Mesoplasma rejuvenation of waste aluminium alloy powders for additive manufacturing

M. Kambara[1], K. Kawachi[1], K. Sugita[1], M. Dougakiuchi[1,2], K. Fukuda[2], T. Tanaka[3], A. Takeuchi[3], O. Adole[4], F. Forghani[4], H.B. Nadendla[5]

[1] *Department of Materials and Manufacturing Science, Osaka University, Osaka, Japan*
[2] *Shimane Institute for Industrial Technology, Shimane, Japan*
[3] *Takeuchi Electric. Co. Ltd., Shimane, Japan*
[4] *Alloyed Ltd., Oxford, United Kingdom*
[5] *BCAST, Brunel University of London, London, United Kingdom*

Abstract: In this contribution, we report attempts of rejuvenation of waste aluminum alloy powders used for laser-melting powder bed fusion by employing plasma spheroidization process under mesoplama condition. The waste Al particles with irregular shape containing high oxygen content were successfully changed into spherical shape having lower oxygen content at the same time by a single injection into mesoplasma jet.

1. Introduction

Metal additive manufacturing (AM) is advantageous in producing complex products and also in attaining superior mechanical performance [1,2]. Owing also to its flexibility in product design, the overall weight of the product can be reduced significantly, which is additional advantage in lowering the carbon footprint. For instance, design of online leak sealing clamps can be optimized to reduce the weight by less than half than the sand-casting so that the total CO_2 emission can be lowered by 40%, while maintaining the same functionalities [3]. Furthermore, if one recycles the powders, the total energy for production of the same product can be reduced by 12% [3]. Even so, since the powders used several times in AM process are subject to multiple heat effects, the particle shape becomes no longer spherical and the surface is oxidized. If one uses these powders, the spreadability is compromised and the oxides inclusion increases the pore formation in the product, resulting in the degradation of the mechanical properties of the product [4,5]. However, as aluminium oxide is thermodynamically quite stable, there is no report on reduction and re-spheroidization of the waste powders to date. In this work, therefore, making the most of the mesoplasma low temperature cleaning characteristics [6], we have attempted simultaneous attainment of oxide removal and particle re-spheroidization and verified the feasibility of mesoplasma rejuvenation (MPR).

2. Experimental

Inductively coupled plasma jet was generated by hybrid plasma spray system. The conditions were selected by referring the previous mesoplamsa experiment [6]. The Al-Si-Mg alloy powders that were used for the typical AM production for 14 times were injected to mesoplasma jet.

3. Results and Discussion

Figure 1 compares the SEM images of the waste AM powders and the one after MPR. It is obvious that the particles are odd shape by the repeated AM process, but they reform into a spherical shape by MPR. Importantly, there is no nanoparticle satellite attachment. Fig. 1 also shows the change in the total oxygen content in the particle.

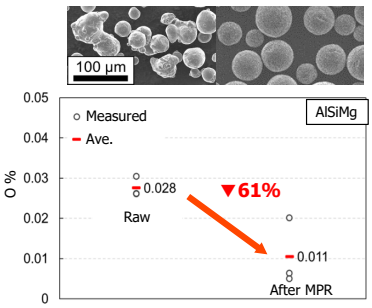

Fig. 1. (Top) Waste Al alloy powders (left) and rejuvenated particles (right). (Bottom) Comparison of oxygen content before and after MPR.

The oxygen is appreciably reduced by MPR, although the average particle size is not changed significantly after MPR. This suggests that the surface oxide layer is removed by possibly the atomic hydrogen etching effect during MPR, not because of the reduced particle specific surface area. In fact, the simple estimation of the H radical impingement flux onto the particle supports the oxygen atom removal from the particle surface oxides by the O-H interaction.

4. Conclusion

We have successfully rejuvenated the waste Al alloy powders by reducing the oxygen content while re-spheroidizing the particles with a single injection into the Ar-H_2 mesoplasmsa jet. This is an important achievement as it promotes the economical and material circulation for AM industries.

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