PARTICLES MORPHOLOGY DESCRIPTION BY IMAGE ANALYSIS

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POPIS MORFOLÓGIE ČASTÍC S VYUŽITÍM OBRAZOVEJ ANALÝZY

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Abstrakt

Parametre výrobkov vyrobených z práškov metódami práškovej metalurgie závisia okrem iného aj na geometrických charakteristikách použitých práškov. Prášky vyrobené rôznymi postupmi sú rôzne - nielen z hľadiska ich veľkostí ale aj tvaru.

Popis morfológie práškov je nevyhnutný pre hodnotenie vhodnosti systému výroby. Použitím vhodných metód a nástrojov pre popis geometrických charakteristík práškov je možné vyhodnotiť a riadiť proces ich výroby - vybrať optimálne metódy ich prípravy a stanoviť čo najlepšie podmienky pre jej jednotlivé kroky.

V práci sú popísané tvarové parametre častíc prášku WC-9Co vyrobeného metódami práškovej metalurgie procesom dezintegrácie častíc po rôznom počte dezintegračných cyklov. Obrazy mikroštruktúry boli získané využitím rastrovacieho elektrónového mikroskopu a analyzované dvomi rôznymi systémami pre obrazovú analýzu. Morfológia častíc bola popísaná pomocou tvarových charakteristík : elongácie, disperzie a tvarového faktoru.

V práci boli zisťované závislosti morfologických parametrov na počte cyklov dezintegrácie. Porovnané boli výsledky dvoch nezávisle pracujúcich výskumných kolektívov (Košice a Tallinn).

Abstract

Structural parameters of a compact body made from powder by powder metallurgy depend also on the geometrical characteristics of used powder. Powders produced by various methods are different - not only from the point of view of size but also with respect to the shape.

Description of powders by their geometrical parameters is necessary for evaluation of a suitable production way. By using rich methods and tools for powder morphology description it is possible to evaluate and control the processes of powder production - to choose the optimal method and to set the best conditions for all its steps.

The morphology parameters of particles in the WC-9Co material made by powder metallurgy processes disintegrated after various number of cycles are presented in the paper. Images of the material microstructure were obtained by scanning electron microscopy (SEM) and analysed by two different image analysis systems. The particle morphology was described by the shape characteristics : elongation, dispersion and shape factor.

Relationships of the particle morphology parameters on the number of disintegration cycles were searched. Two collections of results obtained by two research groups (Košice and Tallinn) were compared.

Key words: WC-Co system, particle morphology, image analysis

Material and methods

Technology of hard metal powder production from the WC-9Co hard metal has been composed of the following operations: preliminary thermo-cyclical treatment and mechanical refining of worn hard metal parts. Final milling of the pre-treated particles by collision was done in a disintegrator mill with disintegrator DSL-160.

Images of microstructure were taken by scanning electron microscopy (SEM) - see Fig.1. Bitmap images were imported into a digital image analysis system which was used for image pre-processing and analysis. The equipment used for image preparation and analysis was as follows : SEM and image analysis system ImagePro 3.0 [1] in Tallinn, SEM TESLA BS 340 with TESCAN digitising system and image analysis DIPS 5 in Košice [2].

Geometrical characteristics can be divided into two main classes : size and shape parameters. Size parameters (for example area or perimeter) describe the geometrical object independently on its shape or location.

On the other side shape characteristics characterise mainly shape without any influence on the size. Mostly only some approximation of the examined object is used for shape description - so called Legendre ellipse is often used instead of the original object. Legendre ellipse is an ellipse with the centre in the object's centroid and with the same geometrical moments up to the second order as has the original object area.

A lot of characteristics of this ellipse can be then used for ellipse (and, of course for the original object) description.

original from SEM processed by DIPS

Fig.1 Image of the powders: direct output from SEM and after processing by the image analysis DIPS

If A and B are axes of an equimomental Legendre ellipse then elongation is defined by relation $EL=\log_2 A/B$ and dispersion by $DP=\log_2 \pi.A.B$. The elongation for a circle is $EL=0$, for an ellipse with the ratio of axes 1:2 is $EL=1$ and EL grows for the ellipses with increasing ratio of the major and secondary axes - see Fig.2. Dispersion DP is a measure which allows to evaluate differences in smoothness. It makes possible to compare smoothness of the evaluated object with the ideal ellipse : dispersion of the ellipse is $DP=0$ and it grows with increasing the object roughness - see Fig.3.

Other well known and often used characteristics is the shape factor (roundness) of the object. If p is the perimeter and a is the area of the object then the shape factor can be defined as $\phi=4.\pi.a/p^2$. The shape factor for circle is equal to 1, if the object shape tends to the line segment, f tends to 0.

Fig.2 Samples with different values of elongation *EL*

Fig.3 Samples with different values of dispersion *DP*

The mentioned parameters were automatically calculated for every particle and they were stored in files. All characteristics were statistically evaluated. The dependence of all characteristics on the number of disintegration cycles was searched.

Results

The analysis was made on WC-9Co powder after 1, 2, 3, 5, 7, 11 and 16 disintegration cycles in two institutes (Košice and Tallinn) using different equipment and different image analyse. For every number of cycle several (from 2 to 5) images were used.

Dependencies of the mentioned characteristics on the number of cycles are shown as follows: elongation EL on Fig.4, dispersion DP on Fig.5 and shape factor f on Fig.6. These dependencies imply to make following conclusions:

EL: with increasing the number of cycles the elongation decrease from the average value $EL=0.82$ (DIPS) or $EL=0.71$ (Image Pro) respectively to the value $EL=0.51$ (DIPS) or $EL=0.64$ (Image Pro), respectively for powders after 16 cycles. With growing number of cycles the particles become more spherical.The elongation measured in Košice drops monotonically, while Tallinn's elongation presents an extreme (maximum) after 3 cycles. Generally, values of the elongation occur only in a small range - maximum $EL=0.82$ corresponds to the ellipse with the axes ratio 7:4, whereas the minimal value $EL=0.51$ corresponds to the axes ratio 7:5.

DP: a higher number of disintegration cycles means a lower value of DP (from $DP=0.095$ after one cycle to $DP=0.039$ after 16 cycles).This dependence is monotonical, e.g., particles become more smooth after each disintegration cycle. The DP value range is again narrow for all cycle numbers.

f: the shape factor slightly grows from $f=0.78$ (ImagePro) or $f=0.89$ (DIPS) after one cycle and then the values are nearly constant, with a common limit $f=0.91$ after 16 cycles. Also this behaviour confirms the fact, that with the increasing number of cycles the particles become more sferoidical.

Fig.4 Dependence of the elongation average values on the number of disintegration cycles

Fig.5 Dependence of the dispersion average values on the number of disintegration cycles

Fig.6 Dependence of the shape factor average values on the number of disintegration cycles

Summary

Particle shape depends on the number of disintegration cycles: with increasing the number of cycles particle shape tends to be more spheroidal and more smooth in shape.

Although samples were processed in two institutes under different conditions (different equipment and ways of preparation of both samples and images) results of the both research groups are quite the same. Any significant differences were not observed nor measured. There are small differences between the behaviour of the *EL* and *f* in the range from 2 to 7 numbers of cycles (see Fig.4 and Fig.6), but maximal differences are 0.13 in the case of *EL* and by 0.12 in the case of *f*, only.

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