Effect of High-energy Ball Milling on the Mg Alloy Powders under Alcohol Protection

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Abstract

Study about the feasibility and effect of high-energy ball milling on a specific Mg alloy under protection medium of alcohol was presented via comparing with conventional vacuum milling. More fine particles with wider powder size distribution but more irregular shape were shown of the powder milled under alcohol. No obvious oxide was revealed from the two kinds of Mg alloy powders with limited milling time. And since slip induced in a preferential direction, the (002) texture was formed in the Mg alloy powders at the initial stage of alcohol milling. More O and Fe contaminants were introduced into the powders milled under alcohol according to the EDS analysis.

Keywords : Ball milling, Magnesium alloy powder, Milling protection

1. Introduction

Magnesium matrix composites could overcome the disadvantages such as low elastic modulus, insufficient UTS and creep resistance of solely Magnesium alloy, and believed to be a strong competitor for vehicle, aerocraft materials. The conventional melt casting processes for producing magnesium matrix composite have to employ very high temperatures which would trigger undesired interfacial reaction and weaken the final performance of the composite materials. Powder metallurgy which debases the fabrication temperature of Mg matrix composites could control the microstructure of the composite and improve the mechanical properties effectively. How to produce Mg alloy powders with fine, regular shape and little contaminant is the key to get excellent Mg matrix composites. It's a good choice to produce Mg powder alloys using ball milling for its economic and stability. However, little work has been done on this area due to the reactive Mg alloys.

During ball milling, protection is necessary to avoid the reaction between Mg and O_2 to form stable MgO. No previous work has shown there is reaction between alcohol and magnesium. In this paper, we select alcohol as the protection media to ball-mill magnesium alloy powder and make comparison with the powder milled under vacuum.

2. Experimental and Results

Chemical composition of the Mg alloy ingot, used as the matrix material in present study, is listed in TABLE 1. The Mg alloy ingot was machined into cuttings with sizes of 0.3~0.6mm. Then the cuttings were ball-milled into powders using a planetary ball miller with a ball-powder ratio of 20:1, a rotational speed of 350r/min, and a milling time of 1~10h. The stainless steel ball used in this paper have three kinds of diameter: 16,9 and 4 mm, and their quality ratio was 4:10:3. The milling process was conducted under the protection of alcohol and vacuum, respectively. The milling process was conducted under the protection of alcohol and vacuum, respectively. Hot-pressing was employed to condense the powders into tensile test samples, and the hot pressing temperature was 400℃ with highest pressure of 375MPa.

Table 1. Chemical composition of Mg alloy matrix

Element	Al	Zn	Cu	Re	Mg
Content(wt.%)	16.0	5.0	5.0	3.0	Balance

Under different protections, The grain size of Mg alloy powder varied with different ball milling time as showed in Fig.1. It is shown that with prolonged milling time, the grain size of Mg alloy powders decreased gradually and ball milling under alcohol reveals better efficiency. And the powders shape under the protection of alcohol is lamellate, while near spheroid grains with more narrow particle distribution were got under vacuum protection.

Fig.2 shows the contaminants in Mg alloy powders detected by EDAX, from which it could be seen that the impurity elements were O and Fe. The O content changed little during ball milling under vacuum protection while it increased rapidly with prolonged milling time under alcohol. Because it is possible that the Mg alloy powders could be reacted with oxygen filtered into the liquid. And with the milling continued, the increased liquid temperature led to the volatilization of alcohol, which accelerated the oxidation further.

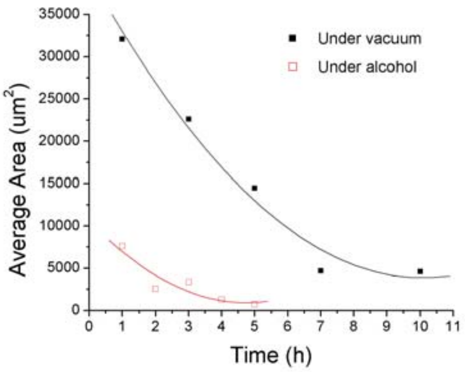

Fig. 1. Change of average size of Mg alloy powder with different milling time.

In Fig. 2, the content of Fe increased with the milling time under the alcohol protection, while no Fe was observed under the vacuum protection. Compared the milling process under different protections, it was found that under vacuum, an average layer of Mg alloy powders were cold welded on the surface of the container and the balls, which prevent the contact between Mg alloy powders and the Fe source; while under alcohol protection, there was no valid obstacle between the ball and the container, so the collision and friction between the balls and the container existed during all the process.

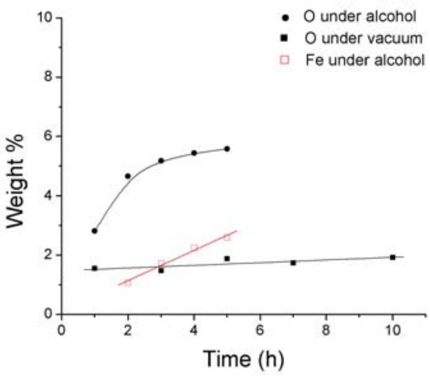

Fig. 2. Contaminants in the Mg powder as a function of the milling time

From Table.2, sample 1 fabricated with Mg alloy powders milled under alcohol shows a higher density than sample 2, but the UTS of sample 1 is a little lower than that of sample 2. It could be explained the grain size of Mg alloy powder milled under alcohol owned a fine particle size which contributed to the high density of sample 1, however the Fe and O contaminants in sample 1 weakened the interface between different particles and led to a lower UTS.

Table 2. UTS of the hot-pressed samples fabricated withpowders milled under different protection

Sample number	Milling protection	Porosity (%)	UTS (MPa)
1#	Alcohol	0.99	120
2#	Vacuum	2.41	124

3. Summary

More fine particles with wider powder size distribution but more irregular shape powders were formed under the effective protection of alcohol during ball milling. Since slip induced in a preferential direction, the (002) texture was formed in the Mg alloy powders at the initial stage of alcohol milling. With deformation occurred randomly, the texture disappeared regularly.

More O and Fe contaminants were introduced into the powders milled under alcohol, for which the hot-pressed Mg alloy samples fabricated with that powders exhibited lower UTS.

To some extent, better Mg alloy powders could be produced by alcohol milling, especially with remarkable macro-morphology & microstructure transformation.

4. References

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