International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

Characterization of Aluminium-7075 Reinforced with Boron Carbide (B4C) Synthesized by Stir Casting.

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***Abstract*— The paper is the result of investigations made on microstructure and mechanical behavior of Al7075 and Al7075-4% B4C. The microstructure of the composites was examined by scanning electron microscopy. Further, mechanical behavior of composites was studied. Tensile properties like hardness, ultimate tensile strength; yield strength were evaluated as per ASTM standards. Microstructural observation revealed uniform distribution of reinforcement particles in the matrix. The analysis disclosed hardness, ultimate tensile strength, and yield strength of composites increased due to addition of reinforcements.**

Keywords—Composites, Al-7075, B4C, Microstructure, Tribological Behaviour.

INTRODUCTION

The application of modern higher properties materials in the aerospace sector and automobile companies have progressed to the gradual improvement of MMCs. In a MMCs consists of Metal or alloy as a matrix material and reinforcements such as ceramics. Composites are heterogeneous at microscopic level and homogenous at macroscopic level.

The main outcome of composites is for a good design it exhibits the class qualities of their components. Composites are available naturally as well as man-made also some of the naturally available composites include wood, here lignin is the matrix which is reinforced with cellulose fibers and also human body is also composed of composites where bone-salt of calcium with phosphate ions reinforce soft collagen.

Al-7075 is alloy, which contains zinc as their major alloying element, and is combined with silicon and magnesium. Aluminum alloys got highest strength in comparison with other alloys. As these are wrought alloys secondary machining is possible. When further heat treatment is done it has highest mechanical strength.

EXPERIMENTAL WORK

Materials

Al-7075 is an alloy with zinc as the primary alloying element. It has good strength comparable to many sheets of steel and average machinability but has high resistance to corrosion than many other aluminium alloys. It's relatively high-cost limits and used in applications where cheaper alloys are not suitable.

Element	Content (%)
Aluminum, Al	90
Zinc, Zn	5.6
Magnesium, Mg	2.5
Copper, Cu	1.6
Chromium, Cr	0.23

The Chemical Formula of **Boron carbide is B_4C** and it falls under third hard material category. First and second are diamond followed by cubic boron nitride. It is the reaction of carbon with boron triozide. Because of unique characterization and also combined properties that make it be used widely in the engineering application.

PREPARATION OF ALUMINIUM ALLOY COMPOSITES

- The stir casting method was used develop the reinforcement metal matrix composites with the temperature of stir casting furnace was maintained at 900^0C. Boron Carbide (B4C) has put into the crucible and the furnace is closed. After twenty minutes, the metals were verified for their molten state and after the confirmation, the metals such as boron carbide and graphite were put inside and the furnace was closed. After 15 to 20 minutes, the boron carbide and graphite was added and the aluminium stirrer was set to 550 rpm, it oscillates by about 700 rpm. After the stirrer is rotated for about five minutes, the stirrer was stopped and the molten metal was taken out. It was kept in cooling nature for about two hours.c field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

Base Material	B4C (%)	Stir Speed (rpm)	Stir Time (mins)	Pouring Temp. (C)	Preheated Temp. (C)
Al-7075	4	550	5	900	350

TESTING OF COMPOSITES

Microstructure study has been carried out on the prepared composite using Vegas Tescan made scanning electron microscope. Basically the test samples of 10-12mm in diameter are cut from the prepared castings using lathe machine and are polished thoroughly as already mention methods it is etched using reagent for better results. The polished specimens which looks like mirror. The specimens are characterized for various magnifications (100X, 200X, 800X) to indicate distribution of reinforcements in metal

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matrix. The microstructures of samples i.e. as cast, 4 wt% B_4C are also examined.

Tensile test specimens were machined from the cast samples. The tensile specimens of circular cross section with a diameter of 9 mm and gauge length of 45mm were prepared according to the ASTM E8 standard testing procedure using Instron made Universal Testing Machine. All the tests were conducted in a displacement control mode at a rate of 0.1 mm/min. Multiple tests were conducted and the best results were averaged. Various tensile properties like ultimate tensile strength, yield strength and percentage elongation were evaluated for as cast Aluminium alloy. Figure 1 showing the tensile test specimen dimensions used to conduct the experiments.

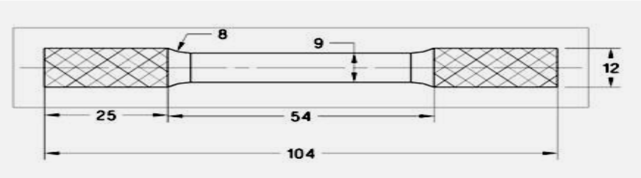
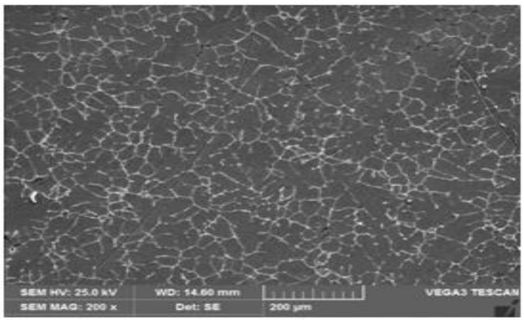


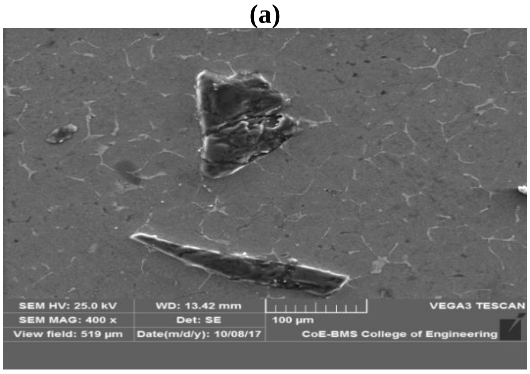
Figure 1: Tensile specimen and its dimensions in mm

RESULTS AND DISCUSSION

Microstructure Study



(a)



(b)

Figure 2: a-b Showing the Scanning Electron Microscope image of Al-7075alloy(a) and 4%B_4C(b)

Figure 2 (a-b) shows the SEM microphotographs of Aluminium alloy as cast and Aluminium with 4 wt. % B_4C particulate composites. This reveals the uniform distribution of reinforcement and very low agglomeration and segregation of particles, and porosity.

Fig. 2 b clearly shows and even distribution of B_4C in the Aluminium alloy matrix. There is no evidence of casting defects such as porosity, shrinkages, slag inclusion and cracks which is indicative of sound castings. In this, wetting effect between particles and molten Aluminium alloy matrix also retards the movement of the reinforcement, thus, the particles can remain suspended for a long time in the melt leading to uniform distribution.

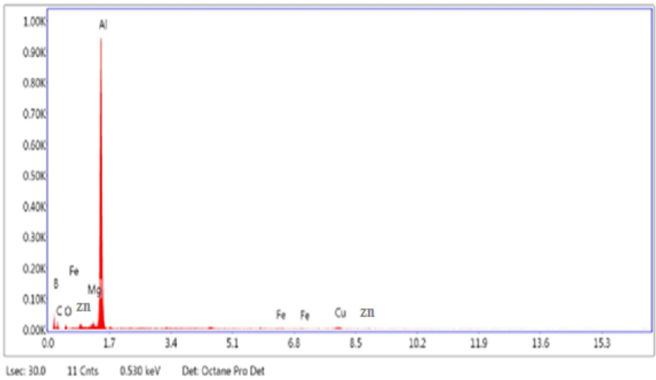


Figure 3: showing the EDS spectrum of Aluminium ally composites

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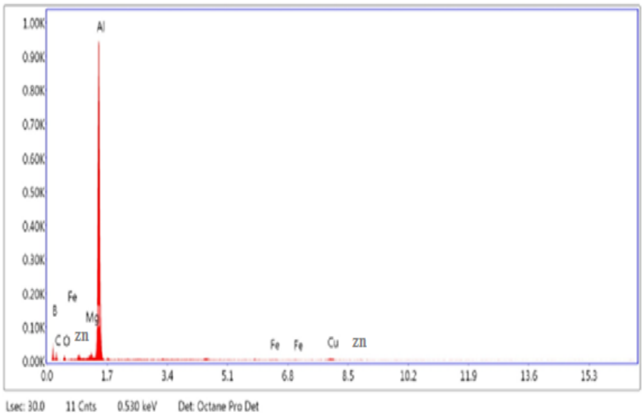

Figure 3: showing the EDS spectrum of Aluminium -4wt. % of B_4C composites

In order to confirm the presence of B_4C energy dispersive spectroscope analysis was carried out at the edge of the reinforcement particle and Aluminium alloy matrix. The EDS spectrum reveals the presence of Al, Zn, Cu and Mg in the interface reaction layer (fig. 3).

TENSILE PROPERTIES

After the test is completed the results are taken on an average and mentioned. We see that the values are increasing as we add the reinforcements to the aluminium alloy. We achieve a maximum yield stress of 196.46MPa for Al7075 with B_4C.

We can easily make out the difference that upon addition of reinforcements there is gradual increase in trend for yield strength. This is because reinforcements act as obstacles to the moment of dislocations and also upon adding the Graphite into molten metal it increases the elongation properties there by yielding more which in turn yield strength increased.

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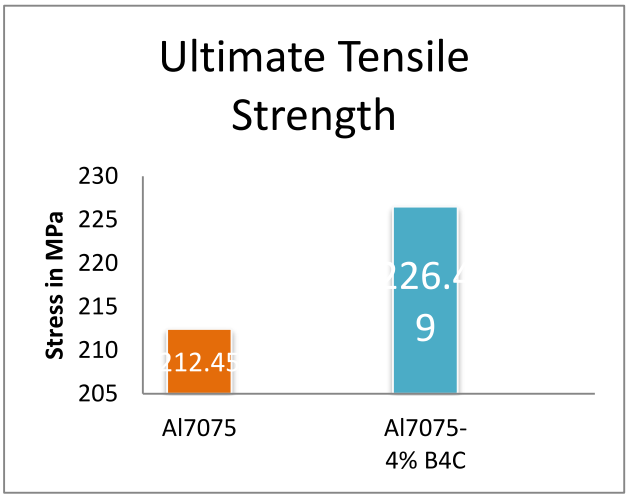


Figure 4a: Ultimate tensile strength of Aluminium alloy composites.

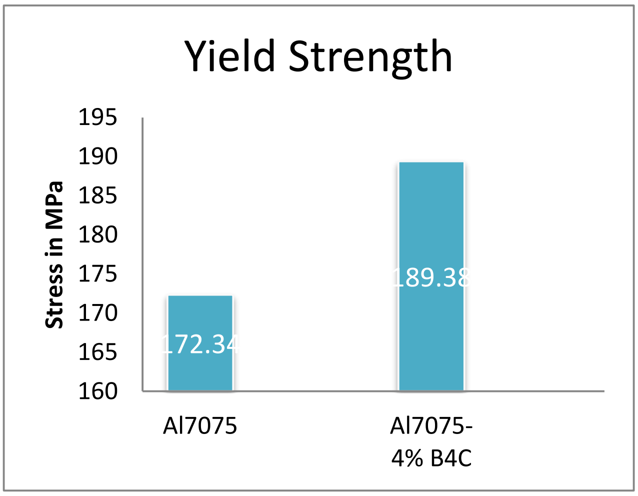
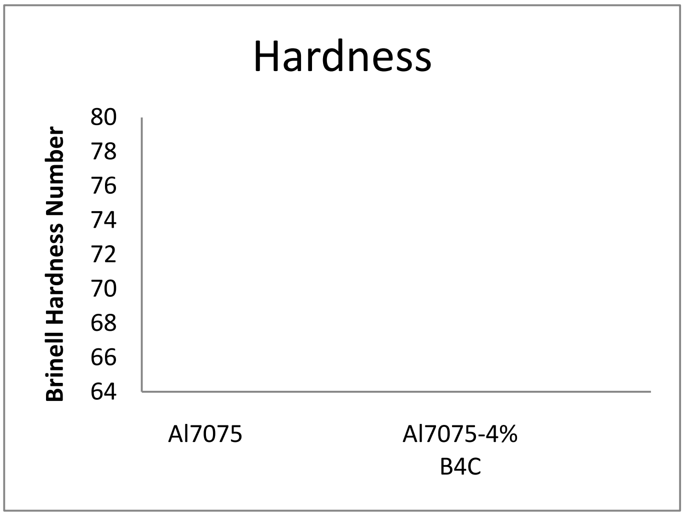


Figure 4b: Yield strength of Aluminium alloy composites

HARDNESS STUDY

The Brinell hardness test on all compositions was conducted using steel ball indenter at an applied load of 60kgf for time of 10 seconds to each sample at different locations. We can see that the hardness values are greater than that of its aluminium alloy. It is clear that hardness values are decreasing due to graphite contenting the alloy. Drop of hardness values due to softness of the graphite, which is soft do not contribute for hardness of the composite as they won't act as barriers for the dislocations moment within the matrix but Boron Carbides does contrary; since B_4C particles which are ceramics having much higher hardness than the base matrix, they obstruct dislocations. The observations made are consistent Increased in the hardness of composites reinforced with B_4C has been reported by several workers.



CONCLUSIONS

The mechanical investigations of the Aluminium alloy composites materials produced by stir casting are remarked as below:

- The liquid metallurgy technique was successfully adopted in the preparation of Aluminium alloy composites.
- The microstructural studies revealed the uniform distribution of the B_4C particulate in the Aluminium alloy matrix.
- The ultimate tensile strength and yield strength properties of the composites found to be higher than that of base matrix.
- Improvements in hardness of the Aluminium alloy matrix were obtained with the addition of B_4C particulate.

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