Investigation of Mechanical Properties on Newly Formulated Hybrid Composite Aluminium 8011 Reinforced With B4C and Al2O3 by Stir Casting Method

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Abstract— Metal matrix composite (MMC) focuses primarily on improved specific strength, high temperature and wear resistance application. From the collected literature it is found that, metal matrix composite are under serious consideration as potential candidate materials and it is mainly used to replace conventional materials in aerospace and automotive applications. So, the MMC are highly used in automotive and space applications. And the aluminium matrix composite is a material with two constituent parts, one being a metal and other being reinforcement. The aluminium matrix can be strengthened by reinforcing with hard ceramic particles like SiC, Al2O3, B4C etc. In this project, Aluminium 8011 alloy is chosen as one of constituent parts, which has good mechanical properties and exhibits good weldability. The mechanical properties like tensile strength, compression strength and hardness can be increased by reinforcing Al 8011 matrix with boron carbide (B4C) and aluminium oxide (Al2O3) particles. In this project, the fabrication of aluminium 8011 with boron carbide and aluminium oxide is done by stir casting process, which is a liquid state material fabrication and cost effective method. Characterization test were conducted on Aluminium 8011 alloy to study the change in tensile, compression and hardness properties of alloy.

Key words: Aluminium 8011, hybrid composite, boron carbide, aluminium oxide, stir casting

I. INTRODUCTION

The metal matrix composites (MMCs), like all other composites consist of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. For many researches the term MMCs is often equated with the term light metal matrix composites. Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. Aluminum matrix composites (AMCs) are the competent material in the industrial world. Due to its excellent mechanical properties, it is widely used in aerospace, automobiles, marine etc. The aluminum matrix is getting strengthened when it is reinforced with the hard ceramic particles like SiC, Al2O3, and B4C etc. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze to manufacture wear resistance parts. MMCs reinforced with particles tend to offer enhancement of properties processed by conventional routes. 8011 Al is widely used in numerous engineering applications including transport and construction where superior mechanical properties such as tensile strength, hardness etc., are essentially required.

8011Al is quite a popular choice as a matrix material to prepare MMCs owing to its better formability characteristics. Among different kinds of the recently developed composites, particle reinforced metal matrix composites and in particular aluminium base materials have already emerged as candidates for industrial applications. Boron Carbide and aluminium oxide particulate reinforced aluminium composites possess a unique combination of high specific strength, high elastic modulus, good wear resistance and good thermal stability than the corresponding non-reinforced matrix alloy system.

II. EXPERIMENTAL DETAILS

The fabrication of aluminium 8011-B4C-Al2O3 compositions are used in this study and it was carried by stir casting method. In this, firstly the Al 8011 in the form of sheet is cut into small pieces and placed in a SiC graphite crucible. Then it is heated in muffle furnace to the desired temperature of 850oC. Before the Al is melted, the B4C micro powder is heated in another crucible to the temperature of 250oC to remove moisture. Aluminium oxide micro powder is sieved for second reinforcement. Then the particulates were mixed into the molten metal. The molten metal was covered with a degassing agent and with the flux to improve the quality of casting and to increase the casting speed of the aluminium 8011. The mixture was stirred by a mechanical stirrer for 5-10 min at a speed of 60 rpm. The temperature of the furnace remains constant at 850oC during the addition of reinforcement particles.

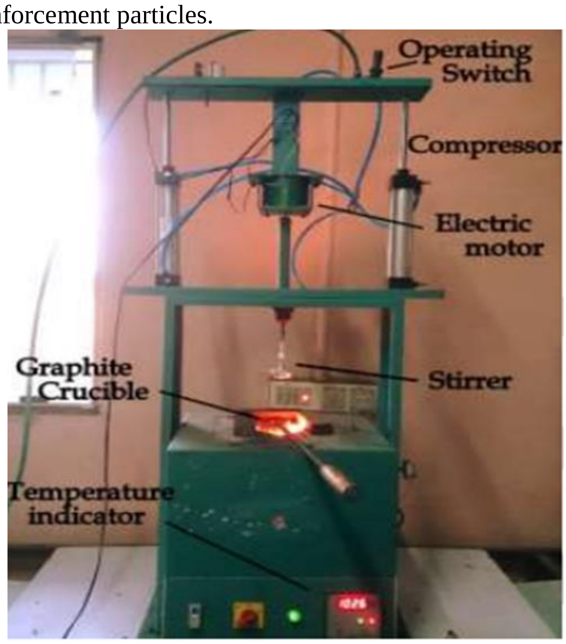

Fig. 1: Stir Casting setup for fabrication of (Al8011/ B4C/ Al2O3)

Then the molten aluminium metal matrix is poured in the preheated die for the preparation of specimen according to the ASTM standard. Same procedure is followed to fabricate remaining five samples.

Sl No.	Parameters	Units	Values
1.	Temperature of Melt	ºC	850
2.	Preheated temperature of B4C Particle	ºC	250
3.	Preheated temperature of die	ºC	400
4.	Spindle Speed	rpm	60
5.	Stirring time	min	10-15
6.	Powder feed rate	g/s	0.8-0.2

Table 1: Process Parameters Used For Stir Casting

III. COMPOSITION FOR FABRICATION OF SAMPLES

In this present study the first sample were prepared by 100% of Al8011 and then the remaining samples were prepared by gradually increasing the weight percentage of B4C and Al2o3 on Al 8011. The following tables shows the full details about the composition of AMCs.

Sample	Aluminium8011		B_4C		Al_2O_3	
	%	gm	%	gm	%	gm
1	100	383	0	0	0	0
2	98	375	1	3.8	1	3.8
3	96	369	2	7.7	2	7.7
4	94	362	3	11.5	3	11.5
5	92	357	4	15.5	4	15.5
6	90	349	5	19.5	5	19.5

Table 2: Composition Table

IV. PREPARATION OF CASTING DIE

The die preparation is the important thing during manufacturing of samples. Initially the die cleaned by using emery papers without damaging the size of ASTM standard in order to remove the rust and already prepared casted sample particle. And the clamped it with two clamps and then place the die on the flat surface. Finally pour the molten AMC on it.

Fig. 2: Cast iron die

V. TESTS PERFORMED

1) Tensile Test
2) Compression Test
3) Micro Hardness Test

Before initializing the testing, the samples were machined to the particular size according to the ASTM standards.

Fig. 3: Manufactured samples

A. *Tensile test:*

The ultimate tensile strength of various compositions was measured using 5 ton capacity servo hydraulic universal testing machine. Testing of the specimens was in the parallel direction of the applied load. In a stress- strain graph the initial portion of the curve is a straight line and it represents the proportionality of varying stress to strain values according to Hooke's law. When the load is increased continuously, in which the stress of the composite is no more proportional to the strain of the following composite. UTS is the maximum stress that a specimen can bear before its fracture due to the load and its original area. All the tests were conducted according to the ASTM E8-82 standards. The tensile specimens of diameter 16 mm and gauge length 100 mm were prepared by Stir Casting method. Six specimens were tested and the average values of the ultimate tensile strength and Elongation were measured.

Fig. 4: Sample for tensile test

B. *Compression test:*

Compression test was carried out using a standard 5 ton capacity universal testing machine. Compression tests were conducted on specimens of 15 mm diameter and 60 mm length machined from the casted composites, by applying the loads gradually; the corresponding strains of the following composite were measured until failure of the specimen. The tests were made according to ASTM E9 at room temperature.

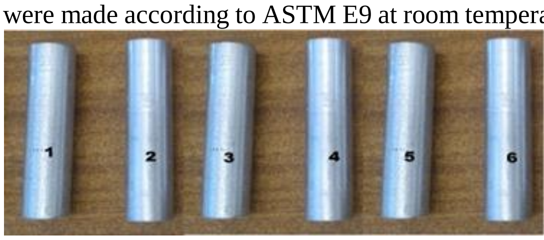

Fig. 5: Sample for compression test

C. *Hardness test:*

Hardness test were conducted to find the resistance of plastic deformation of the composites under static or dynamic loads. The micro Vickers Hardness test is used in this present study to examine the hardness of the specimen. In this test the ball indenter of 0.5mm diameter is made to be tested by applying a load of 0.5 Kg for 20 seconds for each specimen. The averages of four varying positions of the specimen were considered as the highest hardness number.

VI. Result and Discussion

Percentage Composition	Tensile Strength (Mpa)	Vickers hardness (HV)	Compression Strength (Mpa)
100% Al + 0%B_4C + 0% Al_2O_3	181.76	52.48	169.52
98 % Al + 1% B_4C + 1% Al_2O_3	183.73	54.91	173.56
96 % Al + 2% B_4C + 2% Al_2O_3	142.39	60.52	179.25
94 % Al + 3% B_4C + 3% Al_2O_3	249.87	63.45	184.65
92 % Al + 4% B_4C + 4% Al_2O_3	269.85	65.55	188.47
90 % Al + 5% B_4C + 5% Al_2O_3	288.24	69.24	194.15

Table 3: Mechanical Properties of Al 8011 with B4c and Al2o3 Composite

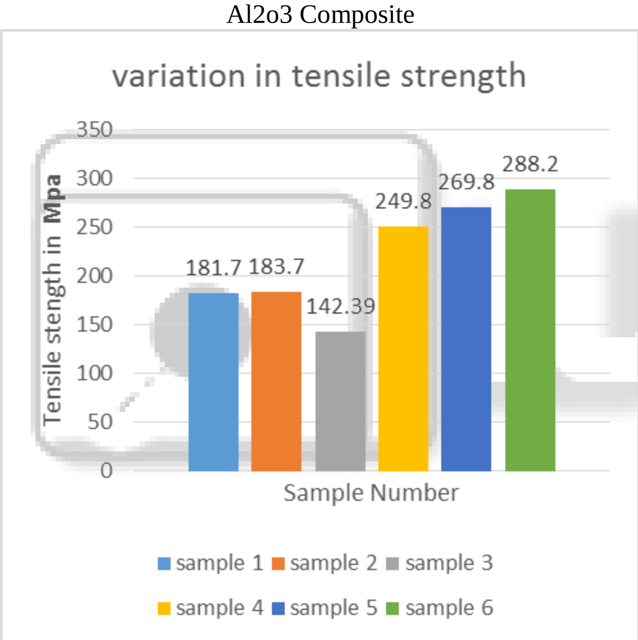

Fig. 6: Graph shows the variation in tensile strength from 1-5% of B4C and 1-5% Al2O3

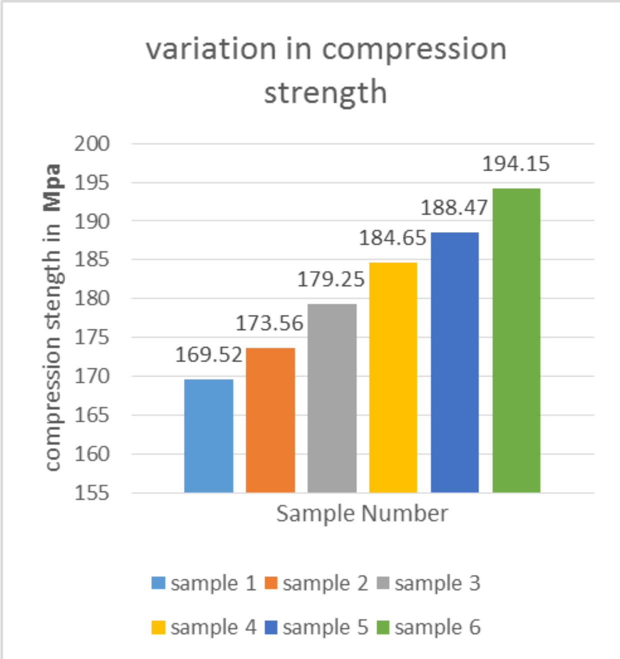

Fig. 7: Graph shows the variation in compression strength from 1-5% of B4C and 1-5% Al2O3

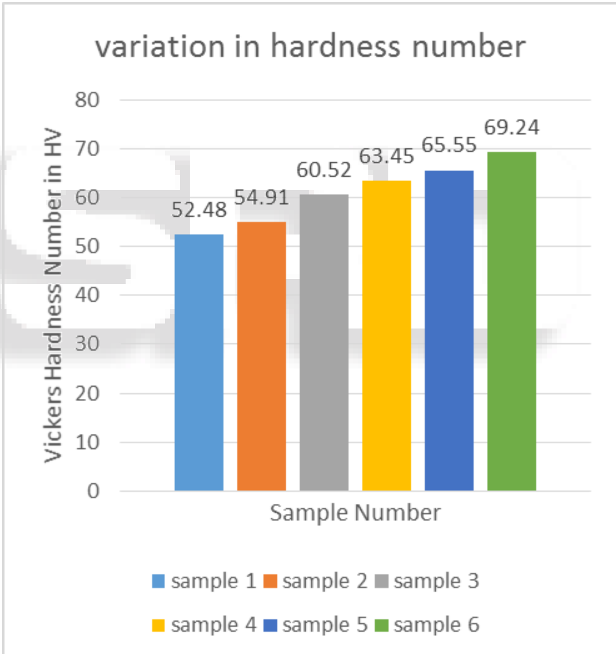

Fig. 8: Graph shows the variation in hardness number from 1-5% of B4C and 1-5% Al2O3

It has been observed that at 90% Al + 5%B4C + 5% Al2O3, there is a considerable increased values in almost all the mechanical properties of the hybrid composite.

VII. Conclusion

The Al8011- B4C-Al2O3 hybrid composites produced by the stir cast method with different weight percentages of reinforcement and the mechanical properties were evaluated. The conclusions from the study are as follows:

- Fabrication of Al- B4C-Al2O3 was much easier and successful by the stir casting method.
- The increase of the wt. % of reinforcement of the B4C and Al2O3 in the stir casting method has led to the increase of the microhardness of the AMCs.

- The tensile strength and compression strength of Aluminum metal matrix composite was found to be on the increase with increasing wt% percentage of reinforcement.
- The composite 90% Al + 5% B4C + 5% Al2O3 have greater mechanical properties compared to the other five composition samples. Decrease in the tensile strength of the sample 3(96% Al + 2% B4C + 2% Al2O3) compared to sample 2(98% Al + 1% B4C + 1% Al2O3) due to a little porous formation on the sample during manufacturing.

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