Sintering Properties of High-pressure Water Atomized SUS 316L Ultra Fine Powder

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Abstract

The MIM industry is currently focusing on parts that are used in automobiles and medical instruments. Many of the parts in these categories are very small and often not easy to machine because of its complex geometry. Therefore MIM is well suited for the production of these parts.
We tested the sinterability of SUS316L ultra fine powders (3,4, 6, 8micron) produced by ATMIX high-pressure water-atomization[1)], and it showed excellent results. A density of 97% theoretical was obtained by sintering at 1373K when using the ultra fine powder (3micron). Specifically, the finer the powder size, higher was the sintered density. The surface roughness and accuracy are also greatly improved with ATMIX ultra fine powder.

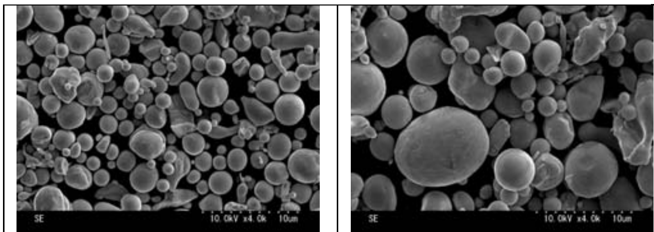
Keywords : MIM, Ultra fine powder, Water atomized powder, Pre-alloyed powder

1. Introduction

MIM process enables mass-production of 3-D complex parts into near net shapes with materials that are difficult to work with because of its excellent advantage compared with other processes. MIM has been adopted in various fields, and recently the focus has been on automobiles and medical instruments. Because many parts in these industries are very small and often not easy to machine, MIM is considered to be very suitable. Besides, finer grade powder has been requested in the market with the aim of improving the properties of parts and open up new fields. This time we did sintering test of SUS316L ultra fine powder (D50 = 3, 4, 6 and 8 µm), which was produced by ATMIX high pressure water atomization process.

2. Experimental and Results

The sintering of SUS316L powder produced by high pressure water atomization was investigated. Four grades of powders designated as PF-15F(D50=8µm), PF-10F (D50=6µm), PF-5F(D50=4µm), and PF-3F(D50=3µm), were used. Fig.1 shows SEM pictures of PF-15F and PF-3F. Specimens were made by MIM process with the powders, and sintered at temperatures from 1273K to 1643K in vacuum-Ar-partial atmosphere in a vacuum furnace after a debinding process. After sintering, mechanical properties, sintered density, carbon and oxygen contents by gas-analysis were examined.



PF-3F (3µm) **PF-15F (8µm)**

Fig. 1. SEM photograph of powders.

First, the relationship between particle size and sintered density with the sintering temperature is shown in Fig.2. The finer the particle size, the higher the sintered density. Especially parts made from the PF-3F powder attained excellent sintered density of 7.71Mg/m^3 (97%) at sintering temperature of 1373K. Besides, the sintered density was almost constant at the sintering temperature from 1373K to 1623K, and high density was attained in all the specimens despite a bias of the temperature inside a furnace. Next, the relationship between particle size and surface roughness after sintering is shown in Fig.3. The surface roughness tends to improve when the sintering temperature is lower. Especially, Ra of the specimen of PF-3F sintered at 1373K was 0.32µm. It was also found that the mechanical properties were improved when the powder particle size was smaller. When sintering the PF-3F powder at 1373K, tensile strength 650MPa and elongation 50% were obtained.

It is considered that this is because grain size became small when using fine particle powder.

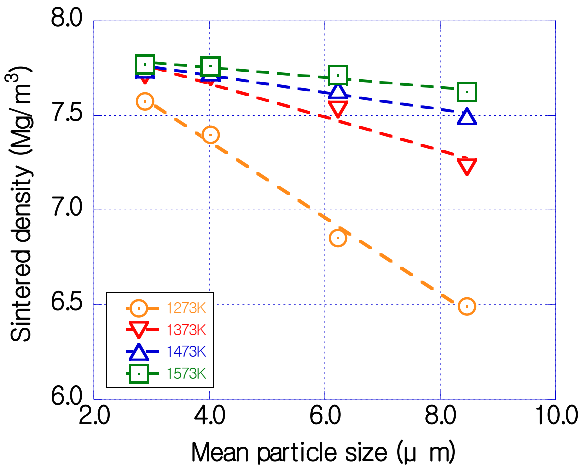


Fig. 2. Relation between sintered density and mean particle size of powders at different temperatures.

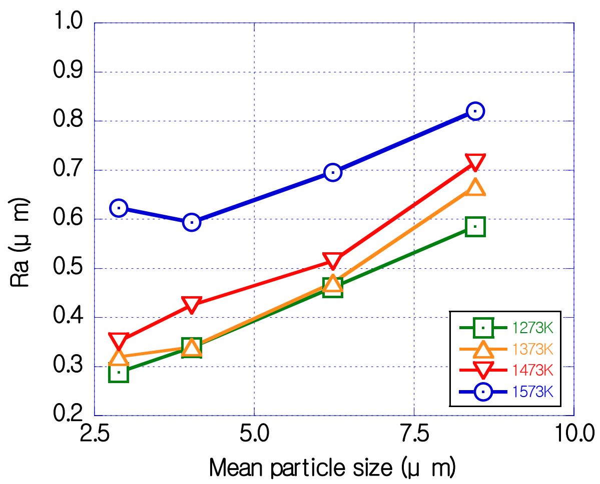


Fig. 3. Surface smoothness of sintered specimen.

3. Summary

(1) Excellent properties of sintered density 7.7Mg/m^3, tensile strength 650MPa and elongation 50% at the optimum sintering temperature of 1373K with PF-3F(D50=3μm) ultra fine powder were confirmed through the sintering test.
(2) The finer the particle size, the lower sintering temperature. The mechanical properties and the surface roughness were improved eventually.
(3) With ultra fine powder, we expect to enable mass-production of more value-added products and open up new areas compared with conventional MIM parts.

4. Future

A more detailed characterization of the mechanical properties of the ultrafine powders will be carried out. The microstructural analysis will be also be reported from future investigations.

5. References

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