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New Process for Ti Alloy Powder Production by Using Gas Atomization

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Abstract

The spherical and high quality Titanium fine powder ''Tilop'' has been produced with gas atomization furnace, Sumitomo Titanium Corporation originally designed. Recently, a new process which can produce Ti-alloy(Ti-6Al-4V) powders by utilizing our gas atomization process, of which raw material is sponge titanium pre-mixed with alloy chips or granules has been also developed. The particle size of gas atomized Ti–alloy powder and the mechanical properties of sintered Ti-alloy compacts prepared by metal injection molding were discussed in this study.

Keywords: **Titanium alloy, Gas atomization, Powder, Metal injection molding, Mechanical properties**

1. Introduction

Titanium alloy of mill product has been mainly used for aerospace application. Ti-alloy applications to other field have been limited by its deformability and high cost. Powder metallurgy can be the solution to the limitation of Ti-alloy application, because of its near net shape forming characteristic.

Titanium powder is mainly produced by HDH (Hydride De-Hydride). Sumitomo Titanium Corporation has been producing CP-titanium powder by the method of gas atomization in addition to conventional HDH. Gas atomization furnace, we originally designed, is able to produce also titanium alloy powder[1]. However, in the case of using alloy ingot as starting material, the manufacturing cost is disadvantage.

We develop a new process that produces gas atomaized Ti-alloy (Ti-6Al-4V) powder by using pre-mixed raw materials. The raw materials consist of titanium sponge and master alloy chips or granules. The properties of Ti-alloy powders and the mechanical properties of sintered MIM specimen were investigated [4].

2. Experimental and Results

Table 1 summarizes the experimental condition in this study. The relation between the gas atomization condition and the mean particle diameter is explained by the fllowing equations [2]. The correlation of the equation with the mean particle diameter of the CP-titanium powder is fairly good (Fig.1). However, in the case of Ti-alloy powder, the deviation from the equation was took placed. It will be needed further study to find out the reason (Fig.1).

Table 1. Experimental condition

Particle Size	Ti sponge	0.5~5.7 mm
	60Al-40V alloy	<1.0 mm
Gas atomization condition		same as routine
Solvent debinding		65~85C, 5hrs
Thermal debinding		r.t.~600C, Ar
Sintering condition		1100~1300C 10^{-3} Pa Order

$$\frac{d}{D} = \frac{mean\ particle\ diameter}{diameter\ of\ melt\ stream} = KP_A^{K2} \quad (1)$$

$$P_A = \left(\frac{M_m}{M_g}\right)\left(\frac{\nu_m}{\nu_g}\right)\left(\frac{1}{We}\right)\left[\frac{(\gamma-1)}{\gamma}\right] \quad (2)$$

ν : kinematic viscosity
U : velocity
We : the Weber number
$We = \rho_m \cdot Ug^2 \cdot D / \sigma_m$
Subscript : m = melt, g = gas

M : mass flow rate
ρ : density
σ : surface tension
K : constant
γ : ratio of specific heat

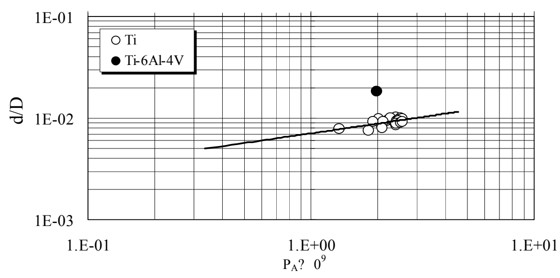

Fig. 1. Correlation of atomization condition and mean particle diameter.

Table 2. shows the chemical composition of the Ti-alloy powder. It is up to ASTM grade 5.

Table 2. Composition of the Ti-6Al-4V powder.

	Al [%]	V [%]	Fe [%]	C [%]	O [%]
ASTM Gr.5	5.50~6.7	3.5~4.	≤0.40	≤0.08	-
Alloy powder	5.75	3.74	0.01	0.01	0.2

Mechanical proreties (at room temp.) of sintered MIM Ti-alloy alloy powder compacts are shown in Fig.2 to 5.

The relative densiy increases to 96% in the maximum (Fig.2). The tensile strength in Fig.3 shows around 810~883Mpa and the tendency depending on the sintering temperature is similar to the relative density behavior in Fig.2. Fig.4 shows that tensile strength increases with an increase in the relative density and become almost the same value as the early study [3].

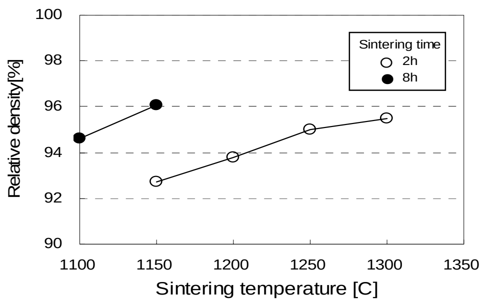

Fig. 2. Effect of sintering conditions on the relative density.

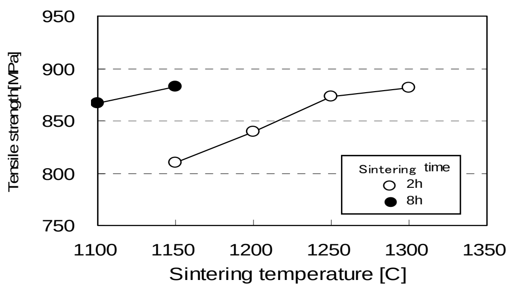

Fig. 3. Effect of sintering conditions on the tensile strength.

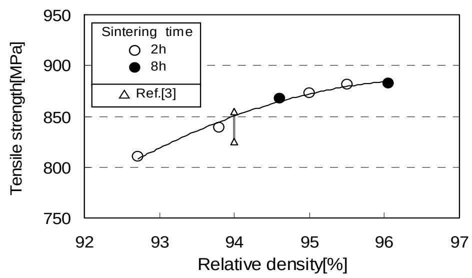

Fig. 4. Relative density versus tensile strength. (Comparison with early study [3])

Elongation of the specimen sintered for two hours increases slightly with increasing the relative density. However, the elongation of the specimen sintered for eight hours decreases at higher sintering temperatures (Fig. 5).

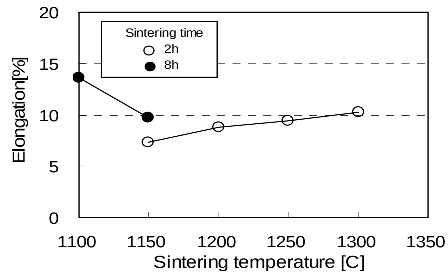

Fig. 5. Effect of sintering conditions on the elongation.

3. Summary

Chemical composition of the Ti-6Al-4V powder manufactured by pre-mixed gas atomization process satisfies ASTM Gr.5.

Sintered MIM compacts using the Ti-6Al-4V alloy powder shows that the tensile strength ranges from 810 to 883Mpa, and the tensile elongation is around 10%.

These results show that this new process for producing of titanium alloy is expected to be applied to various titanium alloys.

4. References

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