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PRELIMINARY COMMUNICATION

The critical apparent density for the free flow of copper powder

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Abstract: A method for the determination of the critical apparent density, which permits the free flow of electrodeposited copper powder is discussed. It was found that powders the apparent density of which were larger than 2.3 g/cm^3 exhibit free flow. This is in good agreement with the literature data.

Keywords: copper powder flowability, critical apparent density for free flow.

INTRODUCTION

The concept of the representative particle of a copper powder was successfully used for the qualitative explanation of branching of the copper powder particles, and hence, of electrodeposited copper dendrites.[1]

This approach consists of the creation of a representative particle, which exhibits the same property, or properties, as the powder in general and can explain its behavior. The aim of this note is to discuss the free flow of copper powder and to correlate it with the apparent density of a copper powder.

DISCUSSION

It is well known that flowability is one of the decisive characteristics of copper powders[2,3] and that it mainly depends on the apparent density of a copper powder. It was shown by Peisseker[3] that free flow of a copper powder can be only expected if the apparent density of the powder is larger then 2.2–2.3 g/cm^3, while poor flow is possible at lower densities also. This can be explained in the following way. It was shown in the previous paper[1] that copper powder can be treated as a continuous medium, the density of which is equal to the apparent density of the powder ρ'. The density of compact metal is ρ. As shown in Fig. 1, the continuous medium can be divided into equal cubes with edge height a. It is obvious that spheres the radius of which is $a/2$ occupy effectively the same volume,

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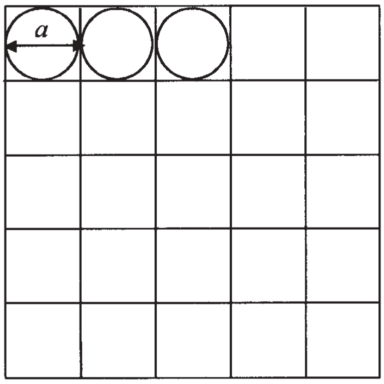

Fig. 1. A cross section of the part of a continuous medium divided into equal cubes and spheres of the same volume as cubes.

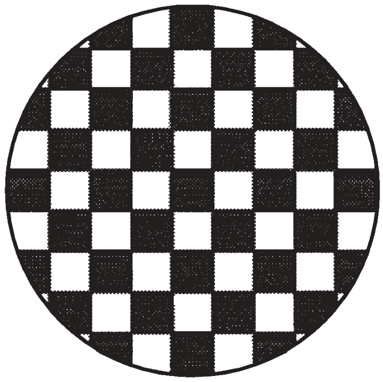

Fig. 2. A cross section of a representative particle of copper powder which permits the free flow of powder.

and that a powder consisting of spherical particles equal to each other will be characterized by free flow. Hence, the representative particle of a copper powder in respect to free flow must be spherical. The relationship between the density of the spherical representative powder particle and the apparent density of the powder can be established in the following way. It can be seen from Fig. 1 that instead of cubes with edge height a and a density ρ', spherical particles with a radius $a/2$ and a density ρ'' can be considered.

Hence,

$$\frac{4}{3}\left(\frac{a}{2}\right)^3 \pi\rho'' = a^3\rho' \tag{1}$$

and

$$\rho'' = \frac{6}{\pi}\rho' \tag{2}$$

This means that the density of the spherical particles of which a powder is composed is about twice as big as the apparent density of the powder. On the other hand, it is necessary to bear in mind that copper powder particles are dendritic by nature,[4] hence they are porous. It is obvious that the free flow of a powder consisting of spherical particles can be expected only if the surface parts of the particles corresponding to the metal segments are larger than, or equal to the pores between them, as is be illustrated by Fig. 2.

Hence, the critical density of a particle itself, ρ'', is then given by

$$\rho'' = \frac{1}{2}\rho \tag{3}$$

or taking into account Eq. (2) after further rearranging one obtains

$$\rho' = \frac{\pi}{12}\rho \tag{4}$$

Using ρ = 8.9 g/cm^3 for copper, it follows from Eq. (4) that the critical value of the apparent density resulting in free flow of copper powder is 2.32 g/cm^3. This is in good agreement with the findings of Peisseker[3] for nonsieved copper powders.

Exceptions to the above reasoning are possible[2,5] due to the following facts. It can be assumed that the flowability of a powder depends mainly on the surface structure of the powder particles, while the apparent density depends on both the surface structure and the grain size of the powder particles, as well as on the particle grain size distribution.

Hence, if an appropriate surface structure of the particles is obtained, the free flow of the powder can be expected, regardless of whether the apparent density of the powder is lower than 2.32 g/cm^3 (in case it is a consequence of the particle shape).

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ИЗВОД

КРИТИЧНА НАСИПНА МАСА ЗА ТЕЧЕЊЕ ПРАХА БАКРА

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Разматрана је метода одређивања критичне насипне масе, при којој долази до течења електрохемијски таложеног праха бакра. Нађено је да течење постоји код прахова чија је насипна маса већа од 2.3 g/cm^3, што је у сагласности са литературним подацима.

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REFERENCES

1. K. I. Popov, N. D. Nikolić, Z. Rakočević, *J. Serb. Chem. Soc.* **67** (2002) 861
2. A. Calusaru, *Electrodeposition of Metal Powders*, Elsevier, Amsterdam-Oxford-New York, 1979, p. 296
3. E. Peisseker, *J. of Powder Metallurgy and Powder Technology* **20** (1984) 27
4. M. G. Pavlović, Lj. J. Pavlović, E. R. Ivanović, V. Radmilović, K. I. Popov, *J. Serb. Chem. Soc.* **66** (2001) 923
5. K. I. Popov, Lj. J. Pavlović, E. R. Ivanović, V. Radmilović, M. G. Pavlović, *J. Serb. Chem. Soc.* **67** (2002) 61.