BALKANTRIB'O5
5th INTERNATIONAL CONFERENCE ON TRIBOLOGY
JUNE.15-18. 2005
Kragujevac, Serbia and Montenegro

RESEARCHES ON THE INTERRELATIONSHIP BETWEEN POWDER FLOW AND HIS CHARACTERISTICS FOR ALUMINUM POWDERS

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Abstract

There is an increasing usage of powder metallurgy products based on aluminum alloys. In order to increase the competitiveness of the P/M parts, there is an urgent need to improve the flow properties of the aluminum-based powder blends. Current research at Birmingham University is focussed on the investigation of flow properties of Al based powder blends as a function of morphology, size distribution, blending conditions, alloying and lubricant additions. The powder flow behaviour and microstructure have been studied using a combination of Hall Flowmeter, Scan Electron Microscopy and laser scattering method. This paper presents a study of the interrelationship between powder flow, blending conditions and powder characteristics.

Keywords: *powder metallurgy, aluminum, flow properties, powder characteristics*

1. INTRODUCTION

During the last decade there have been many major advantages in the use of aluminum for a variety of applications such as cam bearing caps, gears, sprockets and levers [1,2]. The increasing trend to minimize weight in automotive applications has led to an increasing usage of light alloys. P/M aluminum is ideally suited for light weighting of structural parts and internal combustion engine component [3]. Consequently, the demand for Al powders for P/M products in North America has increased by 15% per year to 1353 tones in 1999 [4]. These Al P/M products are primarily based on blended powders.

Powder Metallurgy (P/M) offers the following advantages as compared to other traditional processing techniques:

- Large batch production.
- Tight tolerances at manufacturing„(ability to undergo net shape forming processes)
- Minimal material looses during processing
- Parts with complex geometry.
- Low energy consumption
- Refined microstructures with enhanced mechanical properties.

The advantage of aluminum P/M lies in the inherent cost benefits of the P/M route. In order to increase the competitiveness of the P/M parts based on Al alloys, there is an urgent need to optimize the selection and processing of starting raw materials for the blends so as to improve flow, segregation, pressing and sintering properties. In general the P/M route involves powder production, blending/mixing of starting powders with the addition of lubricant/binders, cold compaction and sintering or hot consolidation [5,6, 7].

Previous studies have found that decreasing surface area to volume ratio and surface roughness tend to reduce frictional forces between particles, resulting better flow and apparent density due to more effective particle packing [8,9].

At present, there is limited published information on the flow properties of Al blends.

This paper presents a systematic study of the flow properties of Al powder as a function of size/distribution and morphology.

2. METHODOLOGY AND MATERIAL BASE

The material for the study consisted of two commercial grade pure aluminum powders supplied by *The Aluminum Powder Company Limited U.K.* They are referred to as Powder A and Powder B. The as-supplied powder A has a mean size of 148 μm and a rough morphology. The as-supplied powder B has a mean size of 41 urn and a spherical morphology.

Initially, each as-supplied batch of Al powders was separated into various sizes using a set of sieves with mesh openings of 45, 53, 63, 75, 90, 106, 125, 150 microns and a Retsch Analytical Sieve Shaker operated at amplitude of 80 for 20 minutes. In addition, bimodal size distributions were prepared by blending two individual size fractions at various proportions using a Turbula mixer-blender operated at 70.5 rpm for 10 minutes. In all the cases the total weight of the powder mixture was kept at 70 grams. Mechanical treatment of 70g air atomized Al powder was performed by tumbling them together with 300g of 2mm diameter Al balls in_the Turbula mixer at a speed <|)f . 90rpm for 10 to 60 minutes.

Finally, lubricant was mixed with Al powder using a Turbula mixer-blender operated at 70.5 rpm for 10 minutes.

The morphology of the starting raw powder before and after blending was examined using a Philips XL30 Scanning Electron Microscope operated at 20 KV.

The flow time of each powder was evaluated using of a Hall Flowmeter according to the Standard No.3 [10] of the Metal Powders Industries Federation based on 50g of powder and 2.5mm orifice flow funnel. In some cases, a gentle knock to the rim of the funnel was applied for powders with poor flow properties. Apparent density of each size powder was measured accordingly to Metal Powder Industries Federation Standard No.4 [10].

Morphological, the powder A is very irregular with a great surface roughness, powder B exhibit an irregular rounded morphology with multiple small satellites.

3. EXPERIMENTAL RESULTS

Both types of powders were separated into narrow size fractions using a set of sieves with mesh openings from 45 to 150 μm.. Each size fraction of each powder was evaluated in terms of flow time and apparent density.

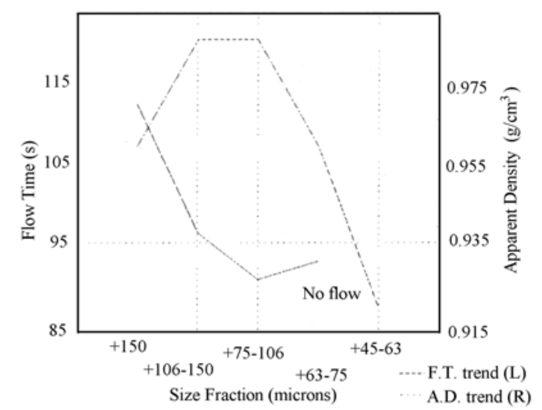

Fig. 1:
Flow and apparent density trends for powder A divided in narrow size fractions

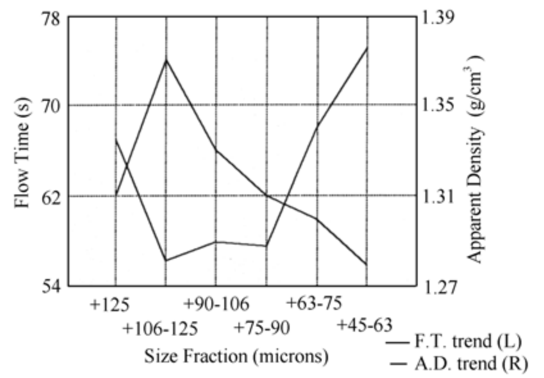

Fig. 2:
Flow and apparent density trends for powder B divided in narrow size fractions

Figures 1 and 2 show the evolution of the flow time and apparent density of powders A and B as a function of size. It was observed that the lowest flow time and highest apparent density occurs for a certain size fraction of each type of powder. Size fraction +106-125 μm gave the shortest flow time and highest apparent density of for powder B.. However, powder A showed the lowest flow time and highest apparent density for +75-106 μm size fraction. It is interesting to note that for both types of powders the lowest flow time corresponds to the highest apparent density. This can be explained by the fact that the amount of powders passing trough the funnel orifice in the unit of time is higher if the packing of the particles is better. However, a higher apparent density than the optimal value can increase the flow time by reducing the free space around the particle and thus inhibiting their ability to move during flow. The differences in flowing time and apparent densities between powders A and B.

The effect of removing finer particles from the bulk on the flow time and apparent density of powders A and B was evaluated and results are shown in Figs 3 and 4.

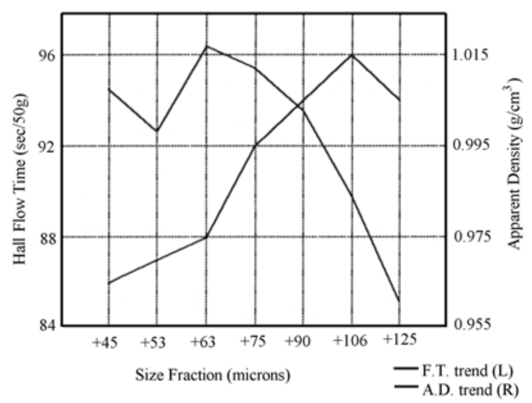

Fig. 3:
Effect of removing fines on the flow time and apparent density of powder A

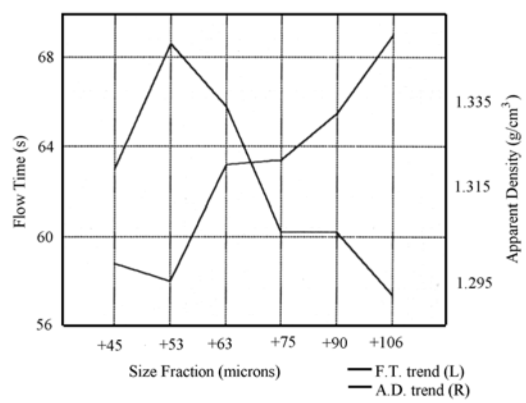

Fig. 4:
Effect of removing fines on the flow time and apparent density of powder B

Filtering of the fine fraction (-45 μm) out of the powder A gave the best flow time and the highest apparent density (Fig. 5). This trend is similar for powder B, but in this case filtering off the (-53 μm*)* size fraction led to the lowest flow time and highest apparent density as seen in Fig.6. The trends of both powders exhibit that a correlation between lowest flow time and highest apparent density can be observed here as well. The removal of fine fraction reduced the bridging effect and interparticle friction thereby improving the flow properties and apparent density. However, an excessive filtering will just reduce the packing factor by leaving voids between particles and thus decreasing apparent density and flow time accordingly.

A bimodal size distribution from the same powders was prepared from a mixture of fine and coarse size fractions. This is to study the effect of bimodal size distribution on the flow properties and apparent densities of the powders. Results are shown in Figures 5 and 6.

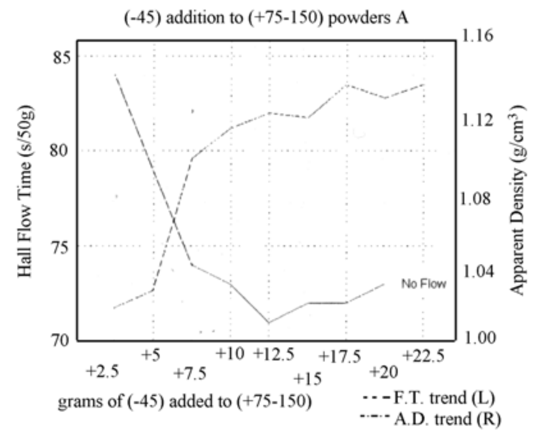

Fig. 5:
Effect of adding fines on the flow time and apparent density of powder A

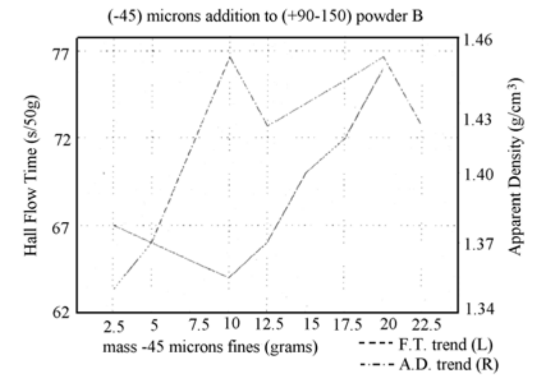

Fig. 6:
Effect of adding fines on the flow time and apparent density of powder B

Figure 5 shows that the lowest flow time for powder A occurred at a composition of 20% of (-45) μm size fraction and 80% of (+90-150) μm size fraction. Similar trend can be observed in Figure 6 for "powder B. About 17% of (-45) μm size fraction added to (+90-150) μm base gave the lowest flow time.

The trend of the lowest flow time corresponding to the highest value of the apparent density can be also noted. This is because smaller particles fill up the voids between bigger particles. However, an excessive addition will lead to bridging phenomenon and increase the flow time.

4. CONCLUSIONS

From these studies of flow time and apparent density of powder the following conclusions can be drawn:

- The flow time and apparent density of aluminum powders is dependent on the size distribution and morphology of the particles.

- Certain size fractions (eg.-125+106-(μm)) and bimodal size distributions of the aluminum powders exhibit low flow time and high apparent density which are beneficial to the productivity of Al P/M products.

- The removal of very fine particles from the as-supplied powders has significantly reduced the flow time.

5. REFERENCES

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