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Fabrication and Analysis of Al7075 Based on Hybrid Composites

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ABSTRACT

Now a day's there will be rapid increase in the utilization of aluminum alloys, particularly in the automobile industries, due to low weight, density, and coefficient of thermal expansion, and high strength, wear resistance. Among the materials of tribological importance, Aluminum metal matrix composites have received extensive attention for practical as well as fundamental reasons. Aluminum alloys and aluminum-based metal matrix composites have found applications in the manufacture of various automotive engine components.

In our study, a stir casting process is used to fabricate aluminum composites reinforced with various volume fractions of B_4C (1, 2, 3wt %) with a mesh size of 150µm and Al_2O_3 (1wt %) of mesh size 150µm particulates. Mechanical properties of unreinforced and Alx%B_4C1%Al_2O_3(x=1, 2, 3wt %) reinforced hybrid composites were examined. Optical microscope is used to study the micro structural characterization of the composites. It is observed that the hardness and compressive strength of the hybrid composite increased and also wear rate decreases as increasing the reinforcement volume fraction. Finite element analysis is done and it will nearly match the experimental values. It is observed that compare to that of base aluminum alloy, the casted composite gives the better mechanical properties and 3%B_4C1%Al_2O_3 is the best.

Keywords – Hybrid composites, Stir casting, Compression and Wear rate, FEA.

I. INTRODUCTION

A composite material is defined as a structural material created synthetically or artificially by combining two or more materials having dissimilar characteristics. The constituents are combined at macroscopic level and are not soluble in each other. One constituent is called as Matrix phase and the other is called Reinforcing phase. Reinforcing phase is embedded in the matrix to give the desired characteristics. Reinforcing phase: fibers, flakes, particulates, whiskers etc.

Matrix phase: continuous phase two operations.

Hybrid composites are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber. The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies.

II. OBJECTIVES

The goals of the proposed work are to:

- Investigation of the trobological behavior.
- Investigation of compression and tensile strength, hardness, brief microstructure analysis.
- Compare the FEA results with experimental results.

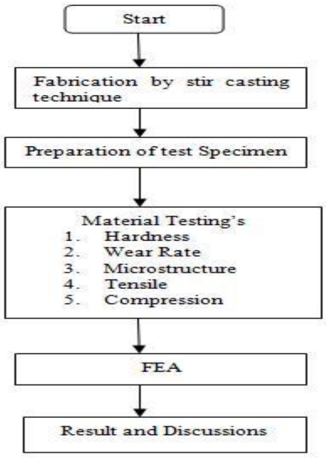
MATERIAL USED AND PROPERTIES

Composite material is made of Al7075-Al_2O_3-B_4C.the properties and composition of Al7075 as shown in the table1 and table 2.

Density (gm/cm^3)	2.81
Melting Point (^{0}C)	630
Tensile Strength (N/mm2)	211
Compression Strength (N/mm2)	646
Modulus of Elasticity (GPa)	70-80
Co-efficient of thermal expansion (µm/m°C)	24.3
Poisson's ratio	0.3
Thermal Conductivity (W/m K)	173

Elements	Cr	Cu	Mg	Zn	Fe	Mn	Si	Ti	Al
%Wt	0.16	1.68	2.15	5.48	0.51	0.29	0.39	0.2	Balance

III. METHODOLOGY



IV. EXPERIMENTAL WORK

The simplest and the most cost effective method of liquid state fabrication is stir casting. In this work stir casting technique is employed to fabricate, which is a liquid state method of composite materials fabrication, in which a dispersed phase (reinforcement particulates) is mixed with a molten metal by means of stirring. The base metal Al7075 was melted at 750^0C in an electric furnace. An appropriate amount (1wt% of the base metal) of boron carbide powder was then added with a constant Al_2O_3(1 wt% of the base metal). slowly to the molten metal. carbide powder was then added with a constant Al_2O_3(1 wt% of the base metal). slowly to the molten metal. Simultaneously, the molten metal was stirred thoroughly at a constant speed with a stirrer. The high temperature molten metal was poured into the pre-heated (600C) cast iron moulds to get the required specimens. Figure 1 shows the electrical resistance furnace setup. The same procedure is followed to produce 2% and 3%.

Fig.1.Electrical Resistance Furnace.

V. TESTINGS

A. Compression Testing

The specimens were machined as per ASTM E-9 standards. Test was carried out on a computerized UTM .The Compression test specimens are shown in fig.2.

Fig.2. Compression Test Specimen

B. Hardness Test

Brinell hardness measurements were carried out on the composite samples by using standard Rockwell cum Brinell hardness test machine. Brinell hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. Load applied was 100 kgf and indenter used was 1/16'.Figure 3 shows the hardness specimens.

Fig 3: Hardness Specimens

C. Wear Test: Wear experiment is carried out on the Pin on Disc machine for constant load and constant speed for 20minutes.

Fig 4: Wear Test Specimen

VI. RESULTS AND DISCUSSION

A. Compression Test

The Compression test results are given in the table 3 and figure 5. The addition of boron carbide leads to improvement in the compressive strength of the composites. So, improving the compressive strength by introducing the B4C particles could be explained by the homogeneous distribution of the B4C particles in aluminum alloy matrix. The distance between the particles decreases hence the ductility decreases.[2].

The fig 5 shows the stress strain curves which is plotted from the compression test result. It is clearly indicates that compression strength increases proportionally as percentage of increase in B_4C. the compression strength is increased almost 40 % percent compare to pure aluminum with 3% of B_4C.

Table 3: Compression Test Results

%of B4C	Compression Strength (N/mm^2)
0	646
1	689.43

2	889.72
3	1061.19

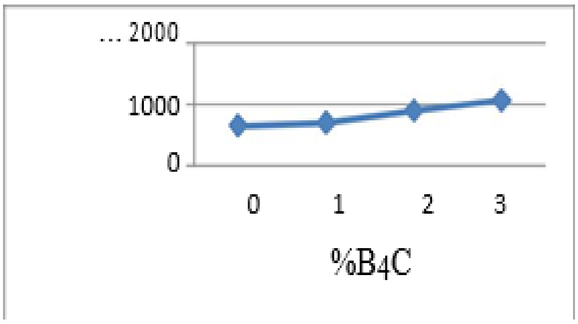
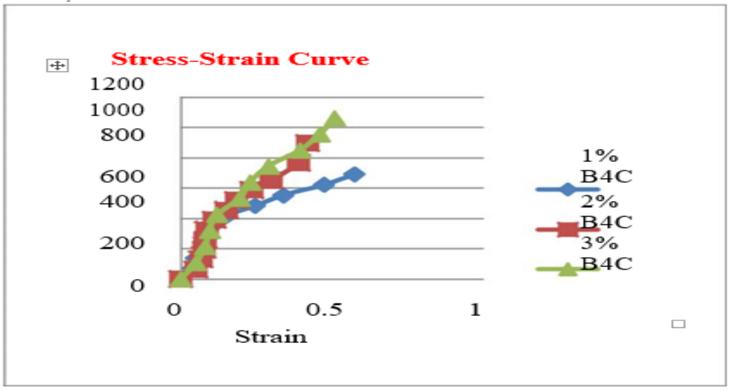


Fig.5: Ultimate compressive strength VS % of B_4C



6: Stress- Strain curves for compression specimens.

B. HardnessTest

The table 4 shows hardness number for different specimen It clearly indicates that the amount of boron carbide increases the hardness will increases due to the presence of extremely harder B4C particles in the aluminium alloy matrix and higher constraint to the localized matrix deformation during indentation. and Figure 7 shows the variation of Brinell Harness linearly. [4].

Table 4: BHN results

%of B4C	**BHN**
0	160
1	188.92
2	200.08
3	223.92

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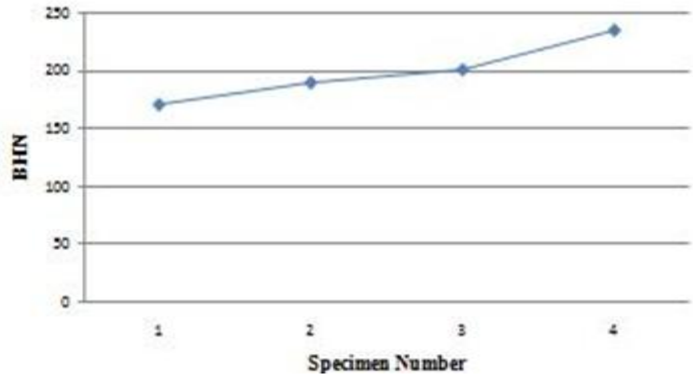

Fig 7: BHN v/s % of B_4C

C. Wear Test

From the figures 8 and 9 shows that the amount of boron carbide particles increases the wear rate goes on decreases due to increasing the wear resistance of harder material. When the materials become harder this resists the wear more hence wear rate decreases.[5-10].

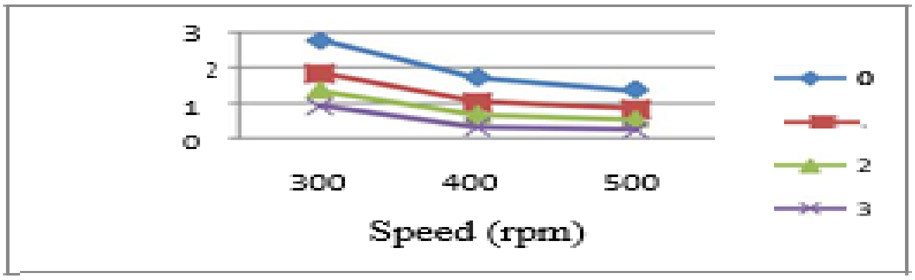

Fig 8: Variation of Wear rate at Constant load of 5kg 0,1,2 and 3 indicates wt% of B_4C

Table 5: Wear Rate At Constant Load of 5Kg at different speeds

%B4c	Speed (rpm)	Initial weight (gm)	Final Weight (gm)	Weight loss (gm)	Wear rate 10^{-8}(gm/mm)
0	300	14.89	14.84	0.06	2.79
	400	14.84	14.8	0.04	1.74
	500	14.8	14.77	0.03	1.39
1	300	15.56	15.52	0.04	1.86
	400	15.52	15.49	0.03	1.047
	500	15.49	15.46	0.03	0.83
2	300	16.4	16.37	0.03	1.39
	400	16.37	16.35	0.02	0.69
	500	16.35	16.33	0.02	0.55

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3	300	15.53	15.51	0.02	0.93
	400	15.51	15.50	0.01	0.34
	500	15.50	15.49	0.01	0.27

Table 6: Wear Rate At Constant Speed of 300rpm at different loads

%B4c	Load (Kg)	Initial weight (gm)	Final Weight (gm)	Weight loss (gm)	Wear rate 10^{-8}(gm/mm)
0	2	14.77	14.72	0.05	2.32
	3	14.72	14.67	0.05	2.32
	4	14.67	14.63	0.04	1.86
1	2	15.46	15.42	0.04	1.86
	3	15.42	15.40	0.02	0.934
	4	15.40	15.39	0.01	0.465
2	2	16.33	16.30	0.03	1.4
	3	16.30	16.27	0.03	1.4
	4	16.27	16.25	0.02	0.934
3	2	15.49	15.47	0.02	0.934
	3	15.47	15.46	0.01	0.465
	4	15.46	15.45	0.01	0.465

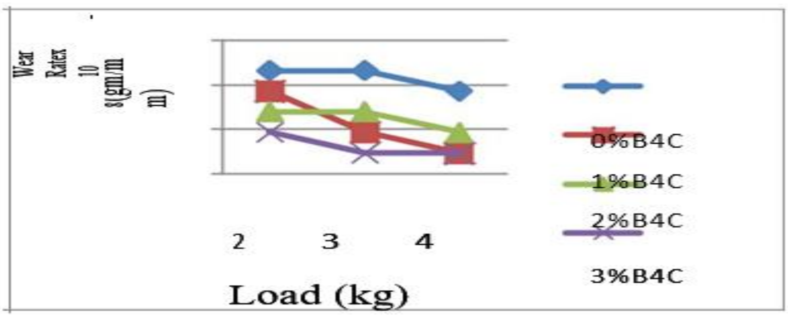

Fig 9: Variation of wear rate at constant speed at different loads

D.Compression Test

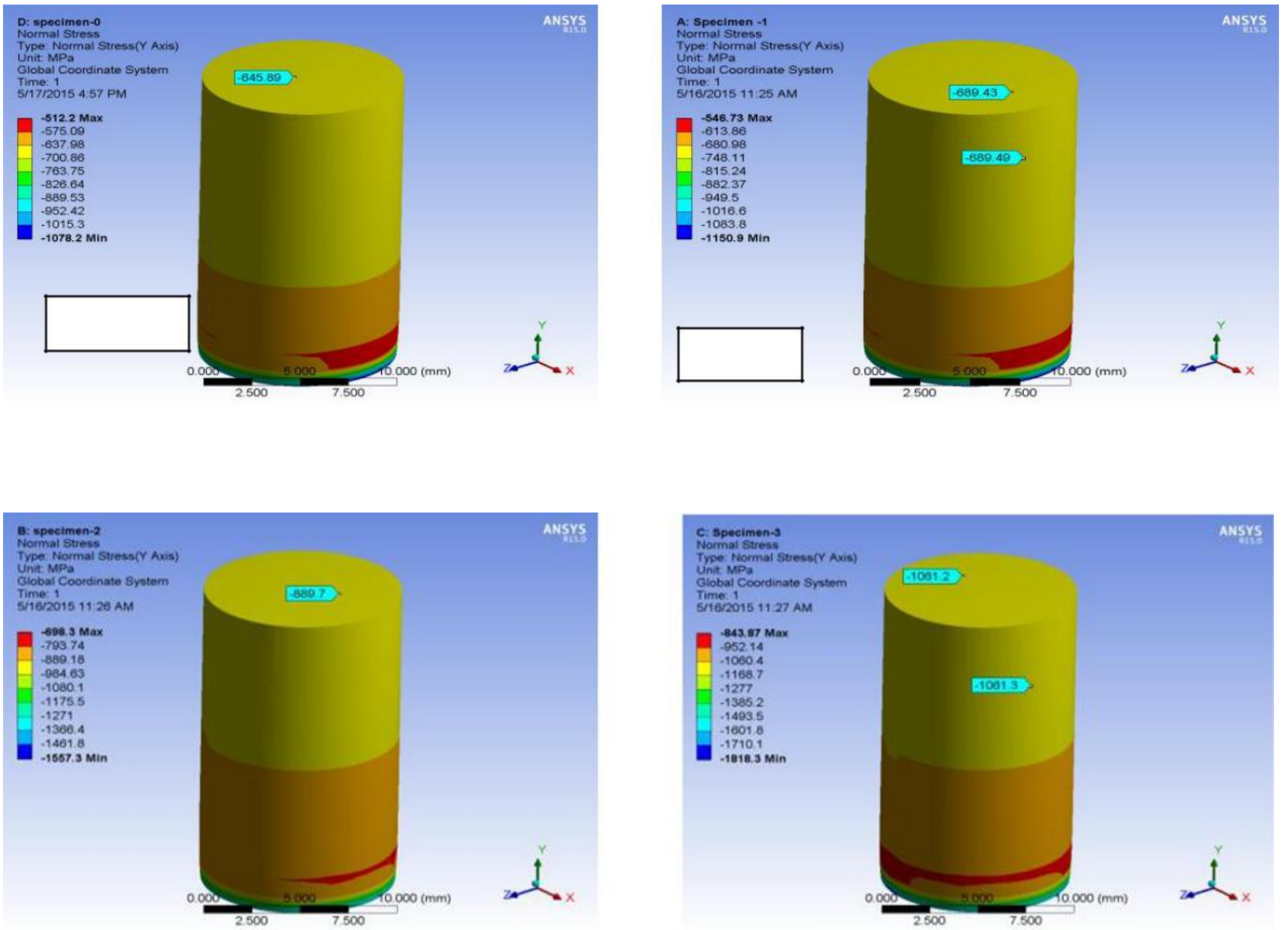

Figure 10: FEA for Compression Specimens for 1,2,3% of B_4C

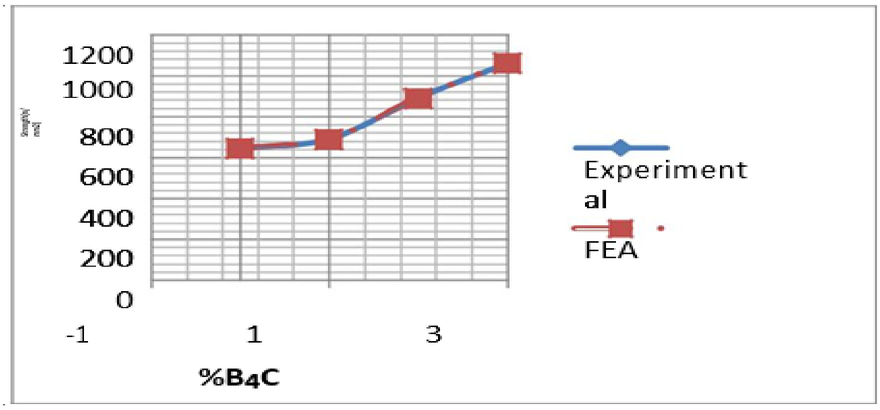

Figure 11: Comparison between FEA and Experimental values

Discussion of FEA for the Compression Test

From the figure 10 red cloor contour shows that the maximum stress is 546.73, 698.3 and 843.87 N/mm^2 and and green colour contour indicates normal stress is 689.43, 889.7 and 1061.2 N/mm^2 for 1,2 and 3% B_4C From the figure 11 it clearly shows that observe the both FEA and Experimental results are results are correlated.

VII.CONCLUSION

1. The aluminum alloy composites containing different amounts of boron carbide particles were produced by stir casting method successfully.
2. The hardness of the composites increases with increasing the amount of the boron carbide in the matrix phase.
3. Increasing the amount of boron carbide particles in composites caused the ultimate compression strength to increase by decreasing the ultimate tensile strength.
4. Boron carbide particles distribute evenly in the matrix phase.
5. From the static analysis it can observed that FEA results are correlated with experimental result.

VIII.SCOPE OF FUTURE WORK

1. By varying the %wt of Al_2O_3 reinforcement mechanical properties can be evaluated.
2. By carry out different heat treatment process variation of mechanical properties can be evaluated.
3. By taking the different mesh size of the reinforcement particles mechanical properties can be evaluated.

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