Study on Effect of Compaction Pressure For 10% of Silicon Carbide Particulate Reinforced With Aluminium Composite Through Powder metallurgy

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Abstract*- Here the work aims to study the effect of compaction conditions for Aluminium Matrix Composite (AMC). . Through powder metallurgy technique Al Composites are prepared where pure aluminium powder is the base metal and weight percentage of 10% of SiC particulate is reinforced with base metal. The compaction pressure needed for producing green compacts was optimized and relation between pressure and densities was established. The green density, sintered density, porosity, and micro Vickers hardness measurement was performed on fabricated Al-SiCp composites of 10% of SiC under varying compacting pressure. From the experiment it is observed that 10% of SiC has an optimized pressure of 509 MPa, which was used for producing green compacts. The measured green density of Al-SiCp composites increases with increases in compaction pressure and porosity decrease with increases in compaction pressure. The micro Vickers hardness number increasing on increasing the compacting pressure.*

Keywords- Aluminium Matrix composite, Pure Aluminium Powder, Silicon carbide particulates, Powder Metallurgy, Sintering, Densities, Micro Vickers Hardness.

I. INTRODUCTION

Aluminium metal matrix composites have the potentials of satisfying the recent demands of superior engineering applications. These demands are met due to improved mechanical properties like high strength to weight ratio, low cost. The performance of composite materials is mostly dependent on selecting the correct combination of the reinforcing particulates. Boron carbide (B4C) is a very hard material with superior tribological properties, corrosion resistance, and mechanical properties, as it is a desirable material for a wide range of engineering applications. B4C has superior ballistic uniqueness due to its excellent hardness, low density, high refractory strength, high melting point and thermal stability. It is extensively adopted in refractory applications where high-resistance materials are required, such as ballistic shield for tank body armor, and as a neutron radiation absorber in the nuclear-power plant industry [1, 2]. Aluminum MMCs have improved material properties such as ultimate tensile strength, elastic modulus, hardness at roomand elevated temperatures and major weight savings compared to unreinforced alloys. Powder metallurgy (PM) is the method of merging/mixing fine pulverized powder materials and followed by pressing them into a preferred shape or form (compacting), and then heating the green specimen in a controlled environment to bond the material (sintering). The powder metallurgy procedure usually consists of four essential steps: pulverization of powder, powder mixing, pressing/compacting, and sintering. Pressing is generally done at room temperature and also elevated-temperature; Sintering Process is usually performed at atmospheric pressure [3, 4, 5,6].

It was investigated that as increase in weight percentage of SiCP from 5 to 30 the compressive strength, porosity, density, hardness and indirect tensile strength of Al-SiCP composites were found to be increased. Mechanical alloying i.e., mixing of powders from 5 to 30 weight % of SiCP results in enhancement of compressive strength and hardness of Al- SiCP composites. The scanning electron microscope is used to study the microstructure of polished and etched surfaces of powder metal Al-SiCp composite samples[7].

II. EXPERIMENTALPROCEDURE

In present work powder metallurgy technique was used for fabrication of metal matrix composites, where 90%Al and 10%SiC was mechanically mixed by using Ball mill. The mixed powders were compacted in a closed die. Compaction of the mixed materials was done by using a die for the required shape and size in a universal testing machine. Then the compacted sample is heated in a tubular furnace at controlled atmosphere, which is usually known as sintering. In this process, bonding of powder particles will takes place to form the final shape and size.

2.1 Mixing of powders

The Aluminum and SiC powders were weighed individually and mixtures were prepared. The Ball mill was run at 500 rpm for 10 minutes. The powder becomes hot during milling therefore it is allowed to cool for 5 minutes then it is taken out of the vials and stored in plastic containers.

2.2 Compacting

In this stage the mixed powder material gets desired shape. Compacting was be done by die pressing, uniaxial press setup is shown in figure 1 & 2.

During compaction process, the mixed powder was taken in to the die and pressure is applied on the powder with a punch. On applying pressure, the bonding of the particles will form by cohesion and adhesion among the powder particles. Thus forming the green strength for the compacts. During compaction process, the gaps or voids between the powder particles will reduce and contact area between powder particles will increase thus the density of the compacted specimen will increases.

Figure 1. Cylindrical die

Figure 2. Universal Testing Machine (UTM)

2.3 GreenCompact

The green compacts have been produced at different pressures using Universal Testing Machine (UTM).

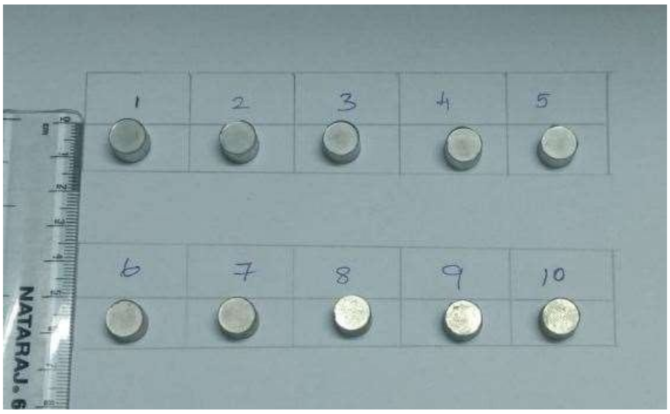

Figure 3. Prepared Green compacts

The Figure 3 (a) shows the Green compacts prepared at 10%, of SiC at varying loads.

2.4 Green Density

Archimedes principle was used for measuring the densitiesof the samples. The green density can be calculated by measuring the mass of the compact specimen and volume of the compact specimen. Hence each cylindrical sample was weighed in air (Wa), then suspended in distilled water and weighed again (Ww). Theoretical density of Aluminum and SiCp matrix composite was determined from the equation(1).

$$\delta e = [Wa/(Wa - Ww)] * \delta w \quad (1)$$

where δe is the experimental density, Wa is the mass of the cylindrical sample in air, Ww is the mass in distilled water, and δw is the density of distilled water. The sample was weighed using a balance with an accuracy of 0.005mg.

2.5 Sintering

Sintering was the process of bonding the mixed particles together at elevated temperatures. This elevated temperature is called as sintering temperature. At sintering temperature, the green compacts are maintained in inert atmosphere for particle bonding. Sintering in tubular furnace cannot reach directly to the sintering temperature. The temperature must be raised at certain rate, so that uniform distribution temperature is achieved. The green compact specimens were sintered using a tubular furnace as shown in Figure 4. The temperature was set to 600ºC with a heating rate of 5ºC/min. At this temperature, a holding time of 20 minutes was maintained. Then the specimens were allowed to cool in the furnace in order to reach the roomtemperature.

Figure 4. Tubular Furnace

The green compacts prepared by applying varying pressure have been sintered at 600˚C using tubular furnace as shown in figure 5.


Figure 5. Sintered Samples

III. RESULTS ANDDISCUSSION

3.1 Compacting Pressure for GreenCompact

The combination of 10% of SiC in weight percentage is reinforced with pure aluminium to produce AMC. The green compacts have been produced by applying pressure, using UTM as shown in Figure 2.

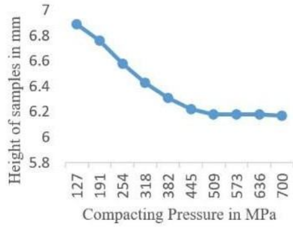

Figure 6.1. Compacting Pressure for Green Compact

The Figure 6.1 shows the optimization ofcompacting pressure for green compact which are produced at different pressure. It is observed that 10% of SiC has an optimized pressure of 509 MPa, which was used for producing further green compacts.

3.2 Green DensityMeasurement

The densities for the samples were measured by using Archimedes principle.

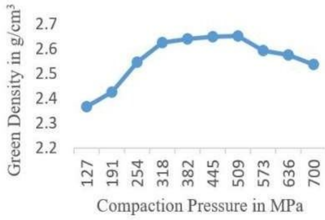

Figure 6.2. Green Density of Samples at Different Pressure

From the Figure 6.2, it shows that at low compacting pressure the density of the green compact is low and on increasing the compacting pressure the density of green compacts also increases until it reaches the optimized compacting pressure. On further increasing the compacting pressure, the green density of samples decreases. For the optimized compacting pressure of 10% SiC reinforced with pure aluminium samples, the green density where found to be 2.651g/cm3.

3.3 Sintered Density Measurement

The method used for the determination of sintered density is similar to those which have already been described for the determination of greendensity.

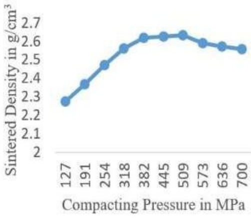

Figure 6.3.

Sintered Density of Samples at Different Pressure. From the Figure 6.3, it shows that at low compacting pressure the density of the sintered samples is low and on increasing the compacting pressure the density of sintered samples also increases until it reaches the optimized compacting pressure. For the optimized compacting pressure of 10% SiC reinforced with pure aluminium samples, the sintered density was found to be 2.635 g/cm3.

3.4 Porosity Measurement

It is very difficult to eliminate porosity in Powder Metallurgy parts produced after sintering. The total porosity present in the sintered part may be calculated from the following relationship is shown in Eqn. (2)

$$P = 1 - \frac{Pp}{Ps} \quad (2)$$

Where P = Frictional porosity, Pp = the density of the sintered sample and Ps = the density of slid material.

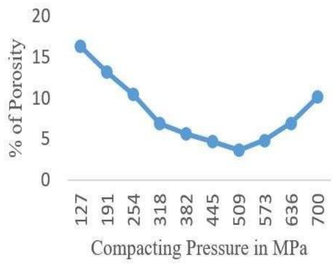

Figure 6.4. Percentage of Porosity in Sintered Samples

From the Figure 6.4, it shows that at low compacting pressurethe porosity of the sintered samples is high and on increasing the compacting pressure the porosity of sintered samples also decreases until it reaches the optimized compacting pressure. When increased the porosity level of the composites the experimental densities were reduced and vice versa. At optimized compacting pressure, the porosity percentage was found to be 3.62.

3.5 Micro Hardness Measurement

The micro Vickers hardness of powder metal Al-SiCp composites increases with increase in compacting pressure. This is because the embedding of the SiC particles uniformly into the aluminum matrix.

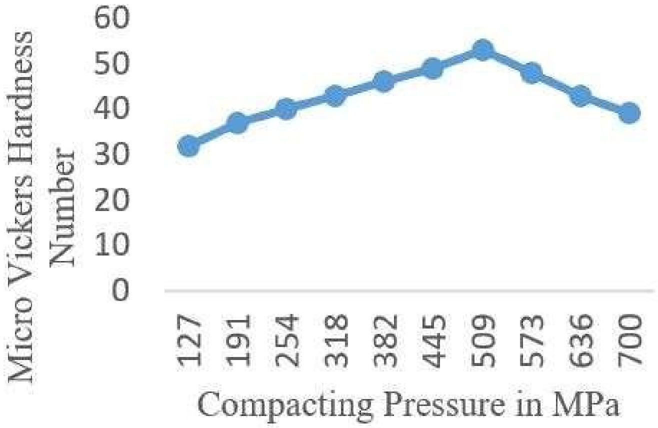

Figure 6.5. Micro Vickers Hardness Numbers of Sintered Samples.

The values shown in the graph are average of the five readings for each composition of the composite and the scatter of the actual hardness values about the average was limited to within ± 5 % of the average hardness values for the Al-SiCp composite samples. The presence of porosity in the samples desires the hardness of the sintered sample. For the optimized compacting pressure of 10% SiC reinforced with pure aluminium samples, the Micro Vickers Hardness number was found to be 53HV.

IV. CONCLUSION

The Al-SiCp composites where pure aluminium powder is the base metal and weight percentage of 10% SiC particulate is the reinforcement was fabricated through Powder Metallurgy technique. From the experiment, it shows that the height of green compact decreases on increasing pressure and remains constant after attains the compacting pressure. The density of green compacts also increases until it reaches the optimized compacting pressure. The density of sintered samples also increases until it reaches the optimized compacting pressure. When the porosity level of the composites increases the experimental densities were reduced and vice versa. The micro Vickers hardness of powder metal Al-SiCp composites increases until it reaches the optimized compacting pressure.

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