using Opti- cal microscope, the study of worn surfaces of pins were analyzed.

Keywords: *Aluminum; Boron Carbide; Mechanical Properties; Wear Behavior; Compo Casting Method.*

1. Introduction

From the past decades in automobile industries, aerospace, defense academy is concentrated on lightweight materials like Al alloys. Because these Al Alloys having Excellent engineering properties like elevated tensile strength, high hardness, better wear resistance and outstanding thermodynamic strength properties. These properties made a remarkable utilization of alloy in various fields. Because of its low-density Al metal matrix composites are very easy to fabricate [1-4]. In general, the SiC, Al2O3, TiC, MgO, Zr and AIN particles are used as reinforcement with Al matrix composites [5-10]. B4C is a third hardest material, and it is very expensive so very partial research has been conducted [3], [8]. The B4C is a striking reinforcement because of their properties density (2.52 g/cm3), elevated strength, high hardness and supe- rior wear resistance [12]. Vortex method is the best opted method for bonding of particle matrix where uniform distribution is at- tained in the reinforcement [23]. This Al metal matrix product affects mechanical properties so it is fit for restricted conditions. There is a dire need of novel material which possesses high hard- ness, tensile strength and wears resistance, properties that impro- vise the Al metal matrix composites. This is attained by the in- crease of ceramic particles. The accompaniments of a little quanti- ty tiny proportion of B4C of 5% vol. to Al-7Si-1mg, lead to it an increase of ceramic particles in reinforcement increases the wear resistance [18]. Boron carbide having a good impact, wear resis- tance and poor wetting time [21]. To improve the Wetting time by pre-treatment of ceramic particles [24]. During casting, K2TiF6 halide salt is used to improve bonding between Al and B4C ce- ramic particles which results improved mechanical properties in
The tailored composite [25]. In this work, at a temperature of 750oC the reinforcement of Al Alloy and B4C was done by using compo-casting method. During composite preparation, B4C par- ticles are pre-heated up to 1hour before mix and to improve wet- ting time AD flux was added in the Al molten metal. Further, the composites are prepared as per the experimentation.

2. Experimental procedure

The Table 1. Shows the chemical composition of Al380 Aluminium alloy. In this practice, the matrix material is Al380 aluminium alloy and B4C is a ceramic particle are reinforced. Aluminium alloy density is 2.79g/cm3 and B4C density is 2.52g/cm3 were used in this experimentation. In a graphite crucible, the Aluminium alloy is melted at a tem- perature range of 700o – 730oC. The B4C ceramic particles are preheated at a temperature of 450oC for 1hour before pouring into the molten Aluminium matrix metal. The pre- heated B4C particles are poured into the crucible and for homogeneous particle distribution in the molten matrix metal, a continuous stirring operation is done for 4-5 mi- nutes at a speed of 600-700 rpm. The cavities formation in the molten liquid can be avoided by using AD flux as min- imum range of is 0.25 wt% and maximum range of 1.5wt%. At 900oC the whole mixture is preheated before totaling into the molten metal. 250gms of matrix alloy is heated in a graphite crucible at 750oC temperature. Once the necessary
temperature is achieved, AD flux is incorporated to im- prove the wettability and remove the unwanted gasses from the Al matrix molten liquid. The vortex was generated with the aid of stirrer. The spindle is made up of stainless steel rod rotates with 300-400 rpm for 5-10 minutes. To avoid the problem of clog and separation of particles for getting uniform distribution proper stirring should be carried out before and after addition of the mixture. The process para- meters of stir casting are shown in Table 2. As per ASTM E8 standards. The molten metal is poured in Die of length 290 mm,

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diameter 10 mm. The same procedure is imple- mented and cast the composites by varying wt% of 1%, 2%, and 3%.

Table 1: Chemical Composition of A380 Al Alloy

Element	Al	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Traces
%	--	9.5	1.00	4.00	0.50	0.30	--	0.50	2.90	--	0.50

Table 2: Process Parameter of Stir Casting

Parameters	Data
Melting temperature 8000C	
Stirring temperature 700-7300C	
Stirrer speed 600-700 rpm	
Stirring time after reinforce-	20 min mint
Incubation time 3 hrs	

The process parameters of stir casting are exposed in Table 2. With the aid of compocasting, the molten metal was stirred it for a vortex. The combination of B4C and AD flux are added one after another to the vortex at a stable feed rate. The total mixture was added slowly to the vortex to make sure all particles are dispersed throughout the en- tire solution for the period of investigational work. Ad flux is to avoid corrosion of Aluminium alloy. The molten metal of total mixture was poured into a cast mold. By varying weight percentage (1%, 2%, and 3%) of B4C, the specimens are prepared as per ASTM E8 standards. The Aluminium metal matrix composite specimens are cooled at room tem- perature. The Micro structural characterization of the pre- pared specimen can be examined by Scanning Electron Microscope (SEM) with EDS. The hardness test were con- ducted by using brinell's hardness tester under a load of 2N with a dwell time of 10 Sec at different locations on the same specimen. With the aid of a Computerized Universal Testing Machine the tensile strength was examined beneath tension. By using computerized pin-on-disc wear testing apparatus the wear test performed on the specimens under different load conditions (30N,60N, and 90N) with constant sliding distance and speed. The load conditions are shown in Table 3. The wear apparatus was cleaned thoroughly with acetone solution. The worn surfaces are examined by Optical Microscope.

Table 3: Test Conditions

Level	Load (N)	Sliding Speed (m/s)	Sliding Distance (mm)	Time (min)
1	30	5.2	100	45
2	60	5.2	100	45
3	90	5.2	100	45

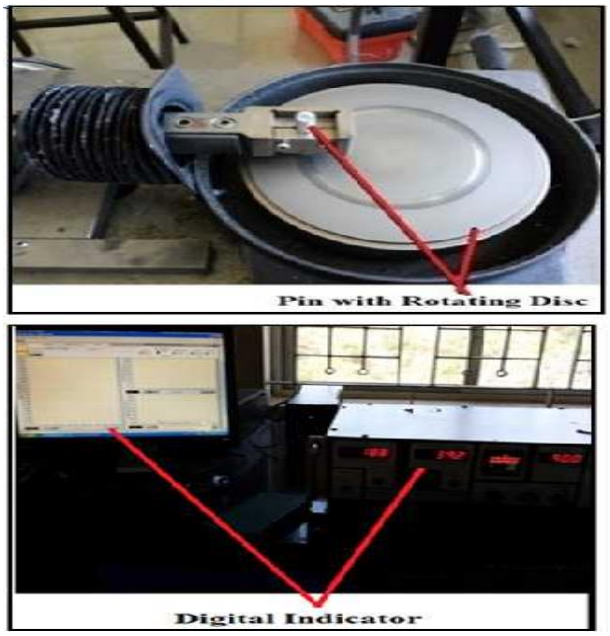


Fig. 1: Pin on Disc Apparatus.

3. Result and discussion

3.1. Evaluation of microstructure

By compo casting method, the reinforcement of Al alloy and B4C are successfully fabricated. Figure.2 a and b shows the Microstructural characterization of fabricated Aluminium metal matrix composite. It observed from
the figure that the B4C particles are uniformly distri- buted in the aluminium matrix it was attained by compo casting. The existence of B4C particles in the corrobora- tion in the matrix is confirmed with Energy Dispersive Spectroscopy.

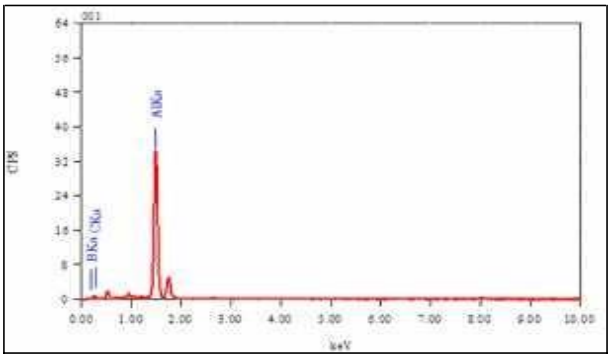


Fig. 2: Optical Micrographs of the As Cast Al Alloy-B4C A) SEM Image of Al- 3 Wtpercentage of B4C B) XRD Pattern of B4C.

3.2. Hardness test results

The Figure.3 shows that the hardness of Aluminium metal matrix composites is increased with the weight percentage of reinforcement. The maximum hardness obtained in the Brinell's hardness for the AMCs is 88 BHN. As compared to the base alloy the hard- ness is increased in the tailored composite. The existence of B4C particles offers better resistance to deformation which leads to increase the hardness of the tailored composites.

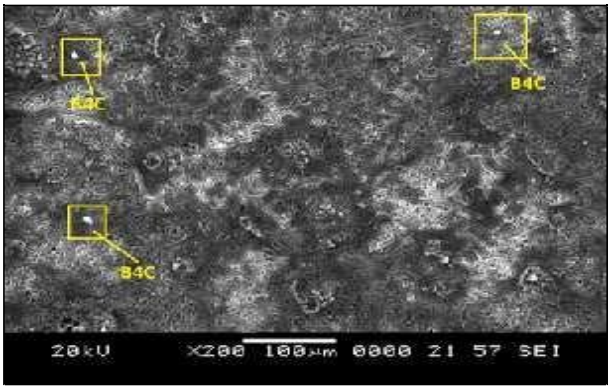
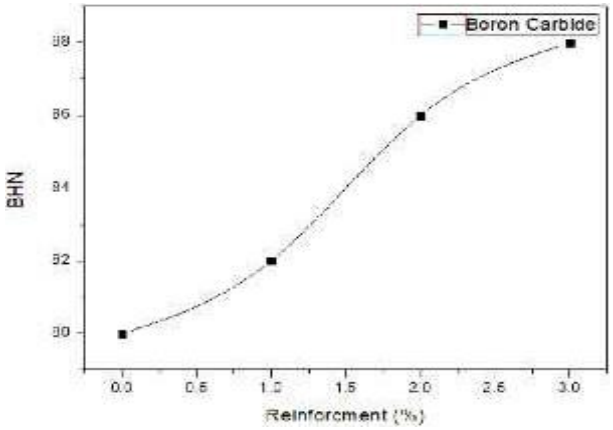
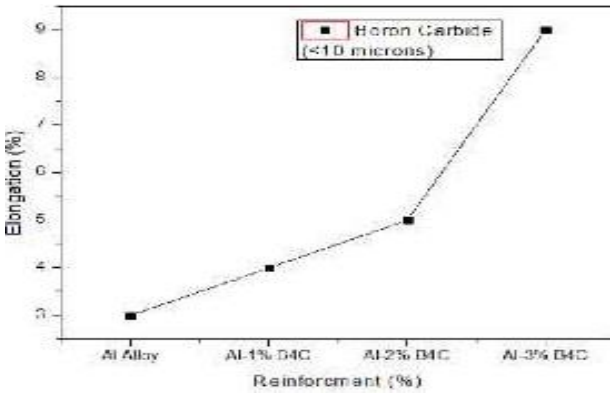


Fig. 3: Hardness of the Cast Al Alloy-B4C with Different WTpercentage.

3.3. Tensile test results

The tensile property was increased in the fabricated metal matrix composite. The Figure.4 shows the tensile strength and Figure.5 shows the elongation of tailored composites of different weight fractions of B4C particles. The improvement of tensile strength is well improved in the composite by incorporating the particles of B4C. while the percentage of B4C is increasing the strength is decreased in the composite. Maximum tensile strength is obtained for Al alloy is 160.16 Mpa and the tensile strength for reinforced composites are found as 132.94 Mpa, 124.91 Mpa and 108.63 Mpa respectively for 1%, 2% and 3% weight percentage of B4C particles. That means the tensile strength decreases because the hardness of composite is increasing





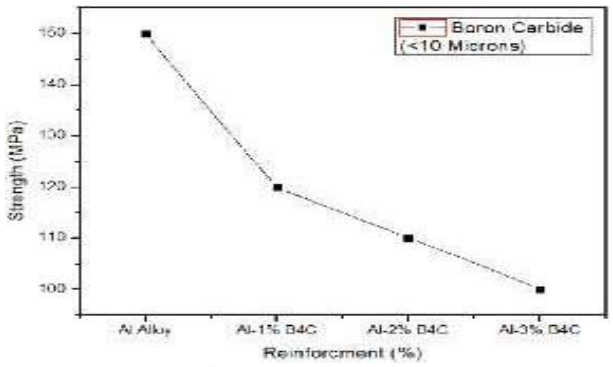
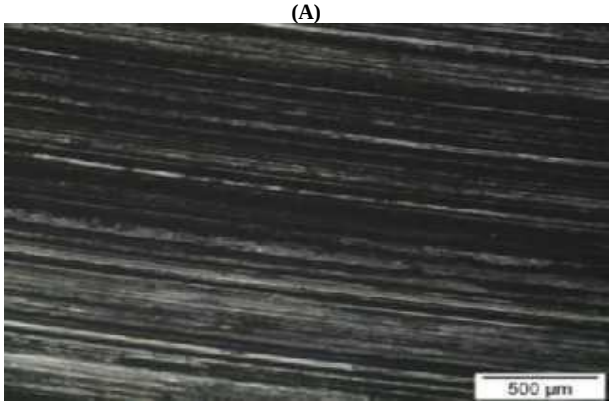


Fig. 4: Tensile Strength of Al+B4C Composites Figure 5: percentage Elon-Gation of Al+B4C Composites.

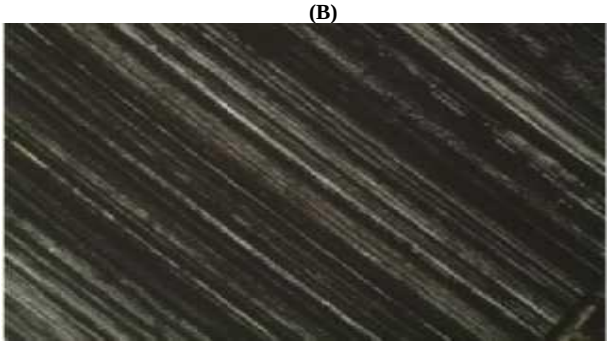
3.4. Wear test results

The analysis of micro structural of composites are analyzed by Optical Microscope at a constant speed (900 rpm) at different loads (30N, 60N and 90N). at different load conditions the wear tracks are obtained in the Optical Microscope. The images are shown in Figure.6 a, b and c.

(A)



(B)



(C)

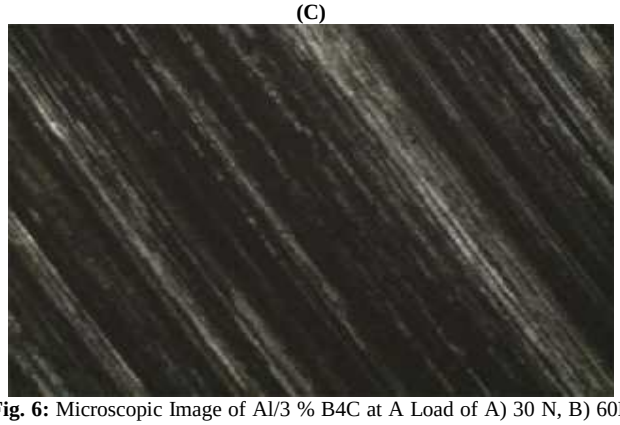


Fig. 6: Microscopic Image of Al/3 % B4C at A Load of A) 30 N, B) 60N and C) 90N.

The wear test samples are prepared as per the ASTM standard. Figure.6 shows the wear rate versus different reinforcement plots at loading conditions of 30N, 60N and 90N. By observing the re- sults the wear rate is increased with the increase of B4C particles. It means the hardness of composite increased by adding of B4C particle in the reinforcement that makes the surface of the compo- site is brittle that results wear rate is increased. The B4C particles are peels out from the specimen when it touches the disc.

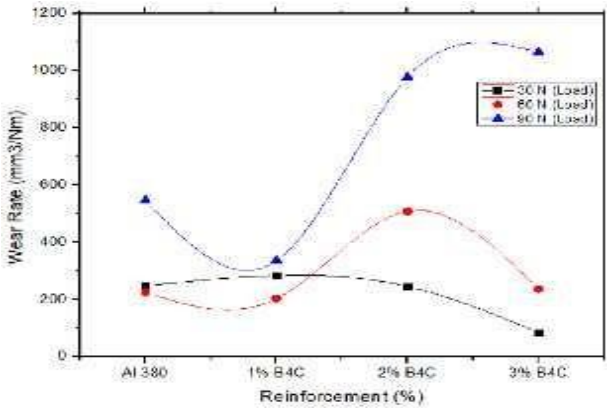


Fig. 7: Varying Load with Al380/B4C.

4. Conclusion

With the particle reinforcement the Al-B4C composites are fab- ricated by compo-casting method and the microstructure, me- chanical and wear properties are evaluated. From the study, the following are concluded.

- Successfully metal matrix composites (Al380-B4C) were fabricated.
- SEM with EDS studies homogeneous dispersion of B4C in the composite.
- The maximum hardness is found in 3 wt% of B4C parti- cles present in AMMC's was obtained by using Brinell's hardness tester.

The tensile strength of AMMC's was found to be maxi- mum for the base material Al380.

- The wear properties are also improved

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