EFFECT OF POROSITY ON MECHANICAL PROPERTIES OF ALUMINUM-FLY ASH COMPOSITE

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Abstract

Aluminum matrix composite (AMC) were prepared from aluminum fine powder as a matrix and fly ash as reinforcement. The amount of fly ash of 2,5%, 5%, 7,5% and 10 wt% was added to the aluminum fine powder. Each composition was mixed using rotary mixer for 3 hr. The mixture was compacted using uniaxial compaction with a pressure of 100 MPa to produce green body and several of it was isostatic compacted with a pressure 100 MPa. Several of each green body were followed pressureless sintering at various temperature of 500°, 525°, 550°,575° and 600ºC for 3 hr, and the other of uniaxial compacted green body were hot pressed sintering (HP) at pressure of 100 MPa and various temperature of 525°, 550° and 575°C. Bending strength, Vickers hardness, wear resistance, porosity of the AMC were tested, and the micro structure observed using SEM. The results show that the bending strength, Vickers hardness and wear resistance of AMC increase with decreasing of porosity. The bending strength, Vickers hardness and wear resistance of 6.3% porosity of hot pressed AMC are 65 MPa, 55 VHN and 0.15 mg/(MPa.m), respectively. The bending strength, Vickers hardness and wear resistance of 3 % porosity of hot pressed AMC are 79 MPa, 75 VHN and 0.02 mg/(MPa.m), respectively.

Key words : AMC, compaction, sintering

1. INTRODUCTION

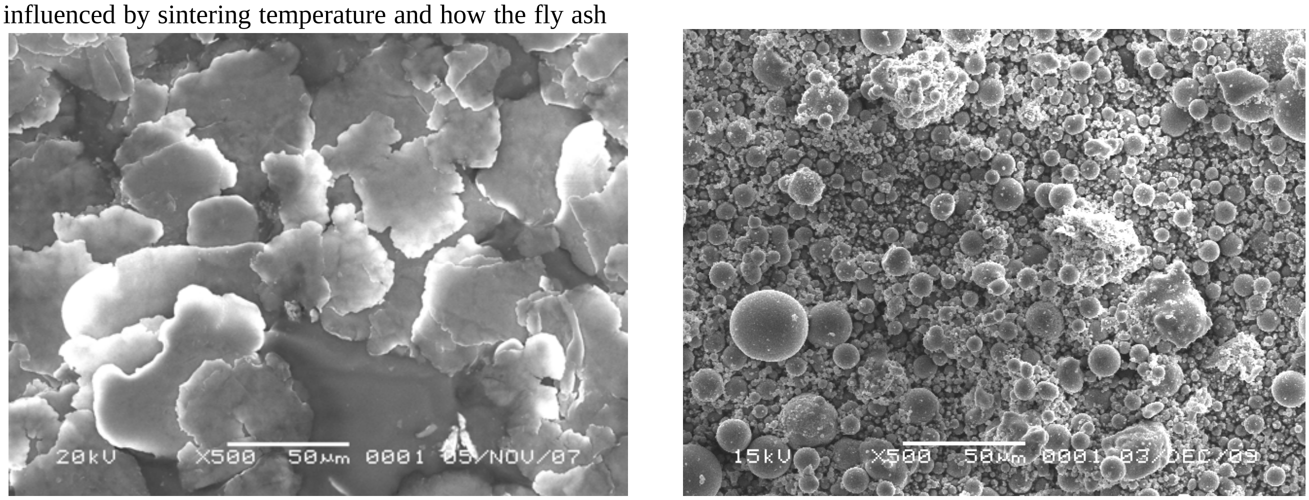
Aluminum Matrix composite has been made, it was manufactured using hot pressing followed by hot extrusion of aluminum powder reinforced by alumina particles. Under tensile as well as compressive loads, a strength improvement of 64 to 100% compared to the matrix material strength was obtained. The percent elongation to fracture ranged from 20 to 30%, which indicates good ductility as compared to the ductility of AMC manufactured by another techniques [1]. Wear properties of stir-cast A356 aluminum alloy 5 vol % fly ash composite against hard SiC abrasive paper have tested and compared to those of the A356 base alloy. The results indicate that the abrasive wear resistance of aluminum- fly ash composite is similar to that of aluminum-alumina fiber composite and is superior to that of the matrix alloy for low loads up to 8 N on the pin. At the loads greater than 8N, the wear resistance of aluminum- fly ash composite is reduced by debonding and fracture of fly ash particles [2]. It was similar but composite produced using powder metallurgy technique. Density, hardness and strength of the AMCs were determined as a function of weight per cent of fly ash particles. The results in slight decease in density and strength of AMC with increasing weight per cent of fly ash, the hardness find to increases slightly up to 10 wt % fly ash, beyond with it decrease [3]. The similar AMC has been made, Al-4,5% Cu was used as the matrix and fly ash as the filler material. The AMC was produced using conventional foundry techniques. The results show an increase in hardness, tensile strength, compression strength, resistance to dry wear, corrosion and impact with increasing the fly ash content. The density decreases with increasing fly ash content [4]. Mechanical properties of aluminum-fly ash composite (AMC) such as hardness, wear resistance and bending strength may be improved with decreasing of its porosity.

2. EXPERIMENTAL PROCEDURE

AMC were prepared from aluminum fine powder (produced by Merck Germany) as a matrix and fly ash as reinforcement, using powder metallurgy technique. Fly ash was taken from electric power plan Suralaya Banten, it calsinated at temperature 900°C for 3 hr. The amount of calsinated fly ash of 0%, 2,5%, 5%, 7,5% and 10% wt, which was added to the aluminum fine powder. Each composition was mixed using rotary mixer for 3 hr. The mixture was compacted using uniaxial compaction with a pressure of 100 MPa to produce green body and several of it was isostatic compacted with a pressure 100 MPa. Several of each green body were followed pressureless sintering at various temperature of 500°, 525°, 550°,575° and 600ºC for 3 hr, and the other of uniaxial compacted green body were hot pressed sintering (HP) at pressure of 100 MPa and various temperature of 525°, 550° and 575°C. Bending strength was measured using four point bending test, hardness measured using Vickers method, wear resistance measured using pin on disc against cast iron disc, porosity tested using Archimedes method and the micro structure observed using SEM.

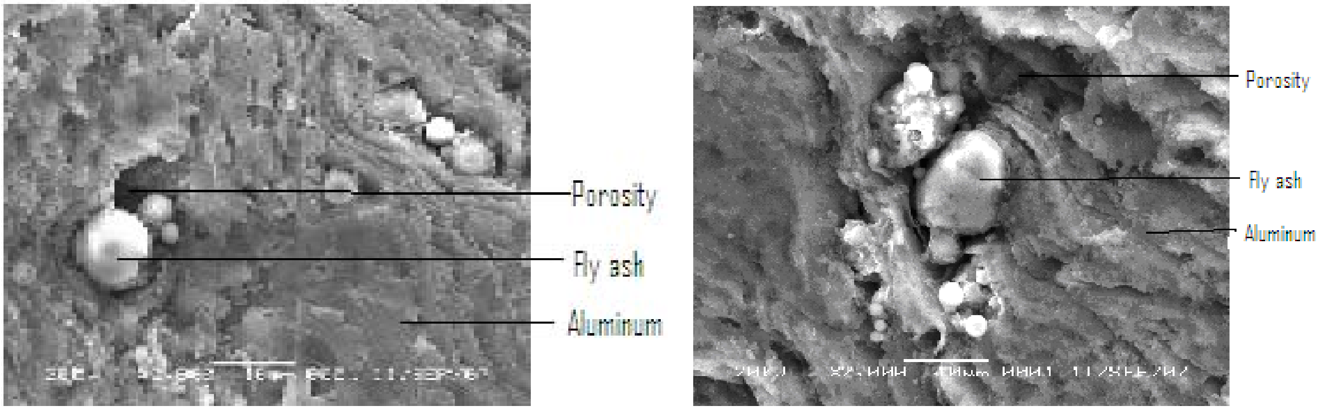
3. RESULTS AND DISCUSSION

The results show that porosity of composites decrease with increasing fraction of fly ash up to 5 wt%, above 5 wt% fraction of fly ash the porosity of composites seems to increase. Low porosity of composites 5 wt% fraction of fly ash indicated that those specimens have high relative density. It can be explained that the porosity is influenced by sintering temperature and how the fly ash particles are distributed in the matrix. This give good interaction or bonding between the matrix and the particle. However, above 5wt% of fly ash, some fly ashes particles are close each other forming clusters of particles leading to less bonding and interaction between matrix and the particles. In this latter case, the pores are easy to occur. If low fraction of fly ash even 0%, relative density was to be low because particles of fly ash is smaller than particles of aluminum (Fig.1), so pores between particles of aluminum can not be filled particles of fly ash. Porosity of composites also decreased with increasing temperature sintering up to 550˚C, if sintering temperature is higher than 550˚C porosity also increased (Fig.2).



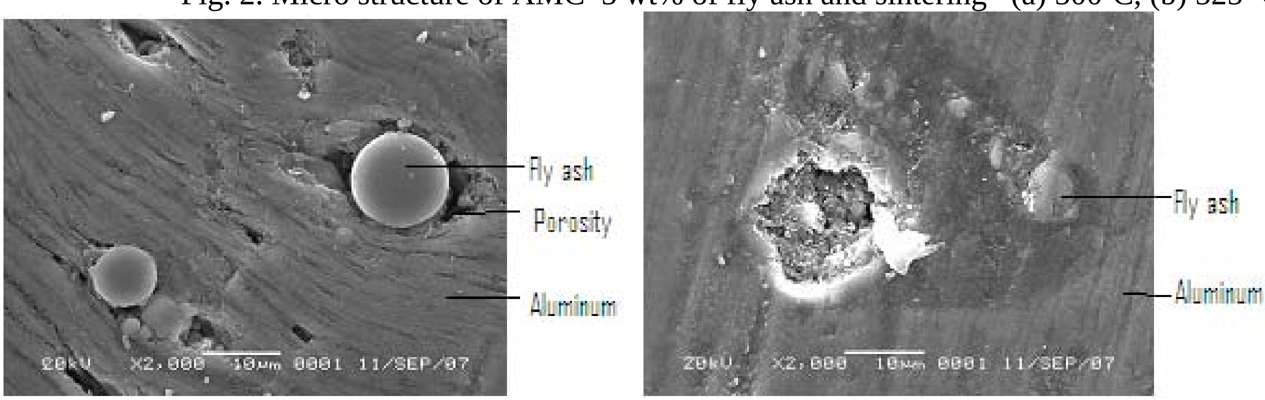
(a) (b)

Fig.1. Micrograph of (a) aluminum (b) fly ash.



(a) (b)

Fig. 2. Micro structure of AMC 5 wt% of fly ash and sintering (a) 500ºC, (b) 525 ºC



(a) (b)

Fig. 3. Micro structure of AMC 5 wt% of fly ash and sintering (a) 550 ºC and (b) 575 ºC

Results of measuring of bending strength was maximum bending load and dimension of speciment, so bending stress could be calculated, it is shown in Fig.3. Bending strength of AMC increases with decreasing of porosity of AMC. Bending strength of brittle materials is usually dominantly influenced by defects or flaws. Pores in materials can be considered as flaws which give stress concentration and reduce the strength. In relation with this, it can be explained that the increase of bending strength of the composites from the reducing of porosity in the materials.

Results of measuring Vickers hardness test was maximum load and diagonal of penetration of identor so Vickers hardness number could be calculated, it is shown in Fig.4. It is similar with bending test that Vickers hardness number of AMC increases with decreasing of the porosity of AMC. In general, this increase of Vickers hardness of the composites is due to fly ash (which consists of most metal oxide) has higher Vickers hardness compared to that of aluminum. And low porosity leads to high dense material which will increase the Vickers hardness.

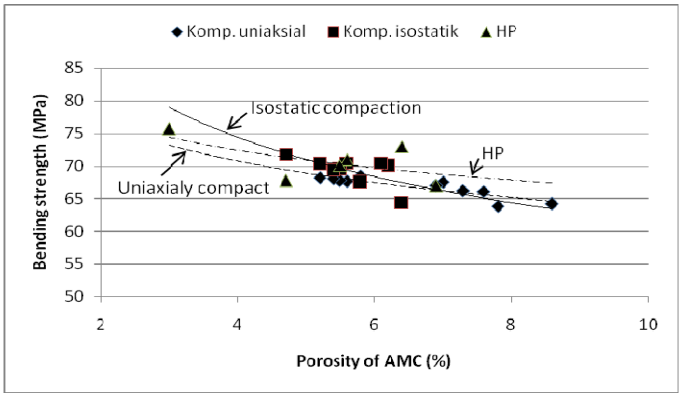


Fig. 4. Effect of porosity on bending strength of AMC

Results of measuring of wear test was maximum load, pin diameter of speciment and number of rotation of disc, so wear rate could be calculated, it is shown in Fig.5. Wear rate of AMC decreases with decreasing of the porosity of AMC. As consequences of the hardness property, the harder material will have lower wear rate during the wear test. In general, this decrease of wear rate of the composites is due to fly ash (which consists of most metal oxide) has higher wear resistance compared to that of aluminum.

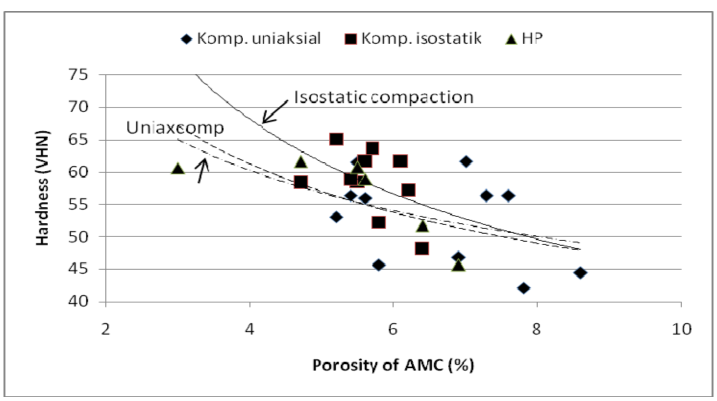


Fig. 5. Effect of porosity on hardness of AMC

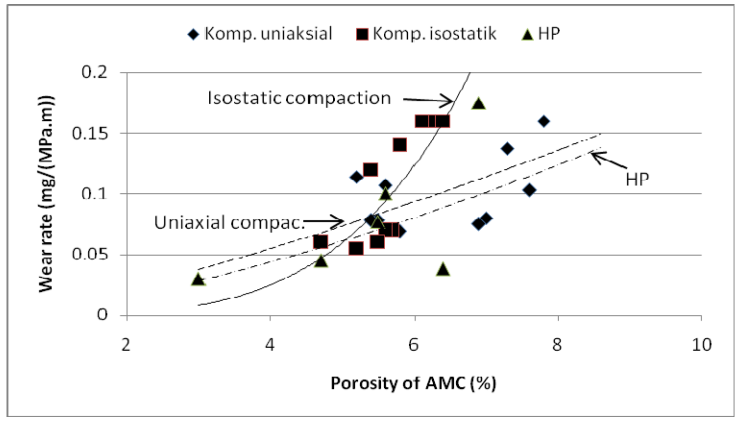


Fig. 6. Effect of porosity on wear rate of AMC

4. CONCLUSION

The bending strength, Vickers hardness increase and wear rate decreases with decreasing porosity of AMC. The bending strength, Vickers hardness and wear rate of 6.3% porosity of hot pressed AMC are 65 MPa, 55 VHN and 0.15 mg/(MPa.m), respectively. The bending strength, Vickers hardness and wear rate of 3 % porosity of hot pressed AMC are 79 MPa, 75 VHN and 0.02 mg/(MPa.m), respectively.

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