https://dx.doi.org/10.22161/ijaers.5.10.7 ISSN: 2349-6495(P) | 2456-1908(O)

Characterization of a Copper Powder for Heat Pipe Wick Applications

Guilherme Antonio Bartmeyer, Larissa Krambeck, Robson Couto da Silva, Davi Fusão & Thiago Antonini Alves

Federal University of Technology - Paraná, 84.016-210, PONTA GROSSA, Brazil
Email: thiagoaalves@utfpr.edu.br

Abstract— *In powder metallurgy, it is necessary to know the powder's nature to understand how the processing of a powder occurs. In this paper, a characterization of a copper powder for heat pipe wick applications was experimentally done. The copper powder manufacturing method was atomization. This metallic powder was characterized by Scanning Electron Microscopy (SEM), X-Ray Fluorescence Spectrometry (ED-XRF), and Laser Diffraction Granulometry. As a result, the purity and the shape are compatible with the powder manufacturing method and great for wicks. Also, the copper powder has a unimodal distribution that is excellent for capillary structures.*

Keywords— ***copper powder, characterization, heat pipe wick.***

I. INTRODUCTION

In essence, powder metallurgy converts a metal powder with specific properties of size, shape, and packaging into a solid, precise, and high-performance form. In this way, powder metallurgy can be defined as the study of the processing of metallic powders, including the manufacture, characterization, and the conversion of metallic powders into useful products for engineering [1].

According to German [2], firstly is necessary to know the powder's nature to understand how the processing of a powder occurs. Usually, powder metallurgy works with particles larger than 1μm, but smaller than sand (25 μm to 200μm). The Scanning Electron Microscope (SEM) is one of the best available tools for observing the discrete characteristics of a metal powder, such as material, powder manufacturing method, particle size, and shape.

The particle size of a metal powder is one of the most import characteristics of powder metallurgy [3]. It is analyzed based on a geometric parameter (diameter, surface area, maximum dimension, volume, among others) and considering a spherical particle shape. There are several techniques of size measurement, such as microscopy, sieving, sedimentation, laser diffraction, and X-Ray [4].

The metal powder manufacturing can occur through various mechanical techniques (such as machining and grinding), electrolytic, chemical and atomization (gas, centrifugal or by liquid) [5].

The most common metal powder that is used in sintered capillary structures for application in heat pipes is copper powder, due to its high compatibility, high thermal conductivity, and ease of processing [6-8].

In this context, a characterization of a copper powder for heat pipe wicks was experimentally performed. The metallic powder was characterized by Scanning Electron Microscopy (SEM), X-Ray Fluorescence Spectrometry (ED-XRF), and Laser Diffraction Granulometry.

II. METHODOLOGY

The sintered capillary structure will be fabricated from an copper powder obtained by gas atomization. This kind of production is a relatively simple physical process. It consists of a pouring the molten metal through a hole that is struck by a gas beam (Nitrogen, Argon, or Helium). This procedure separates the molten metal into small droplets, which solidify forming the powder particles [7].

Subsequently, the particles undergo a process of annealing in reducing atmosphere to decompose oxidized surfaces. The purity of the obtained power is generally above 99%, and the particles are approximately spherical [8]. Figure 1 presents the metallic powder utilized.

Fig. 1: Copper Powder

A *Tescan*™ VEGA3 Scanning Electron Microscopy (SEM) from the Laboratory of Materials Characterization of the Federal University of Technology - Paraná (LabCM/UTFPR) was used to observe the shape of the copper particles. As a result, a micrograph with a magnification of 500x was taken.

The chemical composition of the copper metal powder was determined by a *Shimadzu*™ EDX-7000 X-Ray Fluorescence Spectrometer from the Interdisciplinary Laboratory of Ceramic Materials of the Ponta Grossa State University (LIMAC/UEPG).

For the determination of the average particle size, the Laser Diffraction was applied. The technique consists of the scattering of light in a sample of powder dispersed in aqueous medium. A *Cilas*™ 920 Particle Size Analyzer for a range of 0.3µm and 400µm was used to measure the particle sizes by the *Fraunhofer* Diffraction Technique. The tests were done in the LIMAC/UEPG. In this particle size distribution analysis, alcohol was used as the dispersing agent under ultrasonic shaking for a period of 60 seconds.

III. RESULTS AND DISCUSSION

The experimental results regarding the characterization of the copper powder for capillary structures are presented. From the Scanning Electron Microscopy (SEM), a micrograph of the copper particles with a magnification of 500x was obtained and is presented in Fig.2. The shape is approximately spherical.

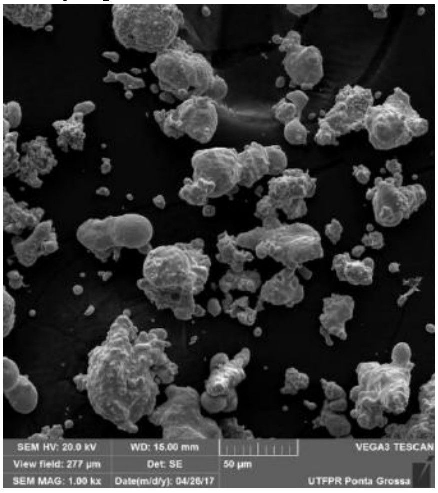

Fig. 2: SEM micrograph (500x).

The result of the X-Ray Fluorescence Spectrometry (ED-XRF) shows that the metallic powder is composed of 100% copper, so the purity is very high. According to the results of the SEM and the ED-XRF, the high purity and the shape are exactly as expect from the powder manufacturing method.

The distribution of the particle size obtained by the Laser Diffraction of the copper powder is presented in Fig. 3. In this graph, the X-axis shows the particle diameter [µm]. The Y-axis presents the relative [%] and the cumulative [%] frequencies. The solid line represents the cumulative frequency for each particle size, defined with 30 size classes. The volume-based average particle diameter was 33µm.

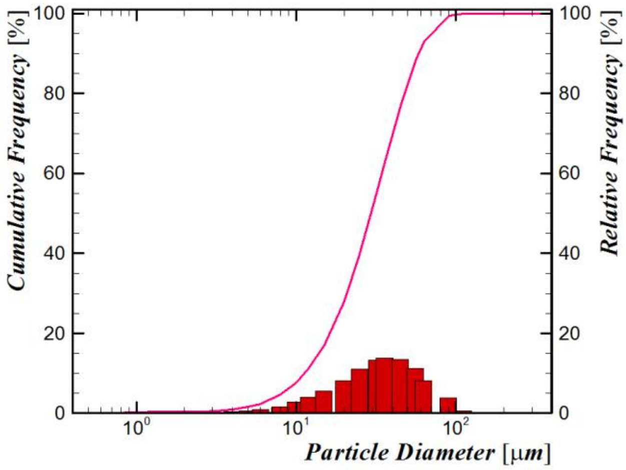

Fig. 3: Particle Size Distribution

According to the distribution, the copper powder behavior is unimodal, which means that there is a size with more frequency. The unimodal distribution is excellent for heat pipe wick applications [4].

IV. CONCLUSION

This paper presented a characterization of a copper powder for heat pipe wick applications. As a result, the purity and the shape are compatible with the powder manufacturing method and great for wicks. Also, the copper powder has a unimodal distribution that is excellent for capillary structures.

ACKNOWLEDGEMENTS

Acknowledgments are provided to the Capes, the CNPq, the LIMAC/UEPG, LabCM/UTFPR/Ponta Grossa, the PROPPG/UTFPR, the DIRPPG/UTFPR, the PPGEM/ UTFPR/Ponta Grossa, and the DAMEC/UTFPR/Ponta Grossa.

REFERENCES

[1] R. M. German, Powder Metallurgy & Particulate Materials Processing. Princeton: Metal Powder Industries Federation, 2005.

[2] R. M. German, Sintering: From Empirical Observa-tions to Scientific Principles, 1st ed. Amsterdam: Butterworth-Heinemann, 2014.

[3] L. F. Pease III and W. G. West, Fundamentals of Powder Metallurgy. Princeton: Metal Powder Industries Federation, 2002.

[4] L. Krambeck, Thermal performance experimental study of copper powder sintered capillary structures in heat pipes, Dissertation (Mechanical Engineering),

https://dx.doi.org/10.22161/ijaers.5.10.7 *ISSN: 2349-6495(P) | 2456-1908(O)*

Federal University of Technology - Paraná, Ponta Grossa, Brazil (in Portuguese).

[5] G. E. Dieter, Mechanical Metallurgy. New York: McGraw-Hill, 1986.

[6] D. A. Reay, P. A. Kew, and R. J. McGlen, Heat Pipe: Theory, Design and Applications. Amsterdam: Butterworth-Heinemann, 2014.

[7] L. Krambeck, G. A. Bartmeyer, D. Fusão, P. H. D. Santos, and T. Antonini Alves, "Experimental research of capillary structures technologies for heat pipes," Proceedings of the 24th ABCM International Congress of Mechanical Engineering, Curitiba/BRA, 2017.

[8] L. Krambeck, F. B. Nishida, V. M. Aguiar, P. H. D. Santos, and T. Antonini Alves,"Thermal performance evaluation of different passive devices for electronics cooling," Thermal Science, in press, 2018.