Boron Carbide and Mechanical properties

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ABSTRACT
In this project work, aluminium-based metal matrix composite is developed by stir casting method. The base material is Aluminium and reinforcement materials are Cashew Nut Shell Ash (CSNA) and Boron Carbide (B4C). The Objective of project is to investigate the properties of aluminium based composite material. In this project, B4C content CSNA varies for each specimen they are reinforcement in aluminium Al-7075 grade matrix will improve the mechanical properties of the material. Optical micrographs is used to view the uniform distribution of B4C and CSNA particles within the aluminium matrix. It is expected that this composite will be beneficial for high strength material developed especially in machinery and aerospace engineering applications.

Keywords: Aluminium, Cashew Nut Shell Ash, Boron Carbide and Mechanical properties

1. INTRODUCTION

Conventional monolithic materials have limitations in achievinggood combination of strength, stiffness, toughness and density etc. To overcome these shortcomings and to meet the ever-increasing demand of modern-day technology, composites are most promising materials of recent interest. Metal Matrix Composites (MMCs) possess significantlyimproved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and high strength reinforcements. Among various reinforcement materials we taking two reinforcement materials to reinforce in base metal which improves the physical prosperities of the aluminum metal matrix composites.

Now a days the particulate reinforced aluminum matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminum matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys. Casting route is preferred as it is less expensive and amenable to mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. The only problem associated with this process is the non-uniform distribution of the particulate due to poor wet ability and gravity regulated segregation. Mechanical properties of composites are affectedby the size, shape and volume fraction of the reinforcement, matrix material and reaction at the interface.

2. COMPOSITE MATERIALS:

A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a macroscopic scale. Generally, a composite material is composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired

shape while the reinforcement improves the overall mechanicalproperties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents. Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc. Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining twoor more compatible materials, different in composition and characteristics.

3. CHARACTERISTICS OF COMPOSITES:

Properties of composites are strongly dependent on the propertiesof their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientationof the reinforcement also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms or platelets), the size and size distribution (whichcontrols the texture of the material) and volume fraction determine the interfacial area, which plays an important role in determining the extentof the interaction between the reinforcement and the matrix. Composites as engineering materials normally refer to the material with the following characteristics:

1. These are artificially made (thus, excluding natural material such aswood)
2. These consist of at least two different species with a well define dinterface.
3. Their properties are influenced by the volume percentage of ingredients.
4. These have at least one property not possessed by the individualconstituents.
5. Generally, a composite material is composed of reinforcement and matrix. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material.

4. The objectives of this project work are: -

1.Fabrication of Aluminium(7075)-Boron Carbide(B4C)- CSNA Metal Matrix Composites by stir casting method

2.To study the influence of B4C and CSNA in Aluminium(7075) matrix metrial on mechanical properties of Aluminium-Boron Carbide-CSNA(Al- B4C-CSNA) while change in percentage of reinforcement.

3.To Know whether the reinforcement of B4C and CSNA uniformly distributed or not by conducting microstructure analysis.

4.To know the strength and hardness of the aluminum metal matrix composite material by conducting hardness test and tensile test

6. EXPERIMENTAL DETAILS

The evolution of different metal matrix composite system has led to the development of newer processing techniques, in addition to conventional metal processing techniques. The major criteria for the selection of a process rely on the type of composite system to be fabricated, the properties to be achieved and the component to be produced. The processing methods are widely classified into primary and secondaryprocesses. The primary process combines matrix and reinforcements to produce the basic composite system and their structures. The primary processing techniques may be classified into liquid state, solid state and

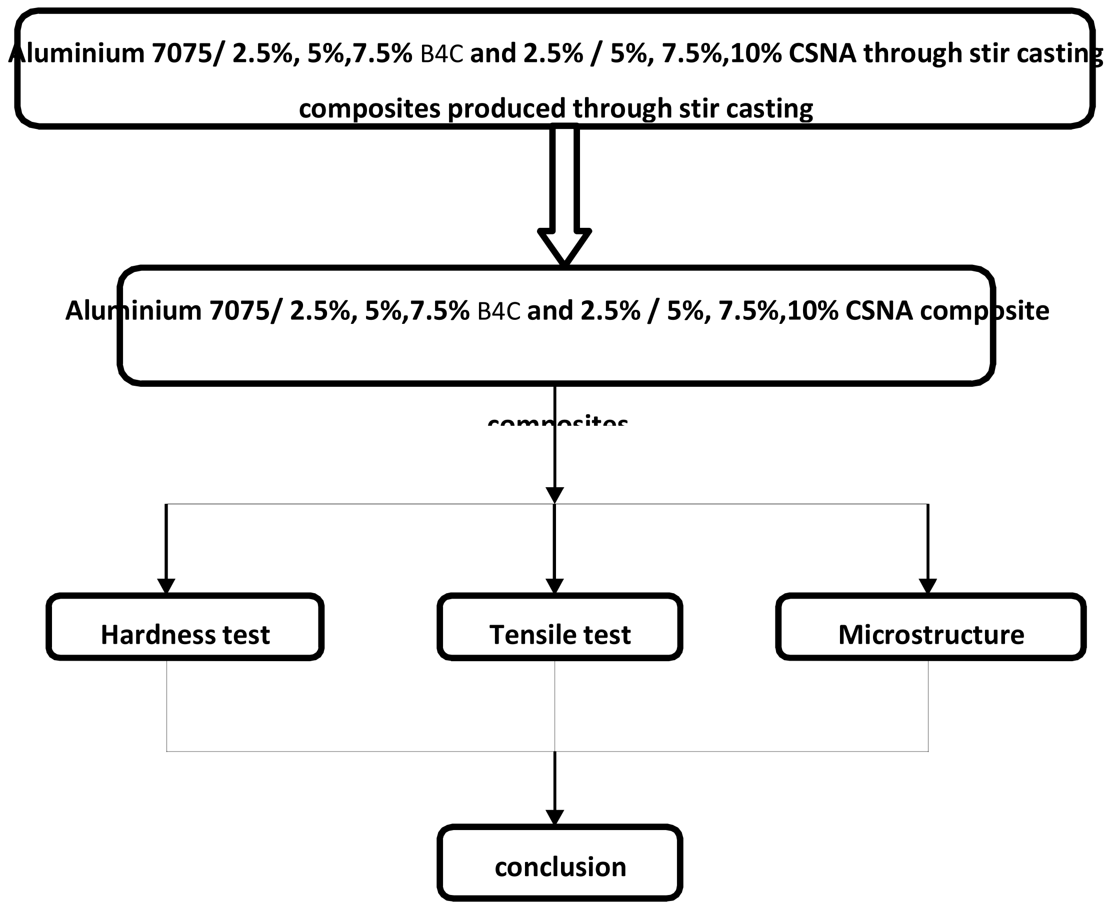

Fig1: -WORK PLAN

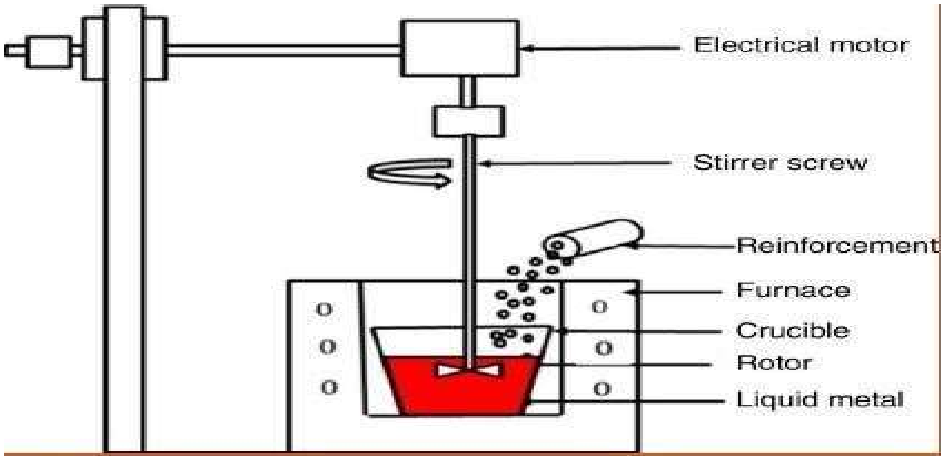

Figure2:- Stir casting

7. COMPOSITIONS OF COMPOSITE:

In this project aluminum metal matrix composites are reinforced with1 wt.% of TiC and (0 wt.%-3 wt.%) of ZrO_2 at an interval of 1 wt.% is fabricated by stir casting fabrication process.

Table1 : Composition and Density's

S.No	**Composition (by wt %)**	**Sample code**	**Density g/cm^3**
1	90%Al-7.5% B_4C - 2.5%CSNA	S01	2.71141
2	90%Al-5% B_4C - 5%CSNA	S02	2.74052
3	90%Al-2.5% B_4C - 7.5%CSNA	S03	2.76963
4	90%Al-7.5% B_4C- 2.5%CSNA	S04	2.79874

7.1**PROPERTIES OF MATERIAL TABLE2:**

S.No	**Material**	**Density 3 g/cm**	**Hardness**	**Melting o Point c**	**Boiling Point o c**	**Young's Modulus Gpa**	**Poisson's Ratio**
1	Aluminium	2.7	40Mohs	477-635	2470	69	0.34
2	Boron Carbide	2.52	9.75 Mohs rockwell	2427	3500	460	0.18

7.2 **PROPERTIES OF MATERIALTABLE3:**

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7.3 ALUMINIUM CHEMICAL COMPOSITION : Chemical Composition of Al-7075

Table 4: Aluminium chemical composition

Element	Al	zn	mg	Cu	Mn	cr
%	90	5.6	2.5	1.5	0.20	0.20

The Casting Size of AMCs are 30mm Diameter and 220 mm length of four composition of rods it done with stir casting each so individually and poured in the mold

EXPERIMENTAL RESULT AND DISCUSSION

Figure 3: Rockwell machine testing

8. ROCKWELL TEST:

In our project we done Hardness test in the Rockwell hardness machine because it gives maximum hardness of the material [13] and better results and easy to operate and divisions of scale we have choose according to the material the amount of load and the size and type of indenter ,In this we choose the B Scale it is better for the hard Aluminum [14] and Red scale as in table on the Rockwell machine. Rockwell hardness test is an indentation hardness test under a calibrated machine to force a diamond cone indenter or a hard steel ball indenter under specified conditions into the surface of the material under test in two operations andto measure the depth of the impression under the specified load condition. This method is used for testing of hardness over a wide range of material hardness's. The hardness of a material is measured by the depth of penetration of the indenter in the material. The depth of penetration is inversely proportional to the hardness. The test gives direct hardnessreadings on a larger dial provided with three scales.

Table 5: Rockwell table

Total test force	60Kgf	100Kgf	150Kgf
Indenter	Diamond Cone 120^o	Ball 1/16 diameter	Diamond Cone 120^o
Scale	A	B	C
Pointer Position on dial	Set	Set	Set
Dial to be read	Black	Red	Black
Typical Application	Thin Steel and Shallow hardened steel	Soft steel, Copper ,Aluminium alloys	Steel, Hard case steel

The sizes of the samples are in cylindrical shape with dimensions16mm Diameter and 40 mm length of every samples in the hardnesstest the samples not depends on the sizes. The plunger and the lever areadjusted as in the chart and turn the hand whell clockwise, so that Specimen will pull indentor and the dial gauge as small pointer at ‘3’ red spot and long pointer at zero the turn the lever the indention happens and pointer is steady the indention is completed.

8.1 Hardness tests of Samples Table 6 :
Hardness test of S01

S.No	Sample	Diameter of Indentor(mm)	Minor Load(Kg)	Major Load(Kg)	Rockwell reading (HRB)
1	S01	1/16	30	100	90
2	S01	1/16	30	100	95
3	S01	1/16	30	100	85

8.2 **Hardnesstest of S02 Table7:**

S.No	Sample	Diameter of Indentor(mm)	Minor Load(Kg)	Major Load(Kg)	Rockwell reading (HRB)
1	ATZ02	1/16	30	100	97
2	ATZ02	1/16	30	100	110
3	ATZ02	1/16	30	100	100

The average of the S02 sample is **102.3**

8.3 Hardness test of S03 Table8:

S.No	Sample	Diameter of Indentor(mm)	Minor Load(Kg)	Major Load(Kg)	Rockwell reading (HRB)
1	ATZ03	1/16	30	100	130
2	ATZ03	1/16	30	100	120
3	ATZ03	1/16	30	100	130

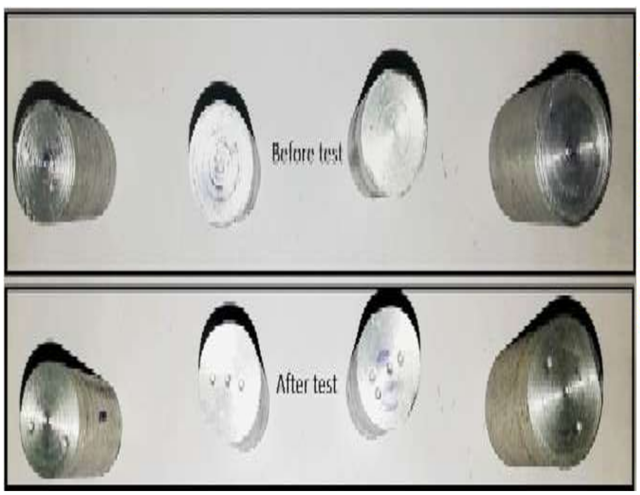
The average of the S03 sample is **126.6**

8.4 Hardness test of S04 Table9:

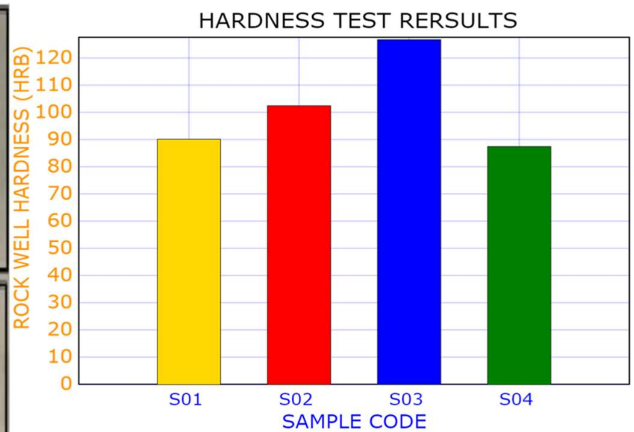
S.No	Sample	Diameter of Indentor(mm)	Minor Load(Kg)	Major Load(Kg)	Rockwell rding (HRB)
1	ATZ04	1/16	30	100	90
2	ATZ04	1/16	30	100	87
3	ATZ04	1/16	30	100	85

The average of the S04 sample is 8 7 . 3

Figure4: Samples for Hardness test



Graph1: Rockwell hardness results



The Rockwell hardness was performed on a polished samples with a constant load of 100kgf .It is found that with increase of percentage of reinforcement of material the hardness of material also increases but it is maximum at S03 after it is decreased as show in below graph. As in the sample S04 has the lowest Hardness among all the samples with 87.3 HRB and the S03 has the highest hardness of all remaining samples with 126.6 HRB

TENSILE TEST:

The testing involves taking a small sample with a fixed cross section area, and then pulling it with a controlled, gradually increasing force until the sample changes shape or breaks. When testing metals, indentation hardness correlates linearly with tensile strength. This important relation permits economically important nondestructive testing of bulk metal deliveries with light weight, even portable equipment, such as hand held Rockwell hardness testers

Tensile test is gripped at either end by suitable apparatus in a testing machine which slowly exerts an axial pull so that the material isstretched until it breaks. The test provides information on proof stress, yield point, tensile strength, elongation and reduction of area.

9. Ultimate tensile test:

In the tensile test the ATZs of samples are made in above dimensions in the lathe machine after the four pieces are made we proceeded to tensile test in that we fixed rod in upper cross – Head and Middle cross – Head in clamping jaws and locked jaws in positions . Now Slowly turn the right control valve to desire load rate. Taking readings of applied load and extension of specmen. The load is applied at same rate until specimen brakes then we get ultimate load and Braking load. then we get ultimate load and Braking load.

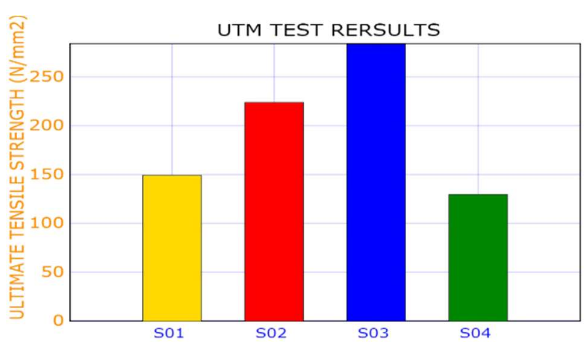
Figure 5 : Universal testing machine

Figure6: Before Tensile test image

Figure7: After Tensile test image

Sample Results Table10:

S.No	Sample Code	Tensile Strength
1	S01	149.2
2	S02	233.8
3	S03	283.5
4	S04	129.5



Graph2 : Tensile test results

we calculated and found that final tensile Strength is increases with increase of percentage of reinforcement of the Metal Matrix Composite at sample ATZ03 shows the maximum tensile strength and the sample ATZ01 shows the lowest tensile strength.

10. MICROSTRUCTURE ANALYSIS:

Microstructure of the composites analyzed to know the difference between the Matrix metal and the composite after stir casting. In case of composites microstructure is also done to see the distribution of reinforcement particles. During this work Zirconium oxide ZrO_2 andTitanium carbide TiC is added as reinforcement in the Aluminium Alloy to analyze the change in the properties of the matrix metal. To analyze themicrostructure of the composites using optical microscope.

Optical microstructure is analyzed under the microscope in Mechanical Engineering Department in Metallurgy lab For better contrast of the images and to detect easily, firstly samples are prepared. Samples are of circular shape of 10mm diameter and width of 5mm grind on the different grit size emery papers.

Figure8: Moulding Machine

To check microstructure the samples are taken to sizes as above shown and it is molding the Specimens for the convenient handling .The specimen is placed in a mould and Bakelite powder is pored in it and in high temperature and pressure of 3000 kg/cm^2 is used for strong molding and placed in the air for the strengthen .first subjected to rough grinding on a mechanical grinding machine. Then it is polished with a series of emery papers, the emery papers used are of 150,240 and 600 grit size. After grinding on the emery papers samples are polished on Disc polishing machine with use of Aluminium fine powder Abrasive. For Etching the material is etched with Ferric chloride anhydrate for removing unprotected parts of samples. Then samples were analyzedunder the optical microscope to analyze the effect of composition on the distribution of the particles. The particle size of the ZrO_2 and TiC particles for removing unprotected parts of samples. Then samples were analyzed under the optical microscope to analyze the effect of composition on the distribution of the particles. The particle size of the ZrO_2 and TiC particlesis 40 micron so a better surface finish and contrast is required to analyze the proper structure of the composites

Figure 9: Disk polishing machine

Figure 10 :Samples for microstructure

Microstructure Images :

The specimens are visualized under magnification (15X). Different figures of optical microstructure are as following

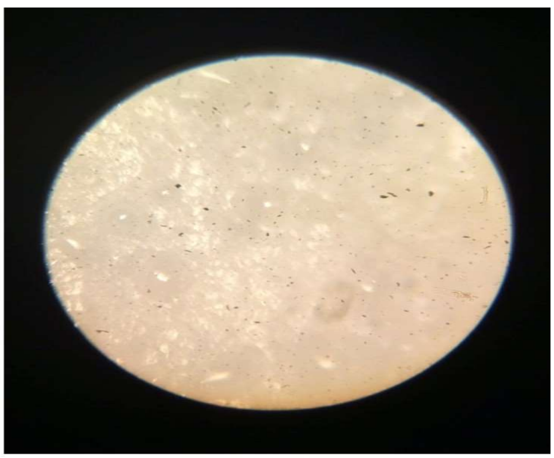


Figure 11 : S01

Figure 12: S02

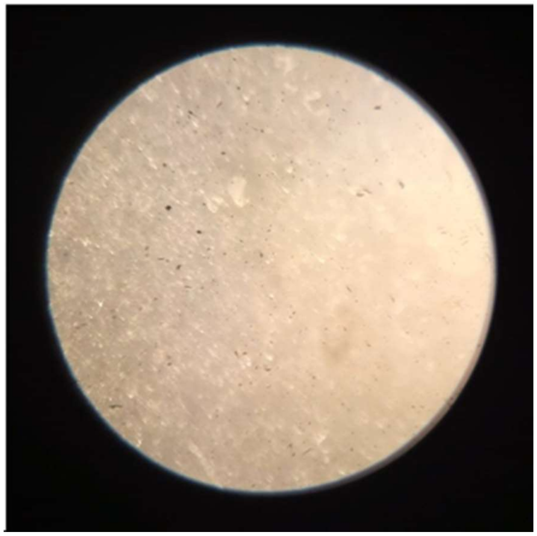


Figure 13: S03

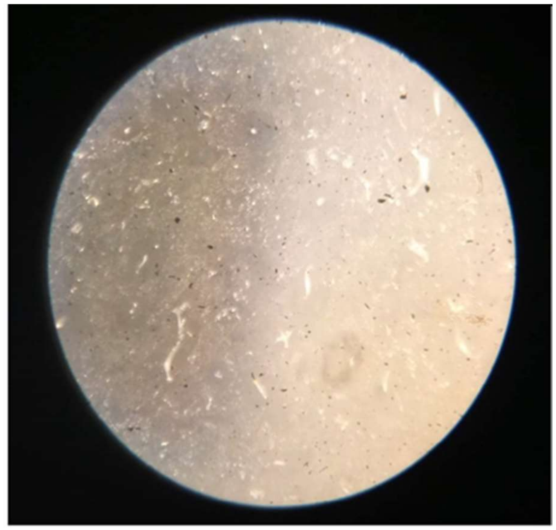


Figure 14: S04

10.1 Microstructure observations:

It is clear from the figure 5.4.1 to 5.4.2 that the particles of the Boron carbide and CSNA are present in the aluminium matrix alloy. From the above figures it was found that the particle size of the alumina is very fine of 40µm that's why at 15X the particles look very small. From above figures it can be easily detected that the distribution of the particles is almost uniform. By comparing the above micrographs it was analyzed that by comparison of the distribution of particles on the basis of percentages then the Zirconium oxide material is varied in S02,S03 and S04 having the micrographs more particles are present in more percentage of reinforcement in matrix So S04 has more particles in it. It is also observed that there is increase in hardness this can be attributed to the increase in interfacial bonding of reinforcement with the aluminium matrix alloy

11. CONCESSION

In this project aluminum-based hybrid metal matrix composite were fabricated by the stir casting process. Al-7075 aluminum alloy was used as matrix material which is reinforced with B4C and CSNA in partial form.

In this project we done in optical, mechanical properties of composites. Based on the present experimental study the following conclusions are drawn.

The Microstructure of the fabricated composite were studied under optical microscope. It is found that the uniform distribution of B4C and CSNA reinforcement at most locations.

The distributed homogeneity of B4C the particles in the matrix, and help to decrease the number of pores and improve interfacial bonding strength of the composites. The 2.5% volume of B4C and CSNA of 7.5% volume aluminium matrix composites showed the maximum tensile and Hardness of the samples Aluminium Composite sample S03 with 2.5%. wt B4C and 7.5%. wt CSNA shows the maximum hardness and tensile strength with 126.6 HRB Hardness and tensile strength is also at S03 with tensile strength of 283.5N/mm2

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