Development of Spherical Fine Powders by High-pressure Water Atomization Using Swirl Water Jet (II)

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Abstract

In order to obtain spherical fine powder, we have developed a new method of high-pressure water atomization system using swirl water jet with the swirl angle (ω).The effect of nozzle apex angle (θ) upon the morphology of atomized powders was investigated. Molten copper was atomized by this method, with ω=0.2 rad (swirl water jet) and ω=0 rad (conical water jet). It was found that the median diameter (D_{50}) of atomized powders decreased with decreasing θ down to 0.35 rad in each ω, but under θ< 0.35 rad, D_{50} increased abruptly with decreasing θ for ω=0 rad, while it was still decreased with decreasing θ for ω=0.2 rad.

Keywords: **high pressure water atomization, nozzle apex angle, swirl water jet, conical water jet, spherical fine powder**

1. Introduction

We have developed high-pressure water atomization system using swirl water jet in order to obtain spherical fine powder.

In a previous paper[1], the effect of jet swirl angle (ω) upon the properties of atomized powder have been investigated. Conical water jet (ω=0 rad) is generated from annuls and concentrated at the geometrical focus. On the other hand swirl water jet (ω>0 rad) dosen't concentrate at the geometrical focus and the diameter of the vortex increase with with increasing ω,therefore the probability of collision and coalescence of fine metal droplets decrease with increasing ω. Therefore the median diameter of powders decreases and particle shape becomes spherical with increasing ω.

However, there are some factors to be investigated besides ω which affects the powder properties.

In this paper, the effect of nozzle apex angle (θ) upon the properties of atomized powders are investigated.

2. Experimental and Results

The water jet was generated from annuls, with water pressure of 90MPa, a flow rate of $5m^3$/ks and the ω=0.2 rad (swirl water jet) or ω=0 rad (conical water jet). Apex angle of the water jet was varied from 0.09 to 0.87 rad.

Molten copper was poured on the water jet axis and atomized under the factors mentiond above, with the pouring temperature of 1573 K and a metal orifice diameter of 4mm. Particle size distribution of atomized powders was measured with the laser diffraction method. Particle shape was observed with SEM.

Fig.1 shows the effect of θ on the median diameter (D_{50}). For ω=0 rad, D_{50} of atomized powders decreased with decreasing θ down to 0.35 rad, but as θ became less than 0.35 rad, D_{50} increased abruptly with decreasing θ. On the other hand, for ω=0.2 rad, D50 kept decreasing with decreasing θ

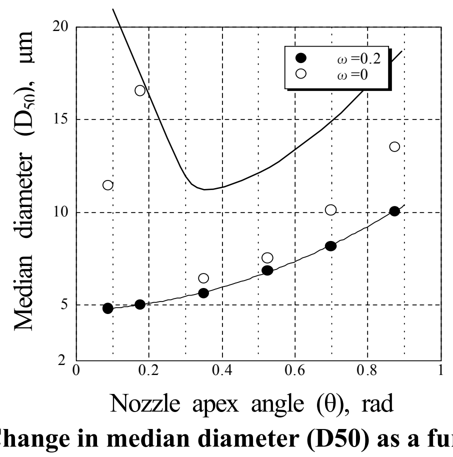

Fig. 1. Change in median diameter (D50) as a function of nozzle apex angle.

Fig.2 shows SEM microphotographs of copper powders atomized at θ=0.17, 0.35 and 0.87 rad in each ω.

In (a) (ω=0 rad) at θ=0.87 rad, it was found that there were many irregular aggregates which were composed of fine primary particles. At θ=0.35 rad, the number of irregular aggregates decreased and the diameter of the powder decreased, however, at θ=0.17 rad there were many coarse particles which were spherical or drip-shaped.

In (b) (ω=0.2 rad), there were few irregular aggregates for each of θ. Almost all the particles were spherical and particles size decreased with decreasing θ.

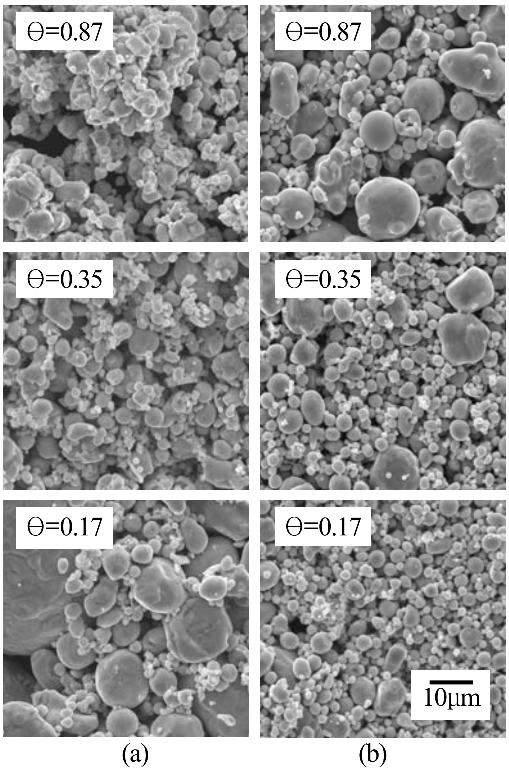

Fig. 2. SEM micrographs of copper powders.
(a) ω=0 rad, θ=0.17～0.87 rad
(b) ω=0.2 rad, θ=0.17～0.87 rad

It was thought that these phenomena were attributed to the difference of the disintegration of metal stream by suction gas between ω=0 rad and ω=0.2 rad. When the high-pressure water jet was generated, suction of atmosphere was taken place and the flow of atmosphere was made by the water jet. The metal stream was disintegrated coaresly by the atomospheric flow, before disintegrated by the water jet. It was presumed that the higher the velocity of atmospheric flow, the intenser the disintegration of metal stream by atmospheric flow, therefore the pressure of atomospher along the center axis of the water jet was measured with the pressure probe each water jet. The suction pressure, which was the minimum value of measured pressure, was shown in fig. 3.

For ω=0.2 rad, the suction pressure was monotonously decreased with decreasing θ. This means the higher the velocity of atomospheric flow, the intenser the metal stream was disintegreated with decreasing θ, therefore the size of metal droplets were finer with decreasing θ, and consequently D50 was decreased with decreasing θ.

While for ω=0 rad, suction pressure was decreased with decreasing θ down to 0.35 rad as well as ω=0.2 rad. But in the range of θ < 0.35 rad, it was inversly increased with decreasing θ. And so D_{50} was increased abruptly as θ become less than 0.35 rad, as shown in a Fig. 1.

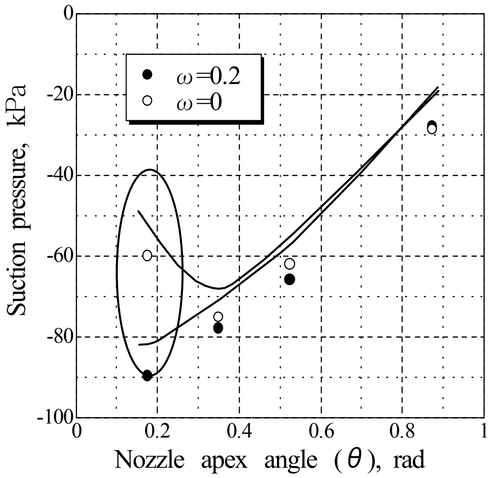

Fig. 3. Relation between nozzle apex angle and suction pressure.

3. Summary

Molten copper was atomized by the high-pressure water atomization using swirl (swirl angle : ω=0.2 rad) water jet or conical (ω=0 rad) water jet. The effect of nozzle apex angle (θ) upon the properties of powders were investigated. The results obtained were as follows.

1) For ω=0 rad, atomized powders of median diameter (D50) decreased with decreasing θ down to 0.35 rad, but as θ became less than 0.35 rad, D50 increased abruptly with decreasing θ.

2) For ω=0.2 rad, atomized powders of D50 decreased with decreasing θ, even if θ became less than 0.35 rad.

3) These results are attributed to the difference of the disintegration of metal stream by the atomosphric flow sucted by the water jet between ω=0 rad and ω=0.2 rad.

4. References

1. M.Kikukawa, S.Matsunaga, T.Inaba, O.Iwatsu and T.Takeda: Proceeding of 2000 Powder Metallurgy World Congress, (2000) 363.