2006 POWDER METALLURGY
World Congress
PM2006

Atomization Using a Pressure-Gas-Atomizer

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Abstract

An update and the latest results on molten metal atomization using a Pressure-Gas-Atomizer will be given. This atomizer combines a swirl-pressure atomizer, to generate a liquid hollow cone film and a gas atomizer to atomize the film and/or the fragments of the film. The paper is focused on powder production, but this atomization system is also applicable for deposition purposes. Different alloys (Sn, SnCu) were atomized to study the characteristics of the Pressure-Gas-Atomizer.

Keywords : Atomization, Pre-film, Pressure Nozzle, Powder Properties

1. Introduction

The global requirement for metal powder and composite materials supports the development of new atomization techniques and processes to manufacture more economic and high-quality products. Different atomization techniques like CCA, (Close Coupled Atomization) [1], and UCWA (Ultrasonic Capillary Wave Atomization) [2], were offered to produce spherical and clean powders. A recently developed atomization system combines Centrifugal Hydraulic Atomization [3] and gas atomization [4] to combine the strengths of both methods. Here, this new atomizer is called Pressure-Gas-Atomizer.

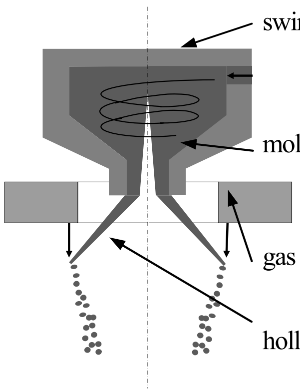

Fig. 1. Schematic of Pressure-Gas-Atomizer.

The molten metal flows tangential into the swirl chamber due to overpressure and rotates inside. The melt leaves the chamber through a small cylindrical hole and at the outlet a conical film is created by the swirl-pressure nozzle. The pre-film is atomized by high velocity gas jets; the thin film gives an ideal surface for efficient disintegration. Fig. 1 shows the schematic of that atomization process [5].

The focus of this present paper is the comparison between atomized tin and tin copper alloys. The particle size, the particle size distribution and the geometric standard deviation of the particles are analyzed and their dependence on the atomization properties are described.

2. Experimental and Results

The experimental parameters of the molten metal experiments with pure tin and tin alloys are summarized in Table 1. A melt flow rate of 174 ± 21 kg/h (Atomizer A3) and 147 ± 3 kg/h (A5) was realized by an overpressure of 0.7 MPa on the top of the melt. A 5 17.7 mm². The pressure nozzles are different as well. The length of the cylindrical hole in the swirl-pressure nozzle is 2mm (A3) and 1 mm (A5), respectively (More details of the atomizer are published in the full paper).

Mainly, the SnCu-particles are spherical (apart of some satellites or agglomerates) which is shown in the SEM pictures for 3 of the powders atomized with a gas mass flow of approximately 100 kg/h. Figure 2 compares the mass

Table 1. Experimental Parameters

Alloy		Sn	SnCu30	SnCu50	Sn
Atomizer		3	3	3	5
Mass Flow Melt	kg/h	174 ± 21			147± 3
Mass Flow Gas	kg/h	97-327	100-226		70-164
Gas/Metall Ratio	-	0,56-1,82	0,6-1,31		0,49-1,14

median diameter (MMD) $d_{50,3}$ of four different alloys in relation to the gas to metal ratio (GMR). Exponential correlation functions are used to describe the measured values.

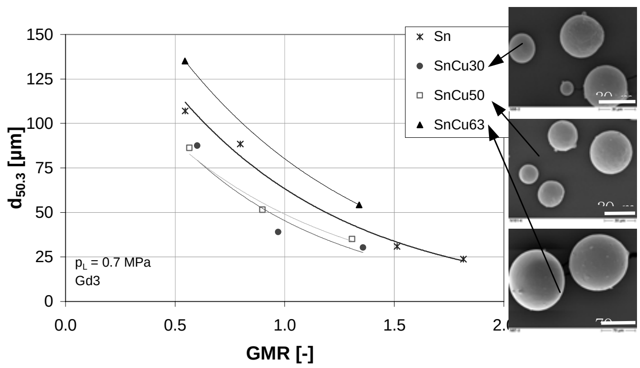

Fig. 2. MMD d $_{50,3}$ versus GMR; SEM of SnCu powder

All results show that the particle size decreases with increasing GMR. An increase of the particle size with a rising copper content is expected due to a higher surface tension. Figure 2 shows the development of these values. Only the curve of pure tin does not follow the expectation because of the lowest surface tension the smallest mass median were expected. The reason for this behavior was offered from the ex-post analysis of the pure tin powder. It turned out that the melt superheat was too low. The melt droplets solidified very fast and did not have time to become spherical before solidification starts. A second point explaining the run of the curve is the affinity of the tin particles to generate agglomerates, especially with very small particles.
Even more important than the mass median diameter based on the GMR is the geometric standard deviation σ_g of the particle size distribution. The standard deviation is calculated by the diameter ratio $d_{84,3}/d_{50,3}$. The dependence is diagrammed in figure 3. In general, the geometric standard deviation is between 1.6 and 2.2 and clearly depends on the mass median diameter.

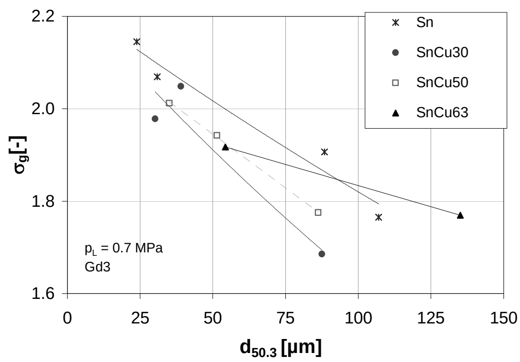

Fig. 3. σ_g versus MMD using different alloys

The correlation is inversely proportional. This holds for pure tin and the different SnCu-alloys as well. The results in fig. 3 of a particle size approx. 30 µm are obtained with gas mass flows higher than 200 kg/h.

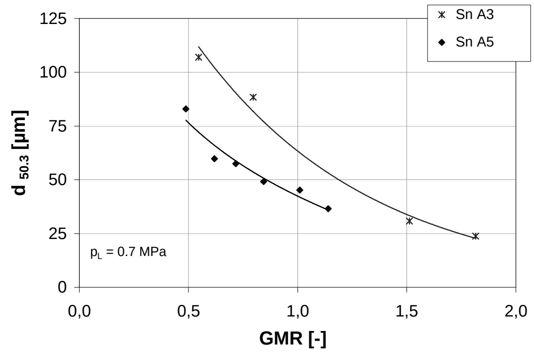

Fig. 4. MMD $d_{50,3}$ versus GMR; different nozzles

To decrease the particle size and achieve a narrow geometric standard deviation the atomizer design was developed. Figure 4 shows the comparison of different atomizers relating to the mass median diameter depending on the GMR. Using Gas-Pressure-Atomizer Gd5 15–30 µm smaller mass median diameters are achieved. The geometric standard deviations for the tin powder produced with gas-pressure nozzle Gd5 is between 1.81 and 1.99 which is significantly better compared to nozzle Gd3.

3. Summary

Different Sn alloys were atomized using a relatively new atomization system called Pressure-Gas-Atomizer. Molten metal flow, gas flow, and atomizer design led to different results concerning mass median diameter and geometric standard deviation. Laser light diffraction and SEM were used to characherize the powder. The mass median diameter strongly depends on the gas to metal ratio (GMR) and the alloy. The correlation between particle size distribution (geometic standard deviation) and mass median diameter is inversely proportional but does not depend on the composition of the alloy. A new design of the Pressure-Gas-Atomizer improved the efficiency of the atomization by decreasing the mass median diameter and the geometric standard deviation as well.

4. References

1. A. Lawley: Atomization; MPIF, NJ, USA, (1992)
2. R. Ruthardt et al. MPIF, Vol. 12, pp. 105-111 (1981)
3. J.J. Dunkley, Sh.M. Sheikhaliev: Single Fluid Atomization of Liquid Metals, Proc. Int. Conf. Powd. Metal. & Partic. Mat., May 14-17, Seattle, USA, (1995)
4. Patent application Nr. DE 102 37 213.6, 14.Aug. 2002
5. S. Lagutkin et al. Atomization Process for Metal Powder, Mat. Sci. & Eng.; Vol. 338 No.1, pp. 1-6 (2004)