Investigation of Mechanical Properties of Engineering Material Using Powder Metallurgy Method

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Abstract *- The boron carbide is most promising alternative reinforcement material for the metal matrix composites. Also alumina reinforcement is used commercially for various automotive applications .The present work is focused on the manufacturing of aluminum matrix composites (AMCs) by powder metallurgy technique. These reinforcement materials are reinforced with pure aluminium in a certain amount by weight percentage in between that use ethanol as a binder. After preparation of homogeneous mixture compaction is carried out on universal testing machine. The sintering is carried out in muffle furnace at 600 ^{0}-650 ^{0} temperature for the period of certain hours. The specimens were allowed to cool at normal atmosphere inside the muffle furnace. After complete preparation of specimen by powder metallurgy technique, specimens were tested to identify the compressive strength and hardness of the AMCs. It is observed that due to addition of reinforcement materials in pure aluminium compressive strength and hardness of material increases with increase in percentage reinforcement. This study will useful in material that plays vital role in the light weight application such as aerospace, automobile and sporting industries.*

Keywords - Aluminium(Al), Boron carbide (B4C), Aluminium Matrix Composites (AMCs), Powder Metallurgy(PM), Metal matrix composite (MMC).

I. INTRODUCTION

Aluminium (Al) is most abundant metal in earth's crust. Aluminium acquires about 8% by weight of Earth's solid surface. Al is widely used due to its availability, high strength to weight ratio, due to enhanced machinability, durability, ductility and malleability.

Aluminum Matrix Composites (AMC):

The purpose of developing Aluminum matrix composite (AMC) materials is to combine the desirable properties of metal and ceramics. The major advantages of Aluminum matrix composites compared to unreinforced materials are greater strength, improved stiffness, reduced density, improved temperature properties, controlled thermal expansion and improved wear resistance.

For these applications, composites are necessary:

a. To increase mechanical strength as well as tribological properties
b. To maintain strength/stiffness at high strength.
c. To improve high strength to weight ratio.
d. To reduce cost.
e. To increase corrosion resistance.
f. To increase secondary use and recyclability.
g. To reduce hazardous effect on environment.

Necessity of Reinforcement in Aluminum:

Aluminum is widely used as a structural material especially in the aerospace industry because of its light weight property. But, the low strength and low melting point were always a problem. A cheap method of solving this problem was the use of reinforcement elements such as Fly ash, SiO2, Bagasse ash, Al2O3, B4C, SiC.

II. LITERATURE REVIEW

S. G. Kulkarniet. al (2014) [1]: The aluminum matrix composites have the wide range of applications in the field of aerospace, structural, marine, automotive, etc. Method used to manufacture the aluminium matrix composite is stir casting which is cost effective technique. In current work hybrid reinforcement of fly ash along with alumina is used to their mechanical characteristics. The major advantage behind the use of fly ash is helps to reduce the density of AMCs. Finally author state that fly can be used successfully as a reinforcement material and it possesses low density and compatible mechanical properties.

Imranhusen N. Pirjade et. al (2016)[3]: This paper reviews the manufacturing of aluminum matrix composites by powder metallurgy (P/M) process. These reinforcement materials are reinforced with pure aluminium in a 5%, 10% and 15% by weight percentage in between that use ethanol as a binder. After preparation of homogeneous mixture compaction is carried out on universal testing machine. The sintering is carried out in muffle furnace at 630^0 C for the period of 2 hr.

The specimens were allowed to cool at normal atmosphere inside the muffle furnace. After complete preparation of specimen by powder metallurgy technique, specimens were tested to identify the lateral compressive strength of the AMCs. And conclusion is the lateral compressive strength of fly ash, bagasse ash and alumina increases with increase in percentage reinforcement than pure aluminum.

III. SPECIMEN MANUFACTURING PROCESS

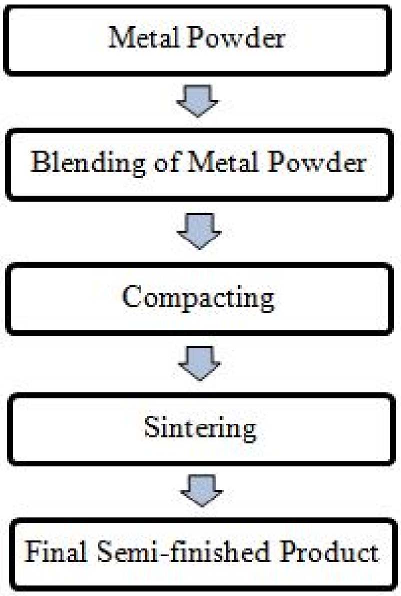

Fig.1 Powder Metallurgical Process

IV. TABLE 1 MECHANICAL ALLOYING ELEMENTS IN DIFFERENT WEIGHT PERCENTAGE

Sr. No.	Material	% Reinforcement
1	Pure Aluminum	100% Al
2	10% Al- B_4C composites	90% Al + 10% B_4C
3	20% Al- B_4C composites	80% Al + 20% B_4C
4	30% Al- B_4C composites	70% Al + 30% B_4C
5	10% Al-mica composites	90% Al + 10%Mica
6	20% Al-mica composites	80% Al + 20%Mica
7	30% Al-mica composites	70% Al + 30%Mica

V. COMPRESSION TEST OF SPECIMENS

Parameters

a. Compressive strength : Load In KN
b. Load Application time : 10 to 15 min
c. Machine : Universal Testing Machine
d. Maximum Load of Machine : 1000 KN
e. Temperature : 30^0C

Table no.2 Compressive strength of all sintered specimen:

Sr. no.	% Reinforcement	Compression Load	% Increment / Decrement
1	Pure Aluminum	202	-
2	10% Boron Carbide	235	16.33 ↑
3	20%Boron Carbide	246	21.78 ↑
4	30%Boron Carbide	309	52.97 ↑
5	10% Mica	162	19.80 ↓
6	20% Mica	106	47.52 ↓

VI. HARDNESS TEST OF SPECIMENS:

For Brinell hardness test, the hardness of materials are test by pressing a steel ball or tungsten carbide ball for a time of 10 to 15 seconds into the surface of specimen by a standard load *F* [kgf]. After that, the diameter of the indentation d [mm] is measured when the load is removed.

BHN is calculated by following formula:

$$BHN = \frac{2F}{\pi * D(D-\sqrt{D^2-d^2})}$$

Where

F = Load in Kgf
D = Diameter of indenter
d = indentation diameter on specimen

Table no.3BrinellHardness tests pure Aluminum and composite material:

Sr. No.	Reinforcement	Load Applied (kgf)	Ball Diameter (mm)	Indentation Diameter (mm)	Brinell Hardness No.
1	Pure Aluminum	187.5	2.5	2.1	42
2	Aluminum+10% Boron Carbide	187.5	2.5	2.05	44
3	Aluminum+20% boron carbide	187.5	2.5	2	48
4	Aluminum+30% baoron carbide	187.5	2.5	1.9	55
5	Aluminum+10% mica	187.5	2.5	2.45	24
6	Aluminum+20% mica	187.5	2.5	2.49	27

VII. CONCLUSION

From table 2.it is clearly seen that, the Compressive strength of Boron Carbide reinforced material increases with increase in percentage reinforcement due to resistance offered by reinforcement particle. And the Compressive Strength of mica reinforced metal composite Decreases with increase in percentage reinforcement material.

Hence compressive strength=B4C > Pure Al > mica

From table 3.it is observed that as the % reinforcement increases the brinell hardness number of theB4C reinforced specimen and decreased for micareinforced specimen.

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