METAL POWDER PROPERTIES:
A CASE WITH LOW SPECIFIC SURFACE AREA

Introduction

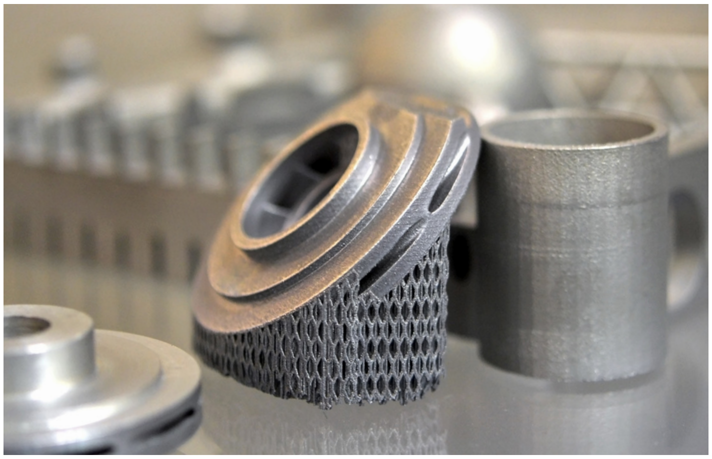
Metal powder metallurgy is the study of transforming metal into powder and the consolidation of powder into desired final product through methods such as sintering, compaction, blending, injection molding, or extrusion. Powder metallurgy is the essence of 3D additive manufacturing [1] and it covers a broad spectrum of traditional applications including orthopedic implants, dental restorations, or paint pigments. The success of any powder metallurgical process, however, depends heavily on the understanding and control of the metal powder characteristics.

In Applications Note 164, "Particle Size and Shape Analysis of Powder Metals [2]," we demonstrated how powder manufacturers used laser diffraction and imaging analysis techniques to set size and shape metrics for powder grades and classifications. In this note, we demonstrate the use of Brunauer-Emmett-Teller (BET) technique to measure another critical metal powder property: specific surface area (SSA).

Materials and Methods

SSA determines how well the metal powder particles sinter. Sintering is a thermal process in which particles are bonded into solid structures. In general, the lower the SSA, the stronger the formation of grain boundaries, and in turn, the lesser the energy input is required by sintering [3]. Therefore, the aim often is to produce metal powder of lower SSA to keep the overall cost of fabricating end user parts low.

The HORIBA SA-9600 Surface Area Analyzer is used in this study to examine five metal powders. The supplier indicated that all five samples have a low surface area, likely below 1 m^2/g, pushing the lower detection limit of the system. In this case, three SA-9600 analyzers were utilized to conduct the study to demonstrate the repeatability and reproducibility.



An example of parts created using powder metallurgy.

Analytical Test Method

The powder samples were introduced into U-shaped sample cells in accordance to ISO 2859-1 Sampling Procedures for Inspection by Attributes and NIST Practice Guide on Porosity and Specific Surface Area Measurements for Solids Materials (Section 4). The samples were degassed directly on the analyzer using the preparation station to remove physically adsorbed materials for 1 hour at an appropriately low temperature (< 100°C) to avoid melting of the samples. Each sample cell was then moved to the analysis station for measurement. After the measurement was complete, the same sample was moved to the next two instruments for degas and measurement.

Metal powder sample inside the U-shaped sample cell.

Results

Sample	Weight (g)	SSA Analyzer 1 (m^2/g)	SSA Analyzer 2 (m^2/g)	SSA Analyzer 3 (m^2/g)	Avg.(m^2/g)	St Dev.
1	5.8271	0.45	0.46	0.45	0.45	0.01
2	5.8169	0.60	0.60	0.60	0.60	0.00
3	6.1483	0.52	0.50	0.50	0.51	0.01
4	5.9679	0.67	0.68	0.66	0.67	0.01
5	7.0814	0.40	0.39	0.38	0.39	0.01

Conclusion

Determination of specific surface area of metal powders is an important parameter in the field of powder metallurgy. In this study, the HORIBA SA-9600 Surface Area Analyzers successfully measured and yielded a reproducibility well within +/- 0.01 m^2/g, showing remarkable system performance. The sample report offered valuable insight on manufacturing quality control and a better understanding of process results.

SA-9600 Surface Area Analyzer

References

[1] "Creative Optimization with Additive Manufacturing." HORIBA, https://www.horiba.com/en_en/products/by-segment/scientific/particle-characterization/particle-analysis-webinar-series/creative-optimization-with-additive-manufacturing/

[2] "Particle Size and Shape Analysis of Powdered Metals." HORIBA, www.horiba.com/en_en/applications/materials/metal-powder/metal-powder-applications/

[3] Miyake, Kimiya, et al. "The Effect of Particle Shape on Sintering Behavior and Compressive Strength of Porous Alumina." Materials, vol. 11, no. 7, 2018, p. 1137., doi:10.3390/ma11071137.

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