Warm Compression of Al Alloy PM Blends

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Abstract

With the onging trend of weight saving in automobiles, the application of light alloys is increasing. Recently, aluminum powder metallurgy has been the subject of renewed attention due to the combination of lightweight of aluminium and the efficient material utilisation of the powder metallurgical process, which offer attractive benefits to potential end-users.

This study is to explore the use of warm compaction process to aluminium powder metallurgy. This paper presents a detailed study of the effect of warm compression and sintering conditions on the resultant microstructures and mechanical properties of Al-Cu-Mg-Si PM blend.

Keywords: warm compaction, sintering, aluminium alloy blends, microstructure, compressibility

1. Introduction

The primary driver for the use of Al PM parts is the unique light weight properties of Al coupled with the ability to produce complex net shape parts which can reduce operational and capital costs associated with intrigue machining and assembling processes[1].

It has been demonstrated successfully that warm compaction of ferrous alloys has led to the production of PM parts with enhanced mechanical properties due to improved green and sintered densities[2]. However, there are few detailed studies on the warm compaction of Al-4.4Cu-0.8Si- 0.5Mg PM blends. This paper presents a detailed study of (1) compressibility, (2) sintering behaviour of warm compacted Al-4.4Cu-0.8Si-0.5Mg PM blends and (3) tensile properties of warm compacted and sintered samples.

2. Experimental Methods

As-supplied Materials: The Al-4.4Cu-0.8Si-0.5Mg powder blends with 1.5wt% Acrawax were supplied by the Aluminium Powder Company Limited, UK. The blends consisted of a mixture of gas atomised elemental Al powders and other master alloy additions with a powder size distribution (+45-150μm) that was optmised for maximum flow properties[3].

Warm Compaction: The powder blends were pressed by a Denison™ uniaxial hydraulic press at pressures upto 20tsi (equivalent to 310MPa) and temperatures upto 250°C maintained with a temperature controlled band heater around a cylindrical and a tensile specimen dies to give specimens of 16mm diameter discs (about 5g by mass) and doggy-bone shaped pieces (about 10g by mass) with a gauge length of 20mm, respectively.

Sintering and Ageing treatment: The compacted samples were sintered at 600ºC for 45 minutes in a Themal Elite™ horizontal tube furnace with a dynamic flow of N_2 to maintain a dew point of -45°C. This was followed by solution treatment at 550ºC for 120 minutes and immediate quenching in a bath of alcohol prior to artificial ageing in a Themal Elite™ box furnace at 200ºC for 5 hours.

Materials Characterisation: The densities of green compacts and sintered samples were determined by water immersion method (e.g. Archimedes' Method). Microstructures of green compacts and sintered samples were characterised by SEM (JEOL 6060) operated at 20kV. The tensile properties of sintered samples were determined using an Zwick™ test frame under a constant strain rate of 0.005 s^{-1}, following EN BS 10002-1:2001 standard.

3. Results and Discussions

Figure 1 shows compressibility curves of Al-4.4Cu-0.8Si-0.5Mg with 1.5wt% Acrawax pressed at various temperatures and pressures. In general, the green density increases with increasing pressure and increasing temperature.

Figure 2 shows plots of sintered density versus compaction pressure for various compaction temperatures. It can be seen that the sintered densities of samples compacted at elevated temperatures appeared to be greater than those obtained by room temperature compaction for a given compacting pressure with an exception of 233MPa, 250°C compacted samples.

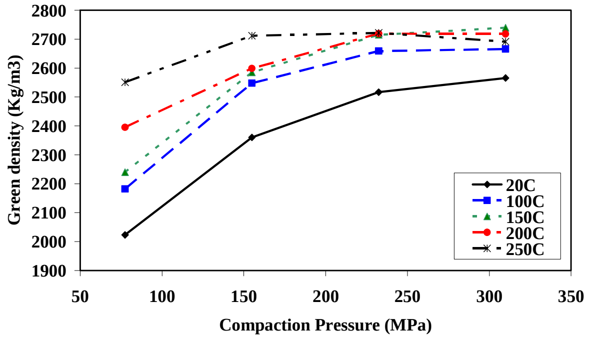


Fig. 1. Compressibility curves of Al-4.4Cu-0.8Si-0.5 Mg with 1.5wt% Acrawax

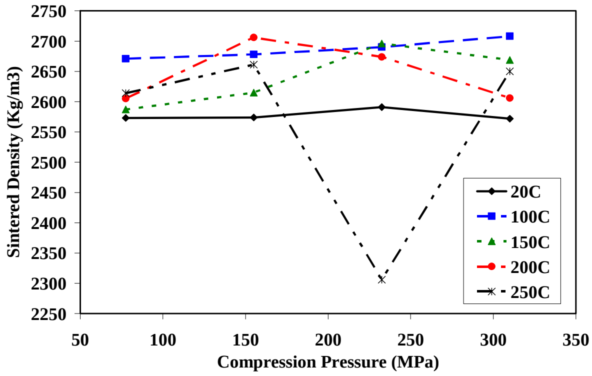
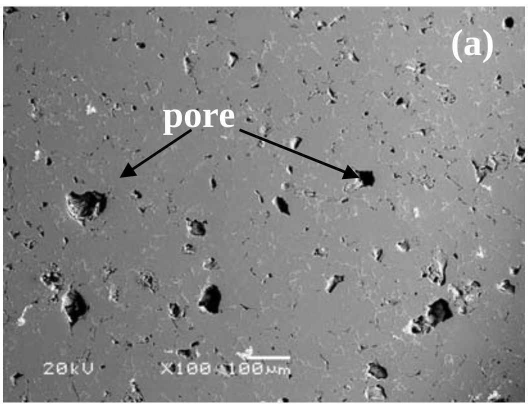


Fig. 2. Sintered Density vs compacting pressure for various compaction temperature.

A typical sintered microstructure consisted of Cu-riched intermetallic grain boundary phase(white region) and Al matrix is shown in Figs. 3(a) and 3(b).



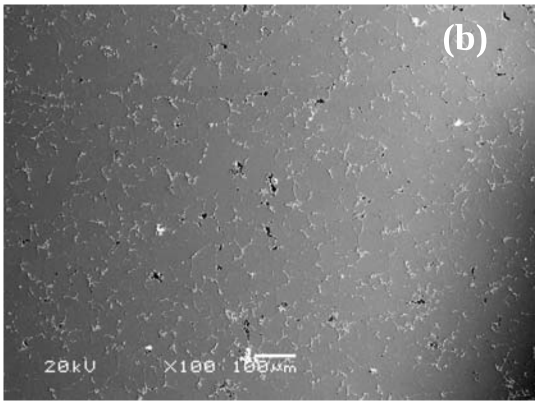


Fig. 3. Typical backscattered electron micrographs of sample compacted at 233MPa (a) room temperature and (b)150°C

The tensile strengths and ductilities of sintered sample compacted at 233MPa at 150°C increased significantly as compared to those compacted at the same pressure but at room temperature, as shown in Table 1.

Table 1 Tensile properties of sintered samples compacted at 233MPa and various temperatures

Temp (°C)	E (GPa)	Yield stress (MPa)	UTS (MPa)	Duct-ility (%)
25	56	226	260	0.6
150	60	315	344	1.0

Warm compaction of Al-4.4Cu-0.8Si-0.5Mg powder blends with 1.5wt% Acrawax was studied. The following conclusions can be summarized:

1. Compressibility increases with increasing compaction temperature.
2. The effect of compaction pressure and temperature on the sintered density is complex.
3. Tensile strength and ductility has substantially enhanced by warm compaction at 150°C.

4. References

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