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STUDY ON MECHANICAL BEHAVIOR OF BORON CARBIDE AND RICE HUSK ASH BASED ALUMINIUM ALLOY 6061 HYBRID COMPOSITE

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Abstract— This present research study based on fabrication of Aluminium Alloy (AA) 6061 based composite for aerospace applications.AA6061 composite was fabricated by bottom pouring stir casting machine. The hybrid reinforcements used were Boron carbide (B_4C) and Rice Husk Ash (RHA). The fabrication was done at different wt% of B_4C and RHA. The Scanning Electron Microscopy (SEM) was used to study the surfaces of developed composite. The Energy Dispersive Spectroscopy (EDS) was used to confirm the proper dispersion of reinforcement in Pure AA 6061. The mechanical property of resultant composite studied was Hardness. All mechanical testing were done according to ASTM standards. The sharp increase in hardness was observed during addition of B4C as compare to addition of RHA. The highest hardness was observed at 5% B_4C along with 5% RHA.

Keywords— Aluminium alloy 6061, Energy dispersive spectroscopy, Hybrid reinforcement, Scanning electron microscopy, Micro hardness

I. INTRODUCTION

Al 6061 used in mineral processing and automotive industries .The main criteria of Al 6061 is good corrosion resistance. These are sensitive to temperature ranging from 200-250°C. Hybrid Composites formed by reinforcing it by other metals or compound. The properties of the base metal enhances by adding the reinforcement like B_4C, SiC, Al_2O_3 and fly ash fibers are the important reinforcement. BLA, fly ash, RHA are some common reinforcement which used to improves the properties of the matrix composites [1]. AMC's are widely used in several application of industries (minerals and chemicals)[2,3]. In MMC the used base alloy act as the matrix material and reinforcements like B_4C, SiC etc in are in form of particles [4]. Gurcan and Baker [5] investigated the wear resistance of monolithic Al 6061 and four AA 6061. Pin on disc test was conducted to find the wear resistance. The authors find the best result with AA 6061+60%SiC.All the obtained result was in T_6 condition. Kalaiselvan et al. [6] fabricated the aluminium Al 6061 in T_6 condition.Modified stir casting was used to fabricate the Al 6061 with different fraction of B_4C particulates. K_2TiF_6 flux used for improving the wet ability. After the fabrication of AMCs the microstructure and mechanical properties are analyzed. Homogeneous dispersion and reinforcement dispersion are analyzed with the help of SEM and XRD. When the B_4C particles are added in increased weight fraction the mechanical properties are increased. Reddy and Zitoun [7] analyzed the various properties of matrix composites. Alumina particulates were used as reinforced. The different grades are 7072, 6063 and 606. Author had made a comparison in all these grades in deceasing order of their calculated properties such as ductility, strength and ultimate strength of Al/Al_2O_3. The Mg content in the matrix alloys was highly reactive with alumina. The fracture mode was mostly ductile in nature. Shankar et al. [8].discussed the comprise effect of metal matrix composite where the base alloy is aluminium. It was found by reviewing various literatures that, there was improvement in material properties used for different applications and also the liquid metal processing technique found very important in manufacturing if metal matrix composites. Anil and Kulkarni [9] fabricated the Al alloy using vortex casting. The reinforcement were Alumina and fly ash. The weight fraction of fly ash was 9%, 12% and 15% and the weight fraction of alumina was 6%. It was observed in the investigation that composites with 6% Al_2O_3 and 15% fly ash have superior properties as compare to monolithic alloys. Ramesh et al. [10] developed situ composites by using the technique liquid metallurgy. 10% of Ti and 3% of Boron with Al are used as reinforcements and the fabrication of Al-6061-TiB_2 takes place by the liquid metallurgy where Al 6061 was the base metal .After the fabrication of composite XRD, EDAX analysis metallographic studies, microhardness and mechanical tests are performed. The properties of fabricated composite increases in comparison to base alloy. Sarada et al. [11] produced hybrid composite of (LM+ activated, carban +Mica) by using the stir casting technique. And this hybrid composite compared with the other two composites which are (LM 25 + activated carban) and in the other composite the reinforcement is Mica. Abrasive test wear testing machine was used for the hardness test and wear properties. Wear process and wear loss checked the proper distribution of reinforcement in the composite. Kumar et al. [12] fabricated Al 6061 with silicon carbide and alumina composites using the liquid metallurgy technique. The variation in wt% was 2-6%. Castings of the composite materials were carefully maintained to prepare the test specimen for several tests. The reinforcement improving the hardness .The microphotograph shows the proper distribution of the particle in the matrix system. SiC and Al_2O_3 enhances the tensile tensile property of composite. Alaneme et al. [13] investigated Al matrix with two different reinforcements. The used reinforcement are natural fibre bamboo leaf ash and ceramic Sic. Two step stir casting method was used.10 wt % phase with aluminum –mg- silicon alloy and 0, 2, 3 and 4 wt fraction of bamboo leaf ash were utilized. It was observed that the mechanical properties of hybrid composites decreased with increase in bamboo leaf ash. Corrosion resistance of 2 and 3 wt % of bamboo leaf have higher values than the single reinforced aluminium. And this was reverse in 0.3 M hydrogen sulphide solution. Baradeswaran and Perumal [14] investigated the AA 7075/Graphene composites for checking the mechanical properties and tribological behaviour under dry sliding condition.The base material was heat treated. The fabrication of composite takes place by conventional liquid casting technique. The Wt% of reinforcement was 5, 10,15 and 20% of graphite. In the investigation authors found that base alloy with 5 Wt% of graphite provides superior result. Deaquino et al. [15] wear method at a 0.367 m/s sliding velocity. The applied load was 20 N and 40 N. SEM was used to determine the worn surface. By the addition of 1.5% graphite and 10 hr of milling the hardness and wear resistance of AMC improved. The distribution of reinforcement was found homogeneous in the composite material. Verma et al .[16] investigated the effect of B_4C and RHA on the Al 7075. They done the SEM analysis also. This was found in this investigation that he hardness increases with the increase in wt% of B_4C and RHA particles. Verma et al .[17] reviewed the addition of reinforcements with two series of aluminium. The base alloys were Al 6061 and Al 7075. In the review the author found that stir casting is best technique of fabrication. Verma and Vettivel [18] study the fractography of samples. They have done the fabrication of Al7075-B_4C-RHA hybrid composite through the two level factorial design. Verma and Rao [19] reviewed the effect of various reinforcement on Al 6061.They concluded that stir casting is best method of fabrication. And mechanical properties increases by adding the various reinforcement in Al 6061.

II. MATERIAL AND EXPERIMENTAL PROCEDURE.

The AMC consists of matrix of Al alloy 6061 and the reinforcements are rice husk ash and boron carbide.

A. Material Used

1) ALUMINIUM ALLOY 6061.

The material purchased from New Delhi. The material was in the form of rectangle. The SEM and EDS test confirms that the purchased material is Al 6061. Zn, Mg, Ti, Cu are found in the test and shown in Fig 1.

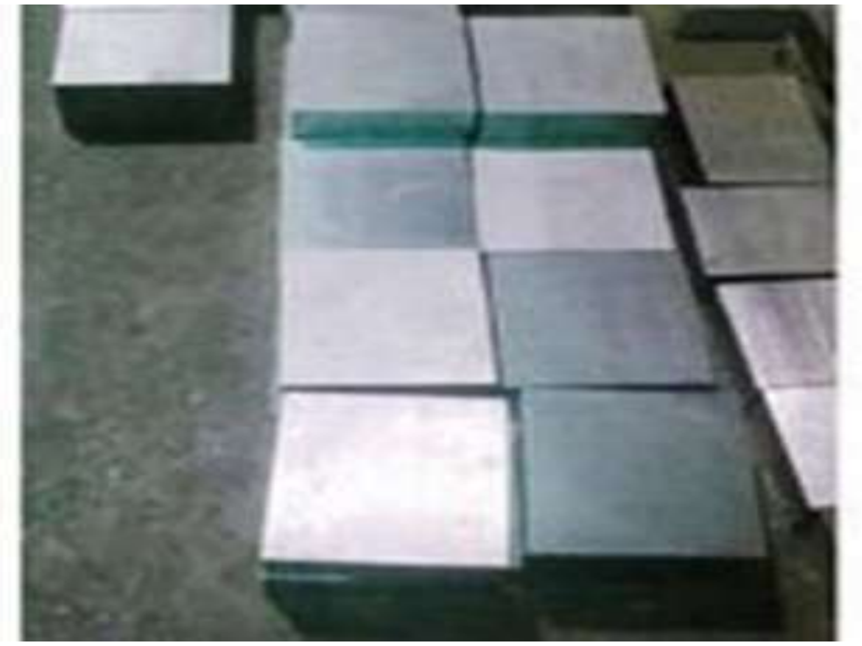


Fig 1. Al 6061

2) RICE HUSK ASH

Rice husk was collected from the Punjab. In order to use it as a reinforcement material it was heated at 200°C for 1 hour. Through heating the rice husk the removal of moisture and organic matter takes place. When we heated the rice husk ash the colour changes from yellowish to black because during the heating the organic matter also changes because of this the change in colour takes place an sis shown in Fig 2. After this process for removing the carbonaceous material it is heated for 12 h on 600°C.

Fig. 2 Rice Husk Ash

3) BORON CARBIDE

Boron Carbide was collected from the Delhi. This is a high performance abrasive .It is similar to diamond because of its physical and chemical properties. Because of hard in nature its nick name is “Black diamond”. It is one of the leading grinding material.

Fig. 3 Boron Carbide

B. Material preparation

Stir casting

The discontinuous metal matrix composite was fabricated by the promising way of fabrication known as stir casting. This method is commercial also. It is popular because large quantity production is possible with simple process and minimum cost with flexibility.

1) Process Parameter

i) DESIGN OF STIRRER

In the stir casting process formation of vortex takes place. Flow pattern of liquid metal will be proper if the blade angle and number of blades are in proper manner. The stirrer was dipped in molten metal till the depth of two third.. These parameters are required for homogeneous distribution of reinforcement and for avoiding the clustering and obtaining perfect interface bonding.

ii) SPEED OF STIRRER

In the present investigation stirring speed is 450 rpm. It is important factor in stir casting process for mixing the reinforcement and base material. The formation of vortex also decides by stirrer speed. The proper dispersion of reinforcement takes place by right rpm.

iii) TEMPERATURE

Melting point of Aluminium is 600°C. The process temperature is responsible for viscosity. For maintaining good wettability temperature should be 800°C. The good binding of reinforcement takes place by increasing the temperature with increasing the holding time.

iv) TIME OF MIXING

Stirring time is 4-5 min because it plays huge role in mixing of reinforcement. Due to less stirring time non uniform distribution of reinforcement takes place and in the case of excess time the formation of cluster takes place.

v) PREHEATING TEMPERATURE

In order to remove oxides and moisture from the reinforcements preheating are done. Porosity also not happened after preheating.

vi) PREHEATING OF MOULD

In the present investigation preheating temperature was in the range of 400-450°C. It is necessary for avoiding the porosity.

vii) ADDITION OF MAGNESIUM:

For increasing the wettability we add magnesium.

viii) FEED RATE OF REINFORCEMENT

In order to avoid porosity and inclusion defect uniform feed rate is necessary. The reinforcement poured at the rate of 0.5 gram per second.

ix) POURING OF MELT

In the present investigation the material starts to melt at 800°C. The distance should be proper between the crucible and mould for good quality of casting. Fig 4 shows the constructional casting equipment.

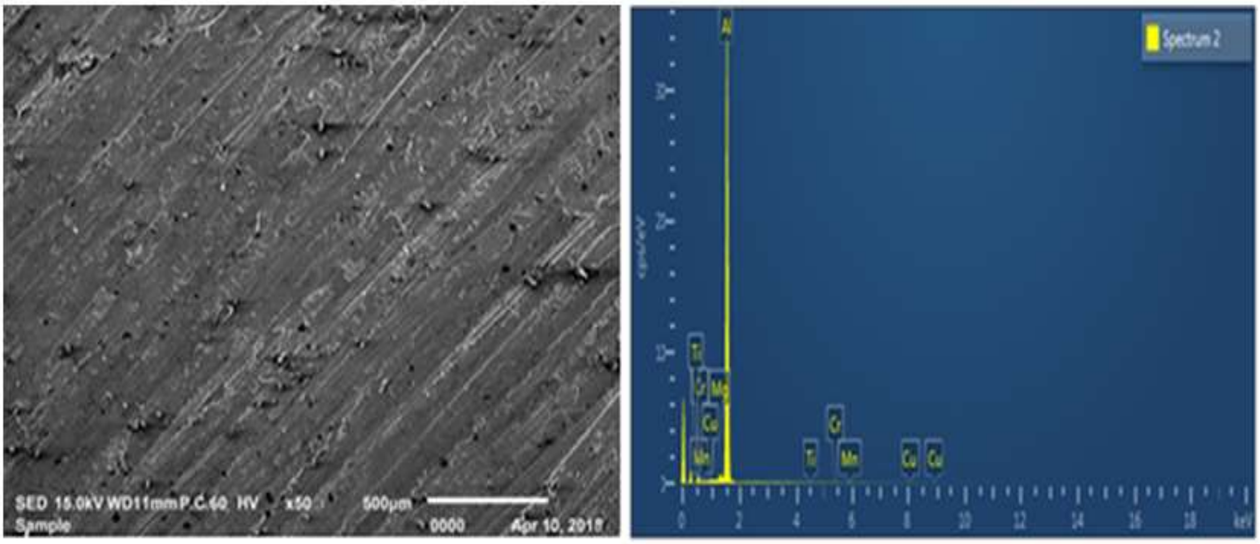
Fig 4. Stir casting set up

III. CHARACTERIZATION AND MECHANICAL BEHAVIOR

2. SEM and EDS analysis of casted samples

The SEM and EDS analysis of Aluminium matrix composite are shown in Fig 5. The SEM images shows the proper mixing of reinforcements with Al 6061 and the EDS shows the major alloying element in it.

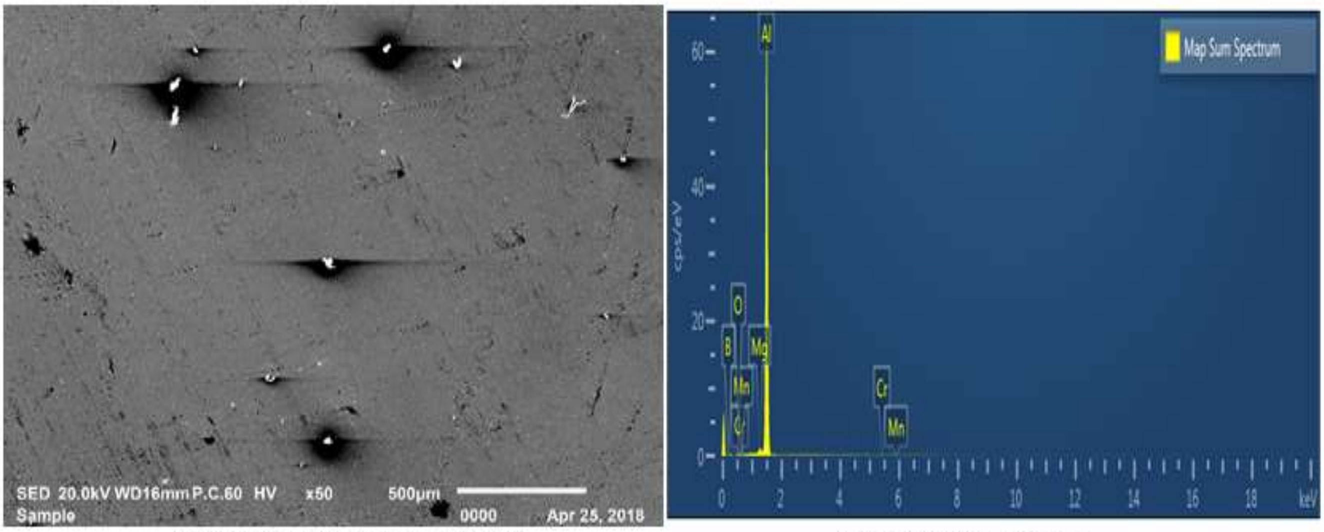
Fig 5(a) shows the SEM image of pure Al 6061.So this is free from oxides and porosity. Fig 5(b) In the Al 6061 through the EDS image we can seen the main alloying elements are Si , Al, Mg, Cu etc.



(a) SEM of Al 6061 (b) EDS of Al 6061

Fig 5.Details of pure AA6061

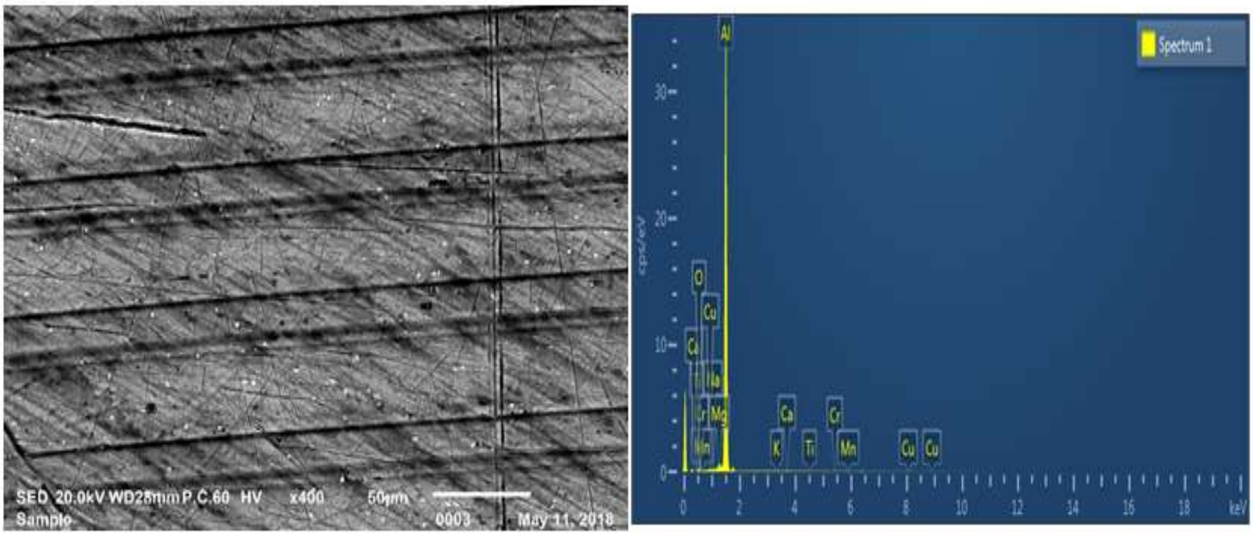
Fig 6(c) shows the SEM image of Al 6061+5% B_4C. It observed from the figure that B_4C particles having grit size 250 appears to be uniform in the base Al alloy 6061. Fig 6(d) shows the major alloying elements like Mg, Si, Cu, Cr. The presence of B and C confirms that there is proper mixing of boron carbide is in the base alloy.



(c) SEM of Al 6061+5% B4C (d) EDS of Al 6061+

Fig 6. Details of Al6061+5% B4C

Fig 7 (e) shows the SEM image of Al 6061+5% RHA.The SEM image shows the proper mixing of RHA. Fig 7(f) shows the EDS image which confirms that major alloying elements are Mg, Si, C are present in the spectrum.

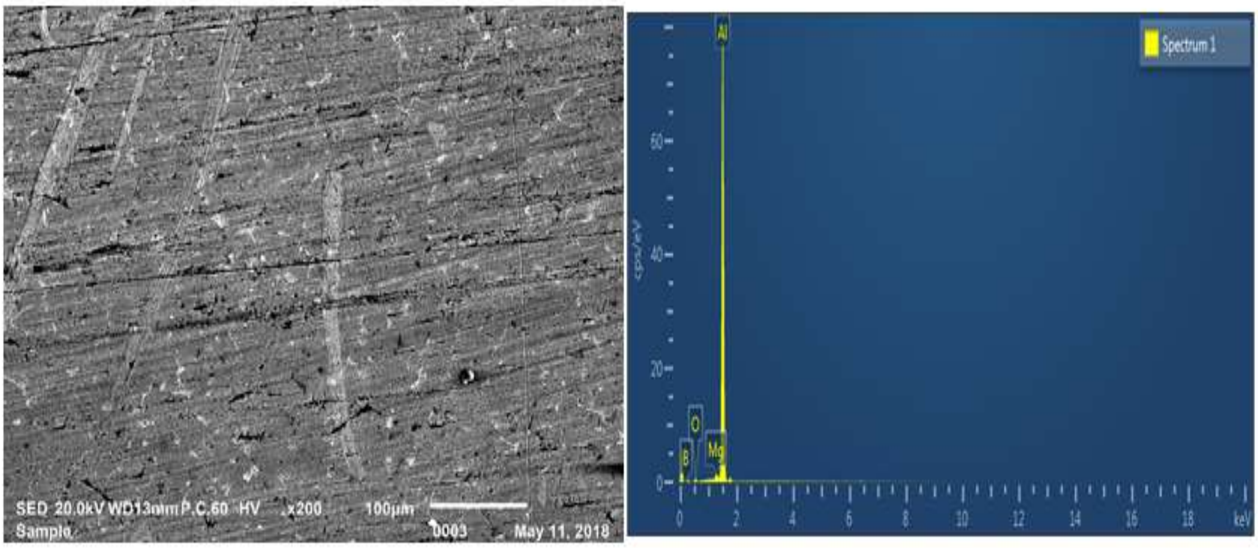


(e) SEM of Al 6061+5% RHA

(f) EDS of Al 6061+ 5% RHA

Fig 7. Details of Al6061+5% RHA

Fig 8(g) shows the SEM image of Al 6061+5% B_4C+3% RHA. The SEM image confirms that there is proper mixing of 5% of boron carbide and 3% RHA particles in the base alloy. Fig 8(h) shows the EDS image of the hybrid composite which confirms the major alloying elements are Mg, Si, B, and C etc.

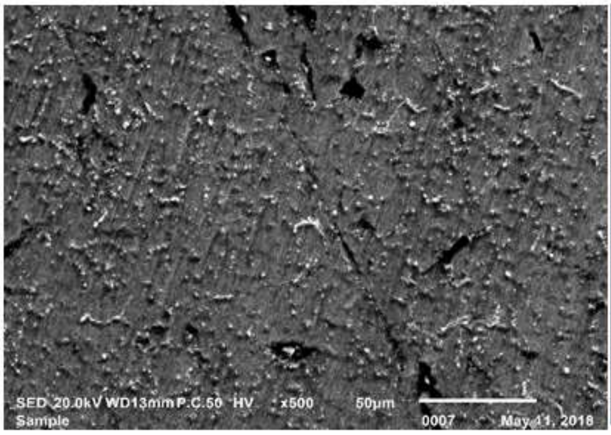


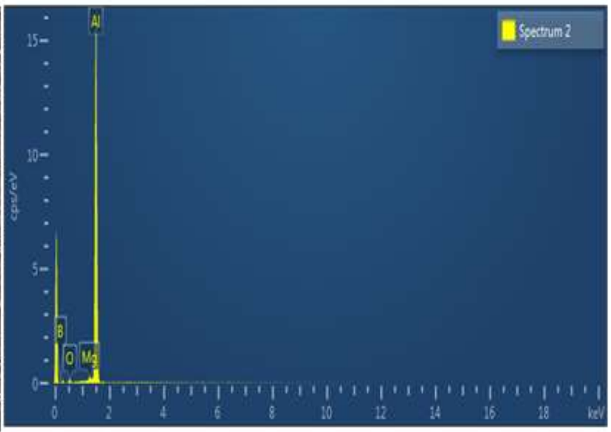
(g) SEM of Al6061+5%B4C+3%RHA

(h) EDS of Al6061+5%B4C+3%RHA

Fig 8. Details of Al6061+5%B4C+3%RHA

Fig 9 (i) shows the SEM image of Al 6061+5% B_4C+5% RHA. It shows that there is uniform distribution of B_4C and RHA particles. Fig 9(j) shows the EDS image of the AMC in which the major alloying elements are Mg, Si, B, C etc.





(i) SEM of Al6061+5%B4C+5%RHA (j) EDS of Al6061+5%B4C+5%RHA

Fig 9. Details of Al6061+5%B4C+5%RHA

IV. HARDNESS TESTING

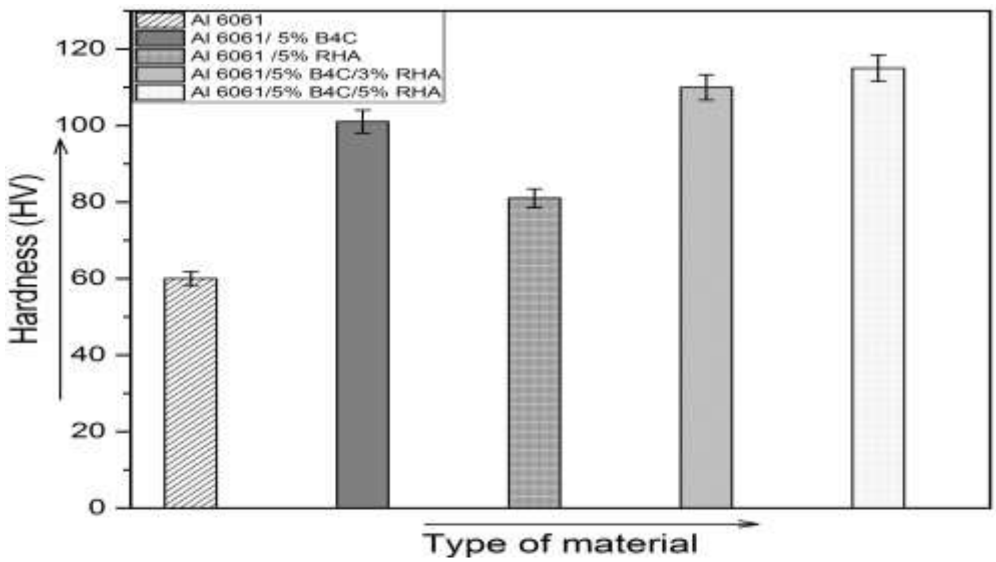
We have taken five different compositions for the test. Hardness is the ability of material to resist plastic deformation, by indentation .We can see the improvement in hardness by adding different composition of reinforcements of boron carbide and RHA as shown in Table 1.

TABLE I
COMPOSITION OF MATERIAL

Sample No	Wt% of AA 6061	Wt% of B_4C	Wt% of RHA	Hardness(HV)
1	100	0	0	060
2	95	5	0	101
3	95	0	5	081
4	92	5	3	110
5	95	5	5	115

V. EFFECT ON HARDNESS

The hardness of pure AA 6061 obtained on Vicker's testing machine is 60 HV. By adding 5% B_4C reinforcement in Al alloy we get the hardness 101 HV and by adding 5% RHA we obtained the value of hardness is 81 HV and by taking hybrid composition of reinforcements of 5% and 3% we obtained the value of hardness 110 HV. The highest value occurs on wt% of 5 of both the reinforcements. The obtained value is 115 HV.



VI. CONCLUSIONS

The drawn conclusion after the work on AA 6061/B_4C/RHA hybrid composite:

- The best method of fabrication is stir casting because proper mixing of reinforcement is possible in it. And due to proper mixing of reinforcement there is no loss of reinforcement and uniform distribution takes place. Porosity and clustering defects not takes place.
- The method of stir casting was successfully used to manufacture the Al 6061 composite with proper allocation of particle in the Al matrix composite.
- The mechanical property of hybrid composite i. e hardness by adding the reinforcements B_4C and RHA particles.
- To control the properties like tensile , compressive and hardness we consider the weight percent of reinforcement as the primary parameter.
- The highest value we get with hybrid composition. Weight percent of both the reinforcement were 5%.The highest value occurred with 5% of RHA and 5% of ceramic B_4C.Obtained value is 115 HV.
- In this investigation, we can also compare the value of hardness separately with boron carbide and RHA. The values obtained are 101 HV and 81HV.
- SEM and EDS results shows that there was good dispersity of RHA and B_4C in AMC which enhances the mechanical strength of the composite material.
- There is no problem occurs in the storage and disposing the waste extracted from rice husk when we use it as the reinforcement.
- RHA reduces the cost of reinforcement when it is used in hybrid composite.

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