High Efficient Metal Powder Production by Gas Atomisation Process

Rahmi Ünal[1,a], and Mehmet Aydin[2,b]

[1]Dumlupinar University, Engineering Faculty, Mechanical Engineering Department, 43100 Kutahya, TURKEY
[2]Dumlupinar University, Technical Education Faculty, Mechanical Department, 43100 Kutahya, TURKEY
[a]runal@dumlupinar.edu.tr, [b]maydin@dumlupinar.edu.tr

Abstract

In this study, a new laval type nozzle was designed and manufactured. Using this nozzle tin powder was produced in close coupled system by using nitrogen gas at different operating conditions. The results showed that the increasing the gas pressure up to 1.47 MPa reduced the mean powder size down to 11.39 microns with a gas/melt mass flow rate ratio of 2.0. Powders are spherical in shape and have smooth surfaces.

Keywords : Powder production, gas atomisation, nozzle design

1. Introduction

The close-coupled atomization process is preferred over the free-fall process in the production of fine powder because the close proximity of the atomising gas to the melt delivery tube, enhancing the molten metal breakup and making the formation of finer powder particles more efficient [1]. Therefore, the desire to achieve a greater yield of ultra fine powders (diameters <20μm) with improved efficiency at high to moderate gas pressure seems to promote the use of confined-feed atomization nozzle in powder metal production industries [2,3]. In this study, a new supersonic laval type nozzle was designed and produced. By using this supersonic nozzle tin powders were produced by varying the atomisation gas pressure. The results of these experiments were given and discussed.

2. Experimental and Results

Atomisation Unit. Atomisation experiments were carried out at the Dumlupınar Atomisation Unit. The atomisation chamber was made of stainless steel. There were three viewing ports on the chamber to lighten inside of the chamber and to observe and record the atomization process at each run using a video camera. Nitrogen gas was used as the atomisation gas for all the runs. Melting was performed in a stainless steel crucible having a capacity of 10 kg of tin, and was heated by a resistance furnace. The melt temperature was controlled using a thermocouple submerged in the liquid metal. The close-coupled configuration of the supersonic nozzle is shown in Fig. 1. The nozzle is an annular slotted type and has 10.10 mm^2 throat gas exit area. The geometry is converging and diverging in order to achieve atomization gas velocities that approach or exceed Mach 3.0. The nozzle has an apex angle of 44°. An alumina ceramic tube was used as the melt delivery tube having a 3 mm inner diameter.

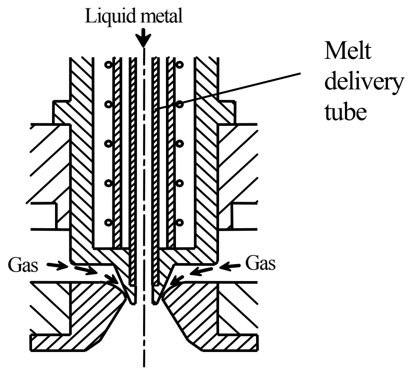
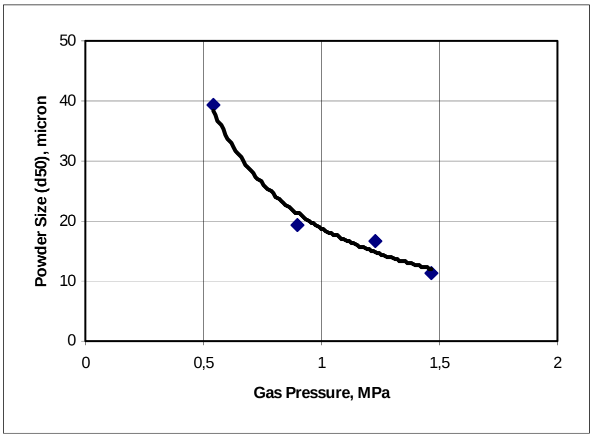
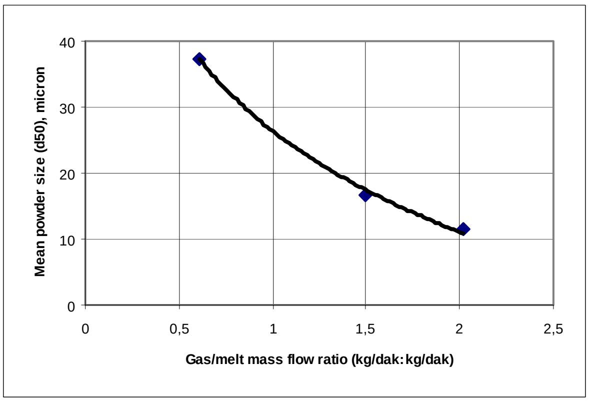


Fig. 1. Close-coupled configuration of the laval type nozzle

Atomization. In the atomization experiments about 1 kg of tin were melted and overheated to 430 °C. Then the atomization pressure was set using the atomizing gas pressure regulator. The metal delivery tube was heated by electric resistance wire just before the beginning of atomization process in order to keep the melt from freezing during atomization. Metal flow is initiated with a pneumatic system by pulling the alumina stopper rod upwards. After the beginning of the melt flow the atomization gas was delivered to the nozzle by opening the ball valve on the atomizing gas line. When the melt flow finished the ball valve was closed to stop the atomization gas flow. In each runs the same procedure was applied. The atomization process was recorded by a video-camera for all the runs. Atomization gas flow rates were measured by SIEMENS Sitrans F C Massflo Mass 2100 flow meter during the experiments. After completing the atomization run the produced powders were collected and contained in plastic bottles. Before starting another atomization run, the unit was cleaned to remove any residual powders present on the surface of the atomizing chamber. The collected powders were sieved with a 180 μm sieve and the coarser powders were discarded. Then the powders were analyzed using a Malvern MastersizerE laser particle sizer. Powder shape was determined by using scanning electron microscopy (SEM).



(a)



(b)

Fig. 2. (a) The effect of pressure on the mean powder size of tin, (b) the effect of gas/melt mass flow ratio on the mean powder size of tin.

The effect of atomization pressure on the produced tin powder size is shown in Fig. 2a. The data show that, as expected, the median particle diameter (d_{50}) decreases with increasing atomization pressure. Median powder size was reduced from 39.37 μm to 11.39 μm with a pressure increasing from 0.54 MPa to 1,47 MPa. The reason of the fine powder size obtained at such a low gas pressure is the reduced melt mass flow ratio due to the back pressure effect at the tip of the melt delivery tube. The effect of gas/melt mass flow ratio on the median powder size is shown in Fig.2b. From the figure it can be concluded that the new nozzle design is efficient for the fine powder production.

3. Summary

Metal powder production was achieved by using close coupled atomization system. The melt delivery tube was heated by resistance wires and the freezing of the tin at the melt delivery tube was avoided. Increasing the atomization pressure decreased the powder sizes. increasing the gas pressure up to 1.47 MPa reduced the mean powder size down to 11.39 microns with a gas/melt mass flow rate ratio of 2.0.The produced tin powders has spherical shapes and clean surfaces**.** This study showed that the nozzle design is very important for the efficient powder production.

4. References

1. J. Ting and I.E. Anderson: Materials Science and Engineering A, Vol 379, Issues 1-2, 110-121 (2004).
2. J. Ting, M.W. Peretti and W.B. Eisen: Materials Science and Engineering A, Vol. 326, Issue 1, p. 110, (2002).
3. R. Unal and A. Aksoy: Powder Metallurgy, accepted in september (2005).

5. Acknowledgements

The authors would like to gratefully acknowledge support of the State Planning Organization (DPT) of Turkey through grant 102M115. They are also thankful to Dr. Ibrahim Uslan of Gazi University for particle size measurement studies.