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MICROSTRUCTURE AND MECHANICAL PROPERTIES OF ALUMINUM- SILICON CARBIDE COMPOSITE FABRICATED BY POWDER METALLURGY

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Abstract. The aluminum powder is mixed with silicon carbide powder with parameters of 0, 0.7, 1.3 and 2 hours milling time. The ball mill type planetary PM 400 with stainless steel jar and zirconium balls with ball to powder ratio 10:1and rotation speed 200 rpm. The silicon carbide reinforcement 10% and the rest aluminum, then the milled powders compacted to samples in stainless steel mold. The maximum hardness at 1.3 hour milling time after this value the hardness starts to drop. With increasing the milling time were observed improvement of the dispersion of silicon carbide in aluminum matrix.

Keywords Milling time; particles size reduction; reinforcement dispersion; mechanical properties.

1.0 INTRODUCTION

Aluminum alloys reinforced with ceramic particulates have significant potential for structural applications due to their high specific strength and stiffness as well as low density. These properties have made particle-reinforced metal matrix composites (MMCs) an attractive candidate for the use in weight-sensitive and stiffness-critical components in aerospace, transportation and industrial sectors

[1]. The Al-SiC composites have seen most wide spread applications and hold the greatest promise for future growth because of their tailorable properties, good forming characteristics and the availability of comparatively low cost, high volume production methods. Aluminum based composite powders are highly compressible. Typically, green densities of more than 90 % of theoretical can be obtained utilizing low compacting pressures, (about 200MPa), allowing the use of presses with smaller capacity. Sintering of Al-SiC composite parts is more energy efficient than for most other PM materials due to the relatively low sintering temperatures. Due to the low density of Al-SiC composites, more than twice number of parts can be manufactured from unit weight of powder as compared to ferrous or copper based powders. During last 15 years various researchers have reported the fabrication of Al-SiC composites and testing of their properties like tensile strength, hardness, wear resistance and microstructural characterization. Most of the researchers have observed an increase in tensile strength, hardness and wear resistance while decrease in ductility with increase in reinforcement content. Several researchers have studied the mechanical alloying of aluminum and SiC powders and identified improvement in mechanical properties of the Al-SiC composites made from mechanical alloyed powders [2].

2.0 EXPERIMENTAL

Aluminum powder is mixed by ball mill with 10% silicon carbide as reinforcement material in the air as atmosphere media, the compacted samples with dimensions of 8mm in height and 15mm in diameter, then the milled powders compacted to samples in stainless steel mold under 10 tons pressure (cold pressing) and sintered with 550° C for 5 hours The X- ray diffraction for the powders before mixing can shows in figure1.

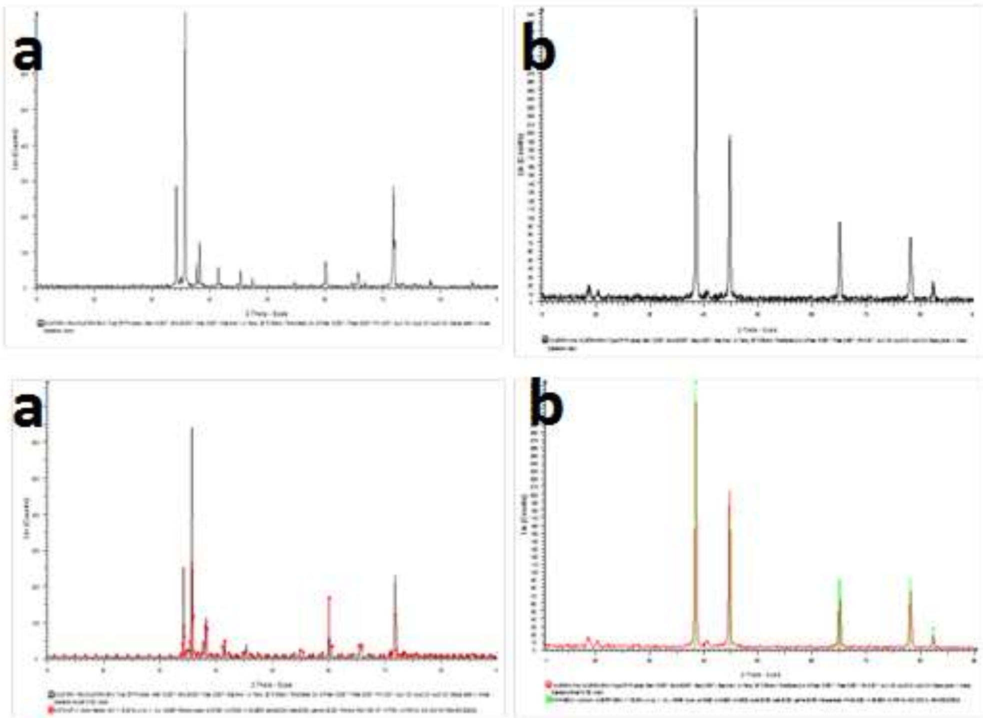

Figure 1: X-RAY diffraction (XRD) of 5%SiC-Al composite powder shows matching of the peaks; (a) for silicon carbide and (b) for aluminum.

3.0 RESULTS AND DISCUSSION

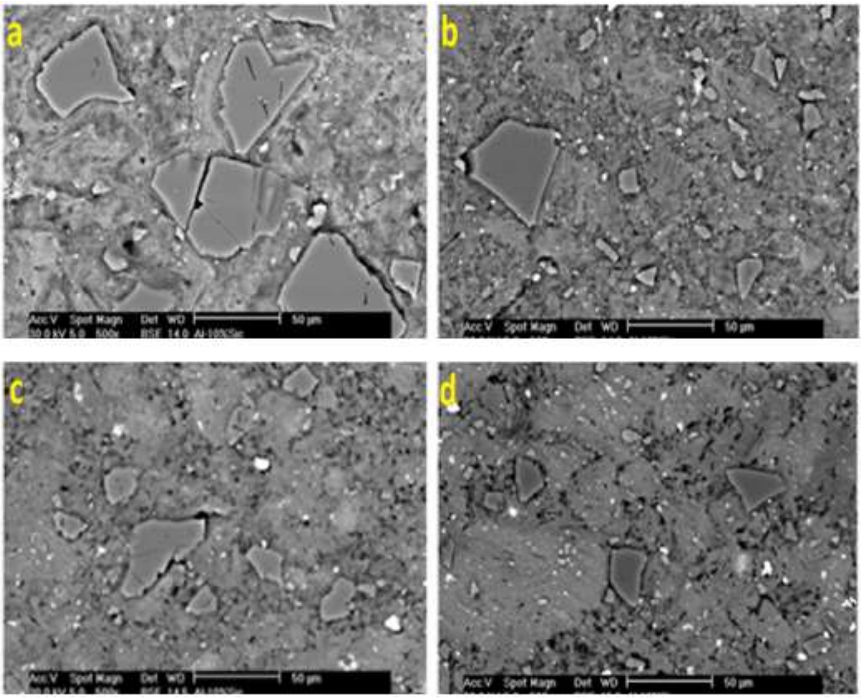

Figure 2: SEM microscope images of 10% SiC- Al sample after hydraulic press and sintering of 550 °C for 5 hour at (a) 0; (b) 0.7; (c) 1.3 and (d) 2 hours milling time.

In Figure 2 the particles size for silicon carbide decreases with the increasing of milling time that causes increasing in the hardness of the compacted and sintered samples of Al- 10% SiC composites, maximum hardness at 1.3 hours milling time but the hardness decreases after 1.3 hours milling time due to segregation of aluminum matrix caused by work hardness and dislocations motion, the work hardness lead to aluminum matrix elongation causes lattice strain and segregation. Also the porosity around the silicon carbide decreases with increasing the milling time. The hardness test were applied is Vickers hardness with three spots taken for each sample shows that for 0 hours milling time the hardness between the three spots so deferent due to bad dispersion of silicon carbide in aluminum matrix while with increasing the milling time the value of the hardness become little pit same for all spots of one sample that due to improvement of silicon carbide particles dispersion in aluminum matrix as shown in the table below:

Table 1 dispersion of silicon carbide particles of Al- 10% SiC

Sample number	Hardness (HV) / Milling time (hours)	First spot	Second spot	Third spot
1	0	77	108	89
2	0.7	151	160	139
3	1.3	177	173	175
4	2	129	131	130

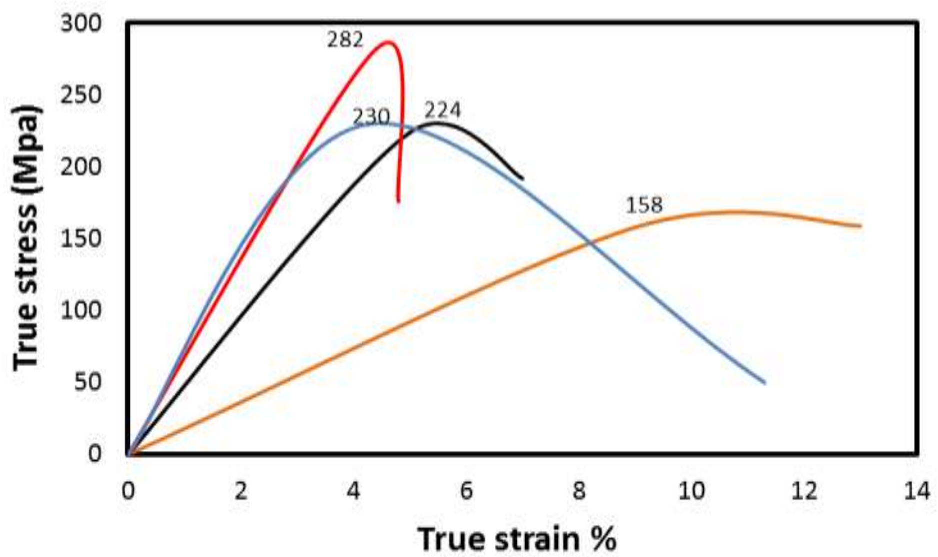

Figure 3: Compressive test of Al- 10%SiC; (a) The yellow line at 0 hour milling time, (b) The black line at 0.7 hour milling time, (c) The red line at 1.3 hour milling time and (d) The blue line at 2 hours milling time.

Figure 3 for (a) at 0 hour shows the maximum compressive strength at 158Mpa with the increasing in milling time, of (b) at 0.7 hour milling time the compressive strength increased to 224Mpa, while (c) at 1.3 hour milling time the compressive strength increased to 282Mpa and for (d) at 2 hours milling time the compressive strength starts to drop to 230Mpa due to work hardness and the increasing of the temperature causes segregation.

4.0 CONCLUSIONS

The particles size decreases with increasing of the milling time and the hardness also increases with increasing of the milling time, maximum hardness and compressive strength at 1.3 hour milling time with increasing milling time the hardness starts to drop which reach the minimum at 2 hours due to work hardness that causes increasing in the temperature and aluminum matrix aggregation. While, with increasing the milling time the porosity around the silicon carbide particles starts to disappear, with the increasing of the milling time the dispersion of silicon carbide in aluminum matrix were improved.

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