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Study of Hardness of Al-SiC Composites Using Powder Metallurgy

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ABSTRACT

In this study, Aluminum metal matrix composites containing several weight percentages of reinforcement particles were prepared using powder metallurgy method. The study presents the results of experimental investigation on mechanical behavior of silicon carbide particle reinforced aluminum matrix. The effect of reinforced ratio of 20, 25 and 30 weight percentage of silicon carbide particles on mechanical behavior was examined. The effect of weight percentage of silicon carbide on hardness of composites was investigated by using Vickers hardness Test. It was observed that the distribution of silicon carbide particles was uniform. The hardness of the composites decreased with increasing reinforcement element addition in it.

Keywords:- Hardness, Powder Metallurgy, Al-SiC Composite,

1. INTRODUCTION:

Silicon carbide particle reinforced aluminum matrix composites have been developed over past few decades, owing to their excellent properties like light weight, high elastic modulus and wear resistance. Thus, the silicon carbide particle reinforced aluminum matrix composites are expected to have many applications in aerospace, aircraft, automobile and electronic industries.The main steps in powder metallurgy are blending, compacting and sintering. The experiments were performed on different composition of silicon carbide powder in the composite.

Powder metallurgy (PM) is a net shape forming process consisting of producing metal powder, blending them, compacting them in dies, and sintering them to impart strength, hardness and toughness. Although the size and the weight of its products are limited, the PM process is capable of producing relatively complex parts economically, in net shape form and wide variety of metal and alloy powders.

Basically, in the conventional PM production, after the metallic powders have been produced, the sequence consists of three steps. Firstly, blending and mixing the powder, and then compaction, in which the powders are pressed into the desired part shape. The last step of PM method is sintering, which involves heating to a temperature below the melting point to cause solid state bonding of the particles and strengthening the part. Blending refers to when powders of the same chemical composition but possibly different chemistries being combine. After that, in compaction (pressing), high pressure is applied to the powders to form them into the required shape. The pressure required for pressing metal powders ranges from 70MPa (for Al) to 800MPa (for high density iron parts). After pressing, the green compact lacks strength and hardness. Sintering is a heat treatment operation performed on the compact to bond its metallic particles. Sintering is a high temperature process used to develop the final properties of the component.

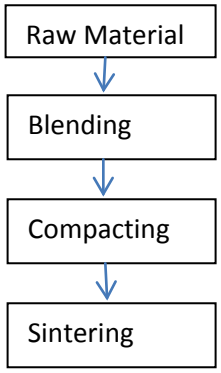


Figure 1: Flow chart of powder metallurgy method

In past, **Li and Mohamed** presented the work on the creep behavior of power metallurgy (PM) 10 vol.% silicon carbide particulate reinforced 2124 aluminum (SiC 2124 Al composite) was studied under experimental conditions identical with those used in an earlier investigation on the unreinforced matrix alloy, PM 2124 Al. The results show that the creep behavior of PM 10 vol.% SiC 2124 Al composite is similar to that of PM 2124 Al with regard to:

(a) the variation in both the apparent stress exponent and the apparent activation energy for creep with applied stress, (b) the value of the true stress exponent (n = 4.5), (c) the value of the true activation energy for creep ($Q_c \approx Q_D$), (d) the interpretation of creep in terms of a threshold stress and (e) the temperature dependence of the threshold stress. Sun et. al. explained about extrusion and temperature.The extrusion and increase of the sintering temperature can break up the oxide coating on the matrix powder surfaces, decrease the number of pores, accelerate the elements' diffusion and increase the density and particle interfacial bonding strength, thus significantly improving the mechanical properties of the composite. Sahin & Acilar studied the effect of SiC volume fraction on the physical properties and hardness of Al/SiCp composites. Composites were produced by the vacuum infiltration technique using an alloy Al-9.42 %Si-0.36 % Mg (wt. %) and up to 55 vol. % SiC. Results showed that hardness and density of the composite increased with increasing load and increasing particle content. G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj concluded that the density of the composites increases with the incorporation of the hard ceramic reinforcement into the matrix material. In view of the above conclusions on density, experiments were conducted on the Al6061-SiC and Al7075-Al2O3 to determine the density by weight to volume ratio and by rule of mixture. The experimental and theoretical densities of the composites were found to be in line with each other. There is an increase in the density of the composites compared to the base matrix.

In this study, three specimen of the composite is produced with different weight percentage of SiC which are 20%, 25% & 30% to investigate the effect on mechanical behavior on the composites. From the specimens that have been produced by the PM method, then they will be analyzed on microstructure and the hardness using the standardized testing method.

Objective

1. To develop the Al metal matrix with silicon carbide at different percentage.
2. Develop the pieces with powder metallurgy method.
3. Hardness test of the specimen

2. Methodology

The specimens that are to be produced by powder metallurgy are pressed using hydraulic press under the load of 3 Ton. The sintering temperature is around 350 degree centigrade for about 2 hours.

It is decided that three pieces with different weight percentage of Sic will be produced. The percentage of Sic will be 20% ,25% and 30%. The different composition of the composites is shown in table 1,

It is noted from the literature survey and with the consultation of the workshop heads that losses will also encountered in the process. Losses in powder metallurgy are 10% approx.

But as we said earlier that losses are not so heavy in powder metallurgy so we require less weight of powder. The compositions are discussed below in table 1

Table 1:

Composition	Weight of Al	Weight of Sic	Total weight
Al+20% Sic	80 gm	20 gm	100 gm
Al+25% Sic	75 gm	25 gm	100 gm
Al+30% Sic	70 gm	30 gm	100 gm

It is decided that the dimension of the specimen should be enough so that no difficulty will be encountered in the testing of the specimen on various machines. So diameter of 25.4 mm will be taken and length varies as according to the test.

3. Experimental Procedure

3.1 Materials Used

- AL A1 GRADE (Powder form)
- SILICON CARBIDE (Powder form)

3.2 Apparatus Used

- Hydraulic Press
- Furnace
- Dies
- Electronic weight machine

3.3 Procedure for Powder Metallurgy

Basic experiments were conducted on Aluminum Alloys metal powder

Aluminum Powder

Atomized Aluminum powder of purity 99.5% and finer than 100 □m was used

Silicon Powder

Silicon powder which was used pure up to 99.5% Powder was very fine.

Preparation of Specimens and Density Measurement

In the preparation of metal powder compacts the following steps are necessary:

- Die preparation
- Compaction

- Sintering
- Polishing
- Testing

Die preparation

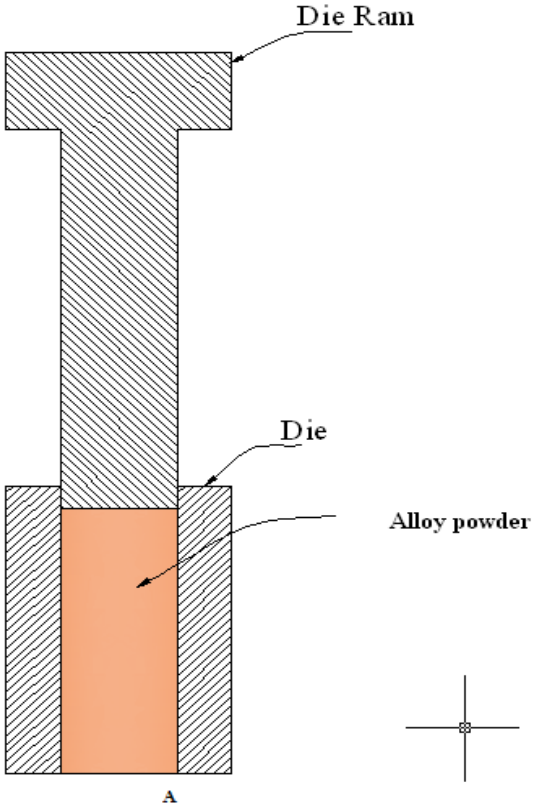
Firstly we made two dies (rectangular, hexagonal) for filling the powder in these, so that we can get the specimen as our required shape and size.

Compaction

For compaction firstly the powder material is filled in the die, in which Aluminum powder is filled up in the die. Aluminum Alloys powder was compacted in a closed hexagonal die using a hydraulic press at various recorded pressures for the different composition of the Aluminum Alloys. The die wall was lubricated with fine graphite powder, after that compaction is done by the help of hydraulic press as shown in fig 2, on which dies are placed and after then pressure is applied as our requirement.

Sintering

The basic purpose of sintering is to develop mechanical strength in the metal powder compacts as shown in fig 3. Sintering of aluminum compacts was carried out at 300° C and for two hours in an endothermic sand atmosphere. All sintering operations were carried out in a muffle type silicon carbide furnace capable of providing sintering temperature of an accuracy of C. In order to minimize the non-uniformity of density distribution, the sintered compacts were re-pressed at the same compaction pressure in the same die. The specimens were re-sintered at the same temperature and time.



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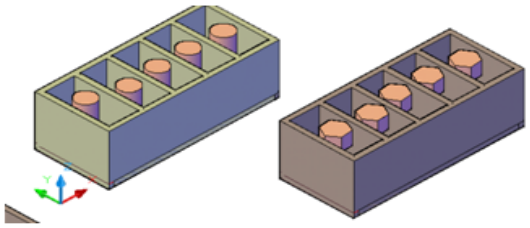

B

C

Figure (A) 2: Filling of Al-SiC powder material (Compaction), Figure (B) 3: Sintering, Figure (C) 4: Final rod of composite material

4. Results and Discussion

Rod of composite material is obtained using powder metallurgy as shown in fig 4. Wastage in PM method is less (~ 10%), tabulated in table 2.

Table 2: Composition of final rod

Sr. no.	Al grade	Al wt. (gm)	% wt. SiC (gm)	Total Weight (gm)	Specimen Wt. (gm)	Wastage (gm)
1	A1	80	20	100	90	10
2	A1	75	25	100	90	10

3	A1	70	30	100	90	10

It is observed from the hardness test that when concentration of the SiCis increases the hardness of Al-SiC specimens is decreases as tabulated in table 3.

Table 3: Results of hardness of Al-SiC

MATERIALS	20% SiC	25% SiC	30% SiC
A1	14(HV 0.1)	13(HV 0.1)	11(HV 0.1)

Where HV is Vicker's hardness

Conclusion

Powder metallurgy method is carried out to obtain a rod of composite material (Al-SiC). It is observed in past by various authors that hardness is increased with increase in percentage of SiC up to 20%. And it is observed from this study that hardness decreases with increase in percentage of SiC from 20% to 30%.

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