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EFFECT OF THE AMOUNT AND PARTICLE SIZE OF SiC SUSCEPTOR ON THE PROPERTIES OF MICROWAVE SINTERED MAGNESIUM

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ABSTRACT

In this study, the effect of different amount and particle size of SiC susceptor on the heating rate and properties of sintered magnesium prepared by microwave sintering has been investigated. Magnesium powder was compacted to produce green sample and then sintered at temperature 553 °C in the microwave oven by using different amount of SiC susceptor i.e. 25 g, 50 g and 100 g and different particle size of 6 µm and 125 µm, respectively. In this study, the hardness test, density test and microstructure observation had been tested. The magnesium sample which has been sintered with 100 g and 6 µm SiC susceptor produced highest heating rate, and highest hardness and density value. From microstructural observation, the grain boundary can be clearly seen with low porosity in all samples. It can be concluded that, sintered sample with 100 g and 6 µm was the optimum amount and particle size of SiC susceptor which could improve heating rate during the sintering process and mechanical and physical properties of sintered magnesium

Keywords: microwave sintering, magnesium, susceptor, sintering.

INTRODUCTION

Powder metallurgy (PM) is a metal processing technology in which parts are produced from metallic powders. In the usual PM production sequence, the powders are compressed into the desirable shape and then heated to cause bonding of the particles into a hard, rigid mass. The heating treatment, called sintering is performed at a temperature below the melting point of the metal. After undergoes pressing, the green compact lacks strength and hardness.

Sintering is a heat treatment operation performed on the compact to bond its metallic particles, thereby increasing strength and hardness [1]. There are challenging demands from the PM industry for new and improved sintering process with finer microstructures and enhanced physical and mechanical properties. And thus, this is where the microwave technology is found to be advantages compared to the conventional sintering technique [2]. Sintering was used to create objects from powders. In sintering processes, the powder material was created in a mould and then heated to a temperature below the melting point. The sintering process was carried out in the range 70% to 90% of the metal's melting point. In microwave sintering process, susceptor material was turned the microwave energy into sensible infrared heat energy which was used to sinter the compacted sample (magnesium). In addition, the susceptor material was helped in distributing tmicrowave energy more evenly which reduced run away heating. So, in this study silicon carbide powder (SiC) was used as susceptor in microwave sintering. The SiC was the suitable material as susceptor due to high loss factor and good refractory characteristics. Recently, there was no specific study on the criteria of SiC susceptor which was most important in order to sinter the compacted sample evenly. Therefore, it is very important to study the effect of amount and particle size of susceptor in order to improve properties of sintered materials.

EXPERIMENTAL PROCEDURE

In this study, the material that has been used was magnesium powder. The magnesium powder has compacted and sintered in modified microwave oven. The microwave oven was modified by inserting three insulator board and used different amount (25, 50, 100g) and particle size (6µm and 125µm) of SiC as susceptor. Before sintering the materials, the temperature calibration has been done to determine the sintering temperature and heating rate. The compacted magnesium has been sintered at 553 °C without holding time because the process was too fast compared to conventional sintering technique. The sintered samples were 15 mm in diameter with 8 mm in thickness. The bulk density of the sintered samples was measured according to Archimedes principle by using electronic balancer with the accuracy of + 0.0001g. Microstructure observation was conducted by using optical microscopy. The hardness of the sintered samples was measured by means of Vickers Hardness Tester with an indenting load of 30kgf and a holding time of 10s.

RESULTS AND DISCUSSIONS

Figure-1 show the heating rates during sintering processr using different amount and particle size of SiC susceptor. In this figure, the sintered sample with 100 g and 6 µm of SiC susceptor obtained highest heating rate compared to the others. This indicated that smaller SiC particle size and larger amount of SiC susceptor would ensure a higher heating rate for the setup. This is because it's allowed the microwaves to penetrate and heat the metal compact directly since the particle size of SiC was smaller than its penetration depth at ambient temperature. The penetration depth was slowly increased with increasing temperature and can be raised by a factor of 2 to 10 times greater when the temperature was approached the melting point of the metal. The quantity of susceptor powder has been determined the electric field at the sample and was selected to ensure that the specimen was adequately exposed to the electric field at high temperatures, even though the microwave penetration depth into the SiC powder bed decreases as the temperature rises. This result also has been reported by [3] and [4].

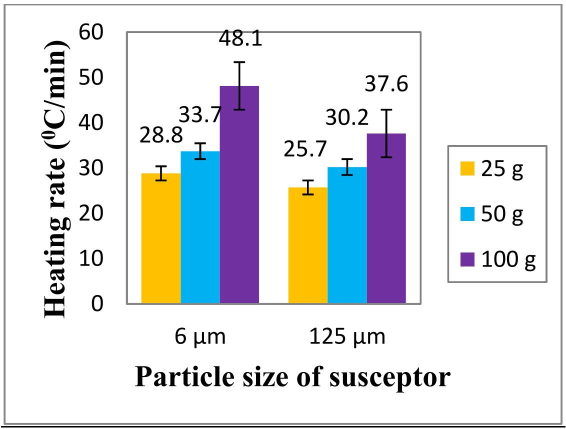

Figure-1. Heating rates during sintering process with different amount and particle size of SiC susceptor.

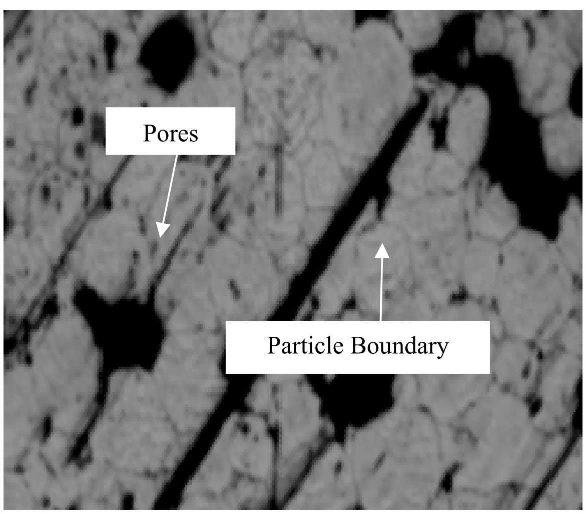

Figure-2. Microstructure of sintered magnesium using 100 g and 6 µm of SiC susceptor with 10X magnification.

The microstructures of sintered sample have been observed through the optical microscope. The 10X magnification that has been used to observe particle boundary. From the microstructures, all samples showed looked similar as pores were decreased and finer grain size with increasing amount of SiC susceptor and smaller particle size (Figure-2). The principle of rapid sintering was based on the assumption that densification and grain growth are thermally activated processes and that the activation energy for grain growth was lower than for densification [5].

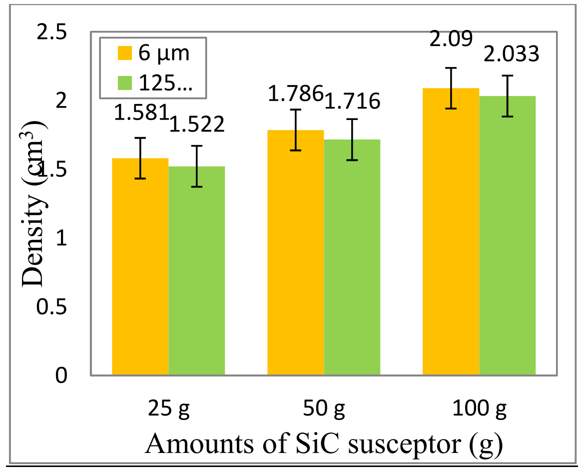

Figure-3. The density value for sintered samples with different amounts and particles size of SiC susceptor.

Figure-3 shows the relationship between density and apparent porosity with different amount and particle size of SiC susceptor. The value of density were increased when increased the amount of SiC susceptor. The highest density value of sintered magnesium sintered by using 100 g and 6 µm of SiC susceptor. The highest density was due to the mass of the compacted sample. The particles presented in compacted sample was bonded to each other and then caused their pores were disappeared. This is because rapid heating generally improved the densification for certain sintered [6]. Rapid heating generated thermal gradients, which drove large diffusion fluxes for sintering process. The rapid heating allows atomic diffusion for sintering process. So, more atoms move to points of contact between powder particles to form sintering necks. When the necks grow, the pore sizes were reduced. This causes an increase of the final density of the sintered products [7].

Figure-4 showed the relationship between the value of hardness with the amount and particle size of SiC susceptor. The highest values of hardness of sintered magnesium were sintered with 100 g, 6 µm and 100 g, 125 µm of SiC susceptor. The lowest values of hardness of sintered magnesium were sintered with 25 g, 6 µm and 25 g, 125 µm of SiC susceptor. However, the value of hardness for sintered sample with 100 g and 6 µm of SiC susceptor was higher compared to sintered magnesium with 100 g and 125 µm of SiC susceptor. This is because this parameters was perfectly dense after undergo sintering process with highest heating rate. When undergo sintering process, the porosity has been reduced and make it harder.

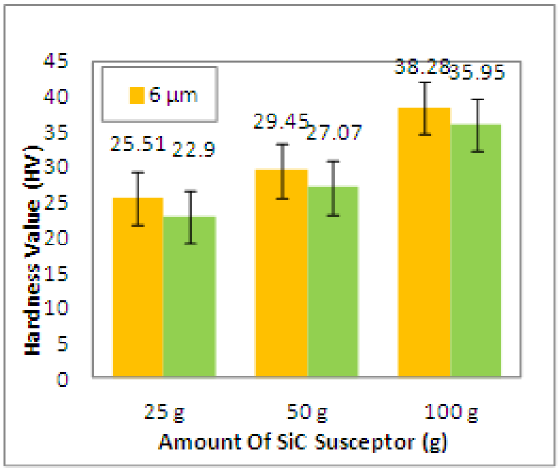

Figure-4. Relationship between hardness with different amount and particle size of SiC susceptor.

CONCLUSIONS

The aim of this study are to determine the purpose of susceptor materials in sintered magnesium and the effect of different amount and particle size of SiC susceptor on the heating rate during microwave. It was found that SiC susceptor would increase the heating rate during sintering process of magnesium. The 100 g and 6 µm of SiC susceptor has been promoted the highest heating rate. In other word, the smaller SiC particle size and larger amount of SiC susceptor ensured a higher heating rate of microwave sintering. The finer grain size of sintered magnesium also has been found when using larger amount and smaller particle size of SiC susceptor. Besides that, sintered magnesium with 100 g and 6 µm of SiC susceptor have high density and hardness due to the particles in sintered magnesium has been bonded to each other and contributed to the disappearance of pores. Overall, it has been concluded that sintered sample with 100 g and 6 µm was the optimum amount and particles size of SiC susceptor which would increase the heating rate during sintering and could improve the mechanical and physical properties of sintered magnesium prepared by microwave sintering.

ACKNOWLEDGEMENTS

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