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Examining The Mechanical Characteristics of Aluminum Alloy Reinforced BORON CARBIDE

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Abstract: Aluminum matrix composites (AMCs) have become increasingly significant in various industries due to their desirable properties, including wear resistance, low density, high strength, and excellent structural rigidity. These composites are particularly favored in aerospace, military, automotive, marine, and other domestic applications. To enhance the properties of the aluminum matrix, it is reinforced with hard ceramic particles such as SiC, Al2O3, B4C, and others. In this study, aluminum LM6 alloy was selected as the matrix material, with 25-micron-sized boron carbide (B4C) particles chosen as the reinforcement, at varying weight percentages. The composites were fabricated using the sand casting technique. The hardness and impact behavior of the prepared composites were examined. The results showed that the hardness of the LM6 alloy increased, while the impact strength decreased with the addition of B4C particles. Scanning electron microscopy (SEM) micrographs confirmed the uniform distribution of B4C particles within the aluminum alloy.

INTRODUCTION

This review examines the changes in the mechanical properties of various Al/B4C composites fabricated using the sand casting method. A metal matrix composite (MMC) consists of at least two constituent materials, one of which is a metal, while the other may be a different metal, ceramic, or organic compound. The review discusses the effects of B4C reinforcement in different aluminum alloys on mechanical properties such as hardness, tensile strength, elongation, and residual stress. Various B4C reinforcements, with different weight percentages and particle sizes, are considered along with aluminum alloys. Aluminum MMCs are widely used in various applications due to their superior mechanical and physical properties compared to base aluminum alloys. Metal matrix composites (MMCs) have emerged as an important class of materials for structural, wear, thermal, transportation, and electrical applications.

Composite materials are defined as structures composed of two or more distinct materials. The starting materials can be organic, metallic, or ceramic. The components of composite materials do not naturally occur as an alloy but are separately manufactured before being combined mechanically. The matrix is the continuous monolithic material into which the reinforcement is embedded. This means that there is a continuous path through the matrix to any point in the material, unlike two separate materials sandwiched together. In structural applications, the matrix is typically a lighter metal, such as aluminum, magnesium, or titanium, providing compliant support for the reinforcement. In high-temperature applications, cobalt and cobalt-nickel alloy matrices are commonly used. The reinforcement material is embedded into the matrix not only to reinforce the structure but also to modify properties such as wear resistance, friction coefficient, and thermal conductivity.

EXPERIMENTAL PROCEDURE:-

LITERATURE SURVEY

1. Emamy et al – Fabricated the nano composite of AA 2024 aluminium alloy matrix reinforced with different volume fraction of nanometer MoSi2 inter-metallic particles ranging from 0 to 5% by using mechanical alloying techniques. For comparison, samples without reinforcing particles and mechanical alloying and a sample with micro metric MoSi2 particles were also synthesized. The prepared composite powder was consolidated cold and hot pressing and then heat treated to solution and aged condition (T6).

2. Celis et al - Studied the tribological behavior of sintered aluminium metal matrix composite containing various volume fractions f articles made of complex metallic alloy (CMA) was investigated in a reciprocating dry sliding ambient air against 10 mm diameter Al203 balls. The al based MMC tested contained either 15 micro meter size AlCuFeB or 25 micro meter size AlCufeCr particles. An improvement in dry sliding wear resistance of aluminium was achieved by incorporation of these CMA particles acting as 2nd phase reinforcement.

3. Suresha et.al. – Studied the effect of % reinforcement; load, sliding speed and sliding distance on stir Cast Al-Sic-Gr hybrid composites, Al-Gr and Al-sic composites. Parametric studies indicate that the wear of hybrid composites has a tendency to increases beyond % reinforcement of 7.5% as its value are 0.242g, 0.0228g and 0.0234g respectively at 3%, 7.5% and 10% reinforcement.

4. Vencl et. al. – Examined and compared the structural, mechanical and tribological properties of heat treated particulate composite of A356 aluminium alloy as a matrix reinforced with ceramic particles (Al2O3, Sic) and graphite particle. Composites are prepared by composite casting process.

5. Raina et al. - studied the hardness of stir and centrifugally cast Al- B_4C functionally graded metal matrix composite with graded distribution of B_4C particles near the outer periphery of casting. Studied show that maximum of 45 and 40% B_4C particles are obtained near the outer periphery of Al (356)- B_4C and Al (2124)- B4C FGMMC casting respectively.

OBJECTIVES

1. The objective of this work is to investigate the effect of B_4C particle reinforcement on the mechanical behavior of AL LM-6 alloy. The composites with 2.5, 5 & 7.5 wt% of B_4C composite will be produced by the sand casting procedure with some special techniques. Structural, mechanical, tribological, thermal, chemical characteristics properties of alloy and composites will be studied on the basis of comparison of property best combination of reinforcement will be find out.
2. In this paper, the mechanical properties of the aluminium alloy will be checked when there is reinforcement of boron carbide by using furnaces. After reinforcing, the mechanical properties of the material will be identified by using universal testing machine, hardness testing machine.

FLOW CHART

Availabilities of Metal Matrix Composites

Problem Identification Selection

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of Composite Materials

↓

Preheating Process

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Fabrication Process Using Sand Casting

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Mechanical Testing Process

↓

Tensile Test
Hardness Test
Elongation Test

↓

Result and Discussion

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Conclusion

SAND CASTING:-

Sand casting, also known as sand molded casting, is a metal casting process characteristic using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand casting produce in specialized factories called foundries. Over 70% of metal casting produces via sand casting.

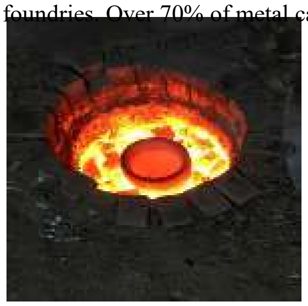


Fig.1- Furnace

Fig.2-

Fig.3- Moulding

Sand casting, also known as sand molded casting, is a metal casting process characteristic by using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via sand casting process.

Molds made of sand are relatively cheap, and sufficiently refractory even for steel foundry use. In addition to the sand, a suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened, typically with water, but sometimes with other substances, to develop the strength and plasticity of the clay and to make the aggregate suitable for molding. The sand is typically contained in a system of frames or mold boxes known as a flask. The mold cavities and gate system are created by compacting the sand around models called patterns, by carving directly into the sand, or by 3D printing.

Fig.4 - Sand Mixer

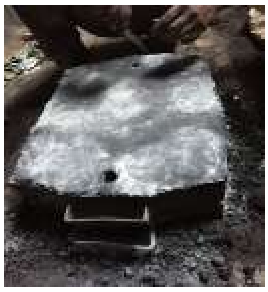


Fig.5 – sand casting mould

Fig.6 – Sand heating for fixed the sand properly

Table No. 1 – Chemical composition of Aluminium alloy (LM6)

Elements	Cu	Mg	Si	Fe	Zn	Mn	Al
% by weight	0.068	0.069	11.62	0.39	0.10	0.069	Remaining

Table No. 2 – Process parameter used for Sand Casting

Parameters	Units	Value
Temperature of Melt	^0C	850
Preheating temperature of B_4C particles	^0C	250
Preheating temperature of die	^0C	600

There are six steps in this process:

1. Place a pattern in sand to create a mold.
2. Incorporate the pattern and sand in a gating system.
3. Remove the pattern.
4. Fill the mold cavity with molten metal.
5. Allow the metal to cool.
6. Break away the sand mold and remove the casting.

RESULTS AND DISCUSSION :-

In comparison with conventional polymer matrix composites, MMC are resistant to fire can operate in wider range of temperatures, do not absorb moisture, have better electrical and thermal conductivity, are resistant to radiation, do not display out gassing.

Strengthening of composite is due to dispersion strengthening and particle reinforcement.

For the results, we have done some tests are following:

i. Tensile
ii. Hardness
iii. Elongation

TESTING RESULTS -

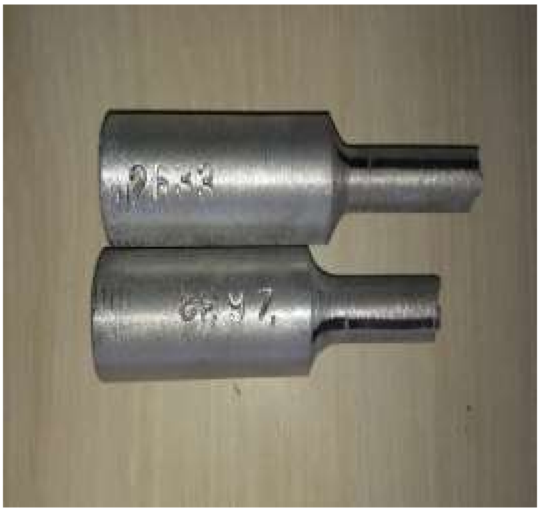
Table No. 3: Testing Results

Sample no.	Al (%)	B_4C (%)	Tensile Test (N/mm^2)	Hardness Test (HBW)	Elongation Test (%)
1	**100**	**0**	**95.0**	**2.5/46.7**	**3.66**
2	**97.5**	**2.5**	**93.8**	**2.5/47.5**	**2.92**
3	**95**	**5**	**93.4**	**2.5/48.3**	**2.76**
4	**92.5**	**7.5**	**98.5**	**2.5/48.3**	**3.70**

SPECIMAN SPECIFICATION :-

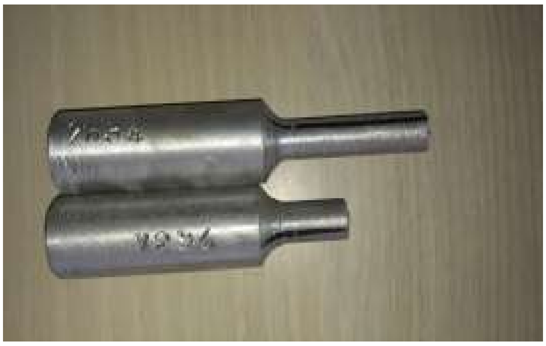
SAMPLE NO. 01

With 100% aluminium without boron carbide



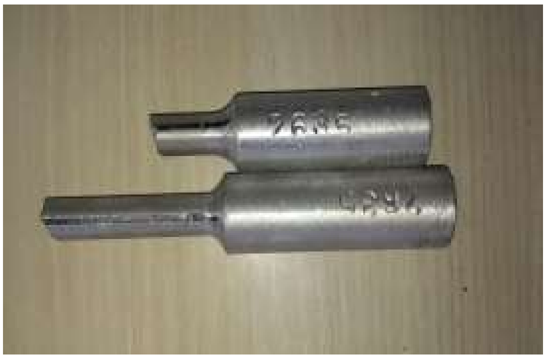
SAMPLE NO. 02

With 97.5% aluminium combined with 2.5% boron carbide



SAMPLE NO. 03

With having 95% aluminium with 5% boron carbide



SAMPLE NO. 04

With 92.5 % aluminium having 7.5% boron carbide

CONCLUSION

The Aluminium LM6/B_4C composite where produced by the sand casting route with different weight percentage of reinforcement and the microstructure, mechanical properties were evaluated. From this study, the following conclusion are derived. The strength of the grain boundaries increases to maximum level and dislocation of the atom is decreased by increasing the weight percentage of reinforcement, which gives strength to the matrix and thereby hardness of the composite gets increased. The tensile strength is increased as the yeild strength is also increased. The B_4C reinforcement has reduced the impact strength of Aluminium Matrix Composite. It is observed that the toughness is decreased by increasing the weight percentage of the B_4C particles in the composite. This is due to the addition of B_4c in various percentages with Aluminium, The Brittleness of the material also increased. Because of high brittleness, the impact strength of the material is decresed.

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