STUDY AND CHARACTERIZATION OF ALUMINIUM 7075 HYBRID COMPOSITE MATERIALS

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ABSTRACT: **- There has been a rapid growth in the utilization of Aluminium Alloys in the recent part especially in automotive sector and Aerospace Industries mainly because of its properties such as low weight, low density, wear resistance and high strength to weight ratio and advancement of MMC's. In this case study the addition of B_4c and Wc as reinforcement to Aluminium 7075 using stir casting process leads to improvement in hardness and toughness; with small deviation in the density, Metal Matrix Composite has improved its mechanical properties like hardness, and good wear resistance.**

Key words: Composites, Stir casting, Aluminium 7075, boron carbide, tungsten carbide

1. INTRODUCTION

Composite materials are those made from two or more constituent materials when fused together produces a material with distinguished properties difference from properties of individual material often resulting in superior product. Generally hybrid composites are those composites, which are made up of two or more reinforcement alongside matrix material the typical examples for hybrid material in nature is bone or nacre. Material technology and engineering design field requires high advanced engineering material with high end mechanical and Tribological properties. To adjust to the requirements of engineering industries, the ceramic particles like Al_2O_3, Sic are mostly reinforced with Aluminium metal matrix for their improved mechanical properties like hardness and low wear rate. Recent studies show that, boron carbide reinforced with Aluminium metal matrix composites has attractive properties like good tensile strength, high hardness and low density than Al-SiC composites.Aluminium alloys are most suitable for engineering material for automobile, aerospace and mineral processing industries for various high performing components and are being used for these diverse applications due to their low density, exceptional thermal conductivity properties. Among several series of Aluminium alloys, Al7075 is ample explored due to their admirable properties. These alloys are heat treatable. Al7075 alloy are extremely resilient to corrosion and exhibits moderate strength. Al7075 finds much useful in the fields of construction, automotive and marine applications. The composites made out of Aluminium alloys are of wide interest owing to their high specific strength, fracture toughness, wear resistance and stiffness. Tungsten carbide is a fine dark powder which can be squeezed and framed into shapes for use in manufacturing industries, cutting devices, abrasives, defensive layer penetrating rounds, other equipments and tools. Tungsten carbide is double the density of steel and is nearly two times stiffer than steel. Cubic boron nitride and diamond powder wheels are used for polishing tungsten carbide which is equivalent to corundum in hardness. This project consists of Aluminium 7075 as base matrix material with boron carbide and tungsten carbide as reinforcement. As known Aluminium 7075 is the hardest of the Aluminium series and boron carbide is one of the hardest material known to mankind, ranking behind diamond, in order to avoid the composite being brittle tungsten carbide is added to give sufficient stiffness and young's modulus to the composites. This composites yields good hardness, low density, wear resistance as per the test conducted.

2. EXPERIMENTAL

Materials

Aluminum 7075 is an aluminium alloy, with zinc as the primary alloying element. It is string, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other aluminium alloys, but has significantly better corrosion resistance than the 2000 series alloys. This is the matrix material chosen by us.

Tungsten carbide is a chemical compound containing equal parts of tungsten and carbon atoms. In its most basic form, tungsten carbide is a fine grey powder, but it can be pressed and formed into shapes through a process called sintering for use in industrial machinery, cutting tools. Tungsten carbide is approximately twice as stiff as steel, with a Young's modulus of approximately 530–700 GPa (77,000 to 102,000 ksi), and is double the density of steel-nearly midway between that of lead and gold.

Boron carbide (B_4C) is an extremely hard boron–carbon ceramic, and covalent material used in tank armour, bulletproof vests, engine sabotage powders, as well as numerous industrial applications. With a Vickers Hardness of >30 GPa, it is one of the hardest known materials, behind cubic boron nitride and diamond.
Boron carbide was discovered in 19th century as a by-product of reactions involving metal borides, but its chemical formula was unknown. It was not until the 1930s that the chemical composition was estimated as B_4C.

Specimen Preparation

We have taken the reinforcements i.e Boron Carbide and Tungsten Carbide in powder format and Aluminium7075 in the form of small billets. The above figures shows the fabrication process; in which we have used Electric Arc furnace and Stir Casting process for the fabrication. The Al 7075 is made to melt inside the furnace at 750°C; once the melting is finished, the reinforcement is added slowly and uniformly into the furnace. Molten Matrix solution was stirred for 3-5mins to ensure the uniform distribution of reinforcement in the matrix. Pink Power is used as a degassing agent and Exocroethine is used to separate the impurities. The matrix solution is then casted in to the pre-heated die and allowed to set and cool

Fig 2.1 Electric Arc furnace

Fig 2.2 Die Casting

Fig 2.3 Specimen

3. EXPERIMENTAL SETUP

In the following table it is shown that all the mechanical properties such as Density, Wear Resistance and Hardness was tested according to the ASTM only.

Sl.No	Test Specimen	ASTM Standard
1	Density	D792
2	Hardness	D2583
3	Wear	G99 - 17

Table 3.0 ASTM Standards.

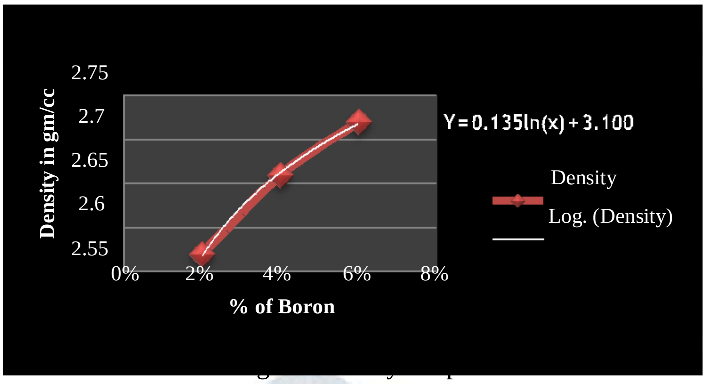
For measuring Density electronic weigh machine was used. The Hardness and Wear Resistance test were conducted. The Hardness is measured by using **BUEHLER's Vickers Hardness Tester**. The specimen is placed under the intender of the Buehler Hardness Tester and a uniform pressure is applied to the specimen until the dial indication reaches a maximum. The depth of the penetration is converted into absolute Vicker's hardness number. Data is expressed as VHN given by the instrument. Pin On Disc apparatus was used to test the wear resistance.

4. RESULT AND DISCUSSION

Following are the result and discussion of mechanical properties of Aluminium 7075 reinforced with Boron Carbide and Tungsten Carbide.

A. Density

The density of specimen is taken randomly throughout the length of the specimen. For calculation of electronic weight mettle balance is used. From the Graph 4.0 it is observed that the density of composite increases as the reinforcement %wt. goes on increasing. Density of specimen without reinforcement is 2.8 g/cm^3 and it goes on increasing as the reinforcement content increases.

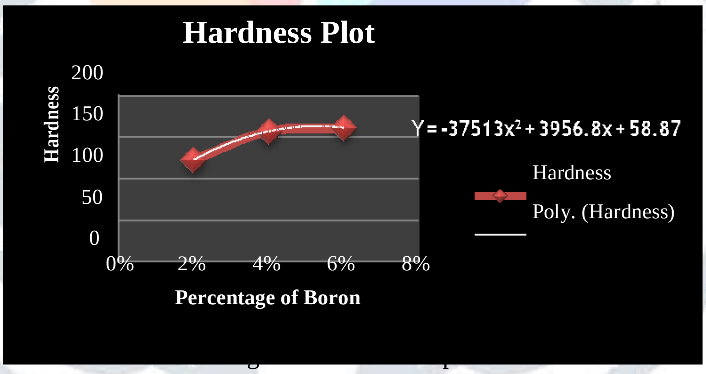


Sl.No	Composition	W_1 (weight in air) in gm	W_2 (weight in water) in gm	Density in gm/cc	Avg. Density
1.	5% Wc 2% B_4C	6.6854	4.092	2.57	2.57
2.	5% Wc 4% B_4C	7.785	4.865	2.66	2.66
3.	5% Wc 6% B_4C	7.454	4.717	2.723	2.72

Table 4.11 Density Test Results

B. Hardness

The Hardness is taken randomly throughout the length of the specimen. For calculation the Vicker's Hardness Test setup has been used. Indentation hardness test has been used to determine the hardness number using Vickers's Hardness Test. From the graph it has been observed that the maximum hardness has been obtained around 4-6% approx. The hardness becomes constant after the 6% of Boron Carbide.



Sl.No	Composition	VHN			Average
		Min	Max	Mean	
1.	5% Tungsten 2% Boron Carbide				123.00
	Specimen 1	95.70	121.60	108.65	
	Specimen 2	104.50	149.20	126.85	
	Specimen 3	102.0	165	133.50	
2.	5% Tungsten 4% Boron Carbide				157.12
	Specimen 1	109.90	191.80	150.85	
	Specimen 2	97.0	125.0	111.0	
	Specimen 3	113.30	305.70	209.50	
3.	5% Tungsten 6% Boron Carbide				161.23
	Specimen 1	106.80	186.70	146.75	
	Specimen 2	100.70	129.40	115.05	
	Specimen 3	113.20	330.60	221.90	

Table 4.12 Hardness Test Results

C. Wear

It is a process of removal of material from one or both of two solid surfaces in solid-state contact, occurring when two solid surfaces are in sliding or rolling motion together. Pin on Disc apparatus has been used to calculate the wear rate of the specimen. From the graph it has been observed that the wear rate is decreasing exponentially as the density and boron carbide increasing.

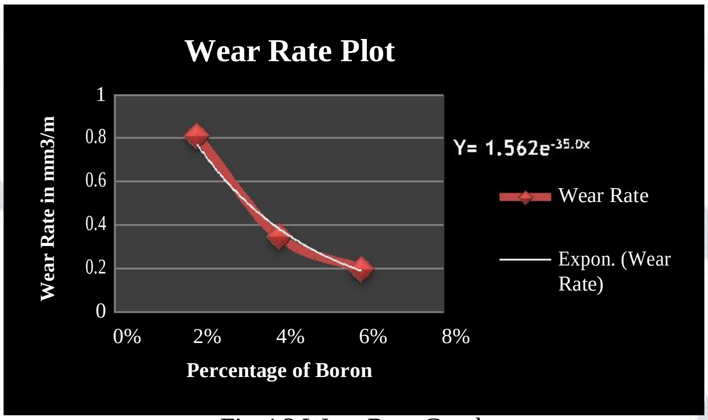


Fig 4.2 Wear Rate Graph

Sl.No	Composition	Wear Rate (mm^3/m)	Avg.Wear Rate (mm^3/m)
1.	5% Tunsten 2% Boron Carbide		0.8123
	Specimen 1	0.83426	
	Specimen 2	0.6982	
	Specimen 3	0.9044	
2.	5% Tunsten 4% Boron Carbide		0.3496
	Specimen 1	0.262	
	Specimen 2	0.2088	
	Specimen 3	0.578	
3.	5% Tunsten 6% Boron Carbide		0.1998
	Specimen 1	0.25157	
	Specimen 2	0.14478	
	Specimen 3	0.08956	

Table 4.13 Wear Test Results

D. Microstructure

It is the very small- scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25X magnification. The microstructure of a material can strongly influence physical properties such as strength, toughness, hardness and corrosion resistance. These properties in turn govern the application of these materials in industrial practice.

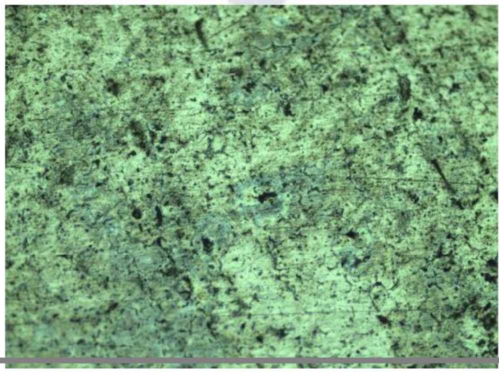


Fig 4.3 Microstructure

5. CONCLUSION

This experimental investigation into the mechanical characteristics of Aluminium 7075 reinforced with Boron Carbide and
Tungsten Carbide composites leads to the following conclusions:

A. The specimens were prepared using Stir Casting method.
B. The addition of boron carbide increases the hardness of the specimen.
C. As Boron Carbide % weight is increased the wear rate has decreased exponentially.
D. As the Boron Carbide was increased the density also increased exponentially.

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