The effect of additive elements on the sintering behavior of Al-Cu-X powder mixtures

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1. Introduction

Individual alloying effects of 3rd element X (X = Mg, Fe, Si) on PM Al-6wt% Cu-X elemental mixtures were studied in regard to their sintering behavior and resulting structure and properties. Al-6wt% Cu was selected as the binary base for its persistent liquid phase sintering behavior and the ternary elements were evaluated to see if any further improvements could be made.

2. Experiment

Elemental powder blends of Al-6wt% Cu-X were prepared by mixing appropriate elemental powders, cold compacted to ~85% theoretical density, and sintered at the temperature range of 580 ~ 625 ℃ for 1 hour in a dry nitrogen atmosphere. As the 3rd element, 0.1-1.0 wt% Mg, 1-5wt%Fe or 5-20wt% Si powder was added to evaluate the individual alloying effects. Sintered density, microstructure and three point bending properties were mainly utilized for studying the effects.

3. Results and Discussion

The addition of 0.1wt% Mg produced little effect on the sintered density and the bend strength as compared to the Al-6wt% base, but higher Mg additions significantly lowered the sintered densities and the bend strengths. Pores were distinctly coarsened and rounded by the addition of the Mg, even with 0.1wt%, presumably due to some formation of a Al-Cu-Mg transient liquid phase during the sintering. The addition of Fe was also found to lower the sintered density and the bend strength to some extent up to 3% addition, but more drastically with 5% Fe addition. Very large pores associated with intermetallic-like phases were observed microstructurally, presumably due to the reaction between Al-Cu liquid phase and iron to form a ternery compounds. The sintering temperature, however, could be raised to higher than 625°C by the Fe addition without having any dimensional control problem. With the addition of Si, however, sintering temperature should be lowered to below 580°C because of the severe distortion of the specimen caused by excess liquid phase. At lower temperatures, some liquid phase formed and penetrated through particle boundaries, increasing the sintered density but lowered the bend strengths below 100MPa. This very negative effect of Si is probably due to the brittle nature of the solidified Si-rich liquid phase.

4. Conclusion

The three elements, Mg, Fe and Si, added to Al-6wt%Cu were found not very effective for improving the sintered properties of the base alloy. In view of the pore rounding by the small addition of Mg, the ternery compound produced by the Fe addition could be useful for facilitating the post-sintering operations like forging or improving the wear resistance, respectively.

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