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Application News

No. Q127

Powder Property Analysis

Quality Evaluation of Powder for Metal 3D Printer: Shape Analysis by Dynamic Image Analysis Method

The properties and homogeneity of metal powders for use in metal 3D printers affects the quality of the molded products. One particle property is the spheroidicity of the particles. As the shape of the particles becomes more spherical, fluidity increases and packing density can be obtained. On the other hand, the existence of irregularly-shaped particles can become a cause of defects, poor mechanical properties, and poor external appearance of molded products.

Although scanning electron microscopy (SEM) can be used in evaluations of the shape of powders with sizes on the order of several 10 μm, the narrow field of observation by SEM is a problem, as the measurement time is long and it may be impossible to secure an adequate number of measurements. In contrast, the dynamic image analysis (DIA) method is suitable for the purpose of conducting rapid shape evaluations, as it is possible to acquire images and quantitative information for a significant number of particles in a short time.

The Shimadzu iSpect™ DIA-10 dynamic particle image analysis system (Fig. 1), which is based on the DIA method, is an instrument which acquires images of particles in liquid samples and measures the particle size distribution, particle concentration, and particle shape. It is possible to analyze tens of thousands of particles in only minutes with an optical system that misses very few particles (image acquisition efficiency: 90 % or higher).

This article introduces an example in which the circularity of SUS 316L stainless steel powder before and after spheroidizing treatment was evaluated by using the iSpect DIA-10.

H. Maeda

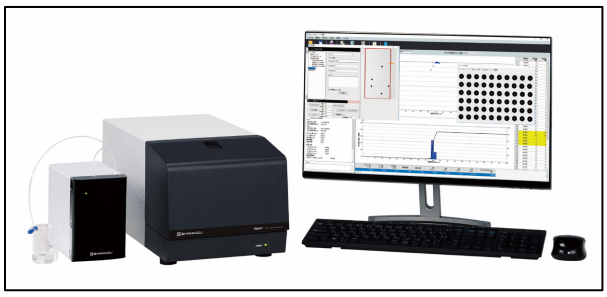


Fig. 1 iSpect™ DIA-10 Dynamic Particle Image Analysis System

Samples and Method

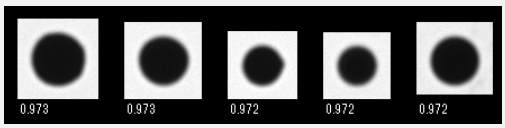
The samples used here were water atomized SUS 316L stainless steel powder (hereinafter, "raw powder") and a powder obtained by plasma spheroidizing treatment of the raw powder (hereinafter, "spheroidized powder") [1]. The measurements were conducted in accordance with the measurement conditions in Table 1.

Table 1 Measurement Conditions

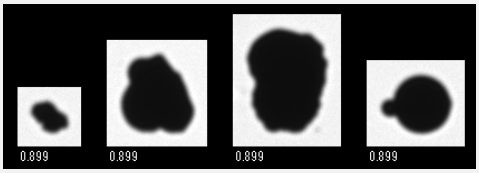
Frame rate	:	8 frame/s
Efficiency	:	97 %
Sample amount	:	50 µL
Threshold	:	110
Flow rate	:	0.1 mL/min

Measurement Results

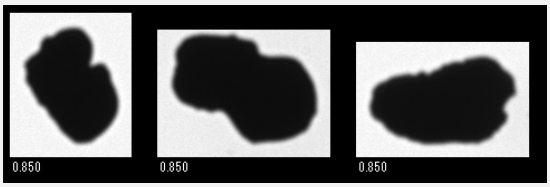
Fig. 2 shows particle images by the degree of circularity, using the spheroidized powder as an example. As the circularity of the particles decreases, it can be understood that the general shape of the particles changes from circular and approaches elliptical, and the irregularity of the particle outline also increases, displaying more concave and convex features.



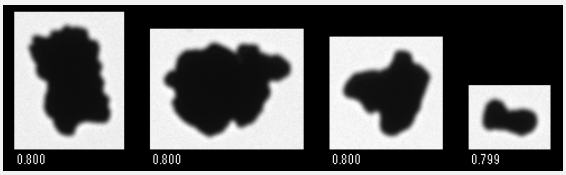
(a) Circularity of 0.95 or higher



(b) Circularity of 0.90



(c) Circularity of 0.85



(d) Circularity of 0.80

(e) Circularity of 0.75

Fig. 2 Particle Images by Circularity

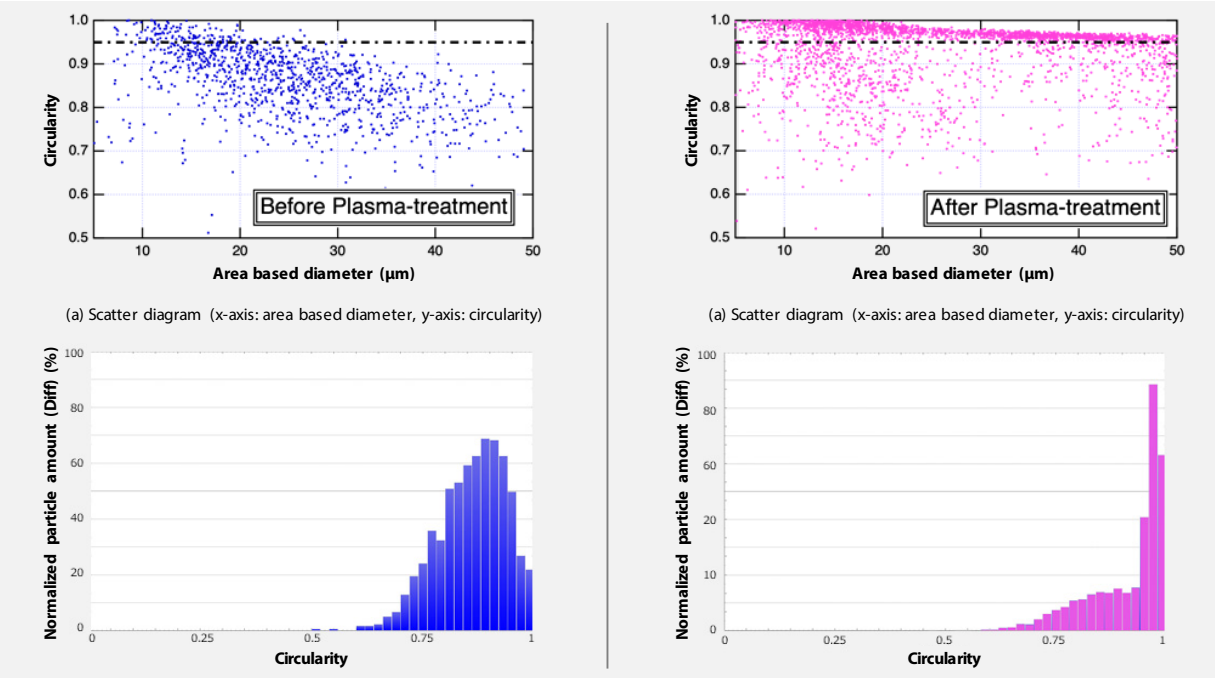


Fig. 3 Scatter Diagram and Histogram of Circularity of Raw Powder

Fig. 4 Scatter Diagram and Histogram of Circularity of Spheroidized Powder

Fig. 3 and Fig. 4 show the scatter diagrams (x-axis: area based diameter, y-axis: circularity) and the histograms of the circularity of the raw powder and the spheroidized powder, respectively, and Fig. 5 shows the average values of circularity of the samples before and after spheroidizing.

From the scatter diagrams and histograms of circularity, in the raw powder condition, circularity is widely distributed from 0.7 to 1, but after spheroidizing, the percentage of particles with circularity of 0.95 or more has increased. The average values of circularity were 0.860 for the raw powder and 0.913 for the spheroidized powder, demonstrating that a quantitative evaluation of the effectiveness of spheroidizing treatment is possible.

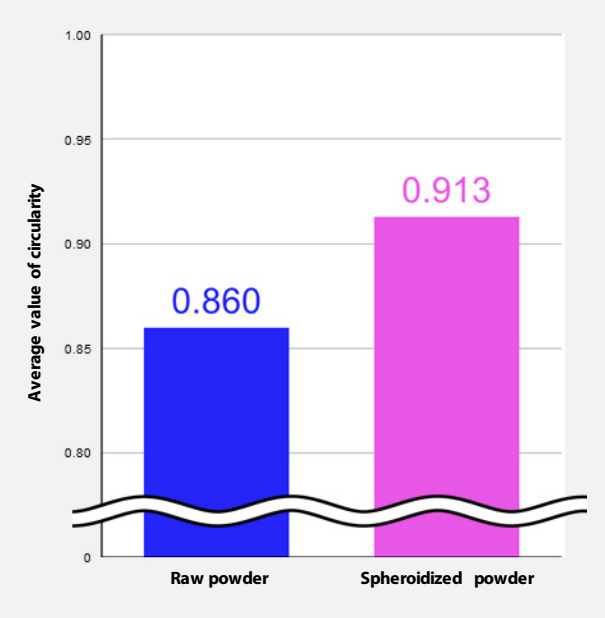


Fig. 5 Results of Measurement of Circularity (Average)

Conclusion

Using the iSpect DIA-10 dynamic particle image analysis system, it was possible to confirm the particle shape and conduct a quantitative evaluation of the effectiveness of spheroidizing treatment by acquiring particle images and measuring the circularity of SUS 316L powder before and after spheroidizing. Because a shape analysis of a statistically significant number of particles can be conducted in a short time by the dynamic image analysis method, the iSpect DIA-10 is an effective tool for evaluating particle properties in quality control of powders for use with metal 3D printers.

<Reference>
(1) H. Itagaki et al., "Spherical particles with and without attached nanoparticles formed by DC-arc spheroidization of irregularly shaped stainless-steel powder" Japanese Journal of Applied Physics, 59 (2020)

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