Bettersize

BETTER PARTICLE SIZE SOLUTIONS

POWDER CHARACTERISTICS GUIDEBOOK

Bettersize Instruments Ltd.

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1: Angle of repose, angle of fall, angle of difference, and angle of spatula

The angle of repose refers to the angle between the free surface and the horizontal plane of a powder cone formed by freely dropping powder on the plane under specific conditions. The magnitude of the angle of repose is an indicator of powder's flowability: the smaller the angle of repose, the better the flowability.

When an external impact force is applied to the powder cone formed during the angle of repose measurement, the powder would fall and begin slipping from the free surface. The angle formed between the surface and the horizontal plane after the falling of powder due to external force is defined as the angle of fall.

Subtracting the angle of fall from the angle of repose yields the angle of difference. A larger angle of difference suggests better floodability.

Angle of Repose

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Angle of Fall

= Angle of Difference

The angle of spatula is an average value of angles between the spatula plane and the free surface before and after applying an external impact force to the powder pile. The powder pile on the spatula plane is formed by first covering the spatula with a certain amount of powder on a pan, then lowering the pan such that a powder pile will form on the spatula. The smaller the angle of spatula, the better the flowability.

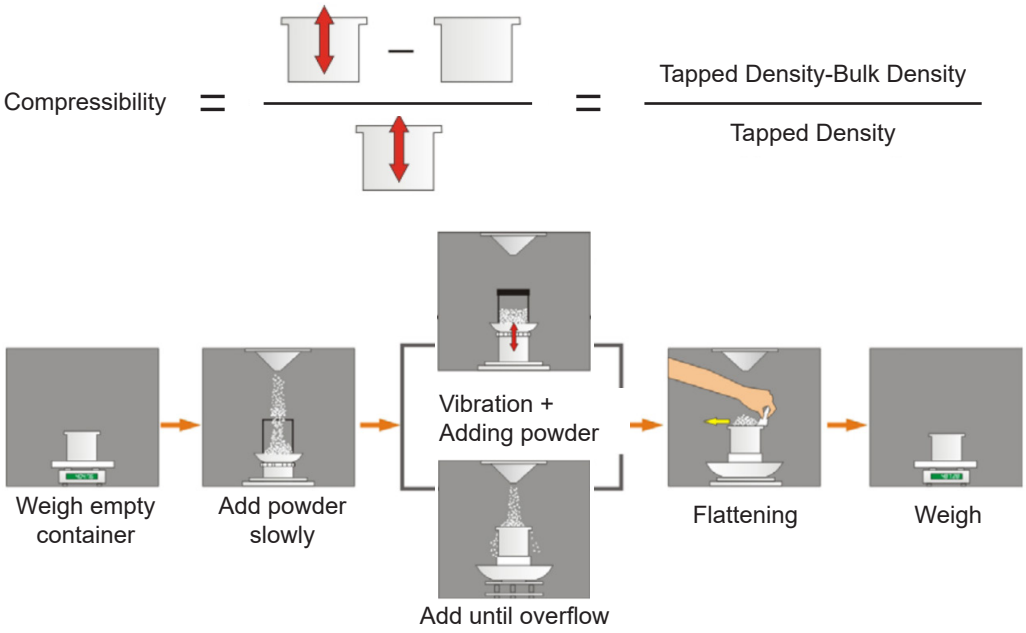
Angle of Spatula

2: Bulk density, tapped density, compressibility and Hausner ratio

The bulk density of the powder is the weight per unit volume when filling loose powder in a container with known volume, and it is usually expressed with the unit of g/cm^3. Factors affecting bulk density include powder characteristics such as its particle size and size distribution, particle shape, and surface roughness.

Dropping a container filled with loose powder under a specific frequency will result in a decrease in powder volume. The weight per unit volume of powder when powder volume no longer decreases inside the container is defined as the tapped density.

The compressibility is calculated as follows: [(tapped density-bulk density)/tapped density]. The Hausner ratio is the ratio of bulk density to tapped density. The smaller the compressibility and Hausner ratio, the better the flowability.



3: True density and apparent density of powders

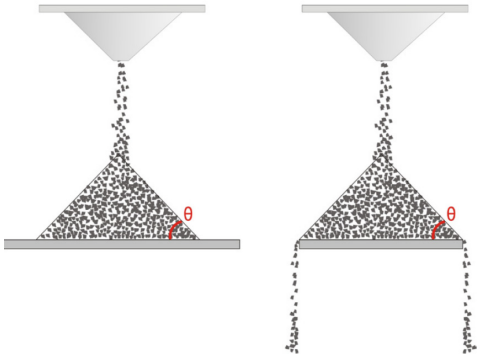
Pycnometer

True density is the mass per unit volume for a material under an absolutely dense state. For powders, the closed pores inside a particle cannot be removed, that means particles cannot be absolutely dense, thus the density of particles usually mentioned is apparent density.

Also known as skeletal density, apparent density is defined as the ratio of the mass to the apparent volume of powders. The apparent volume includes the volume of particles and the volume of closed pores in the particles, which can be measured by a pycnometer.

4: How to measure the angle of repose?

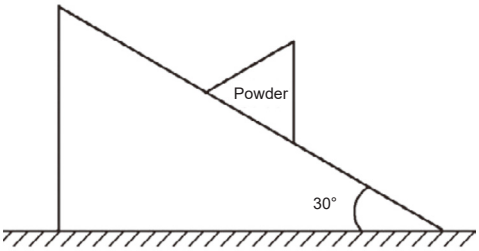
There are two primary methods for the determination of the angle of repose. The first one is the piling method, where powders flow through a funnel at fixed height and form a conical pile on a large surface under gravity. The second one is the discharging method. In the discharging method, powders flow through the orifice of a funnel and fall on a circular plate with a diameter of 80 mm. When powders continue to accumulate, eventually, some powders will start overflowing through the edge of the circular plate. The measurement of angle of repose usually employs the discharging method since it only requires a small volume of sample and it is easy to operate.



5: How to measure the flowability of metal powders?

According to ISO 4490:2018, the flowability of metal powders is usually determined by a Hall flowmeter. The process of measuring flowability is as follows: first, weigh out 50 ± 0.1g of samples, and use a finger to cover the orifice at the bottom of the funnel. Transfer the samples into the funnel, then quickly remove the finger covering the orifice, and simultaneously start timing using a stopwatch. The stopwatch should have a minimum precision of 0.2 seconds. Stop timing once all metal powders are out of the funnel. The quality of flowability could be evaluated by the time it takes for 50g of metal powders to flow through the orifice. The Hall flowmeter should be calibrated using a standard sample with a flow rate of 40 ± 0.5s per 50g.

6: How to measure powder's angle of friction?



Place a pile of powder on a portable surface and gradually lift the surface until the pile begins sliding. The maximum angle between the portable surface and the horizontal plane before the powder pile begins sliding is defined as the angle of friction. Generally, powders with smaller particle sizes and rougher surfaces have larger angles of friction. Powder's angle of friction usually falls in the range between 40° and 50°. Determining powder's angle of friction is a crucial factor in designing conical silo and funnel, and evaluating powder's flowability.

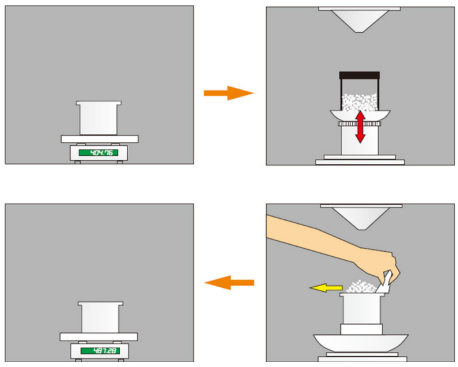
Common bulk density tester

7: What are bulk density and tapped density? How to measure them?

Bulk density is the mass per unit volume of particles that packed into a container without external force. The total volume is the sum of true volume of particles, the pore volume of open and closed pores in powders, and interstitial volume between the packed particles. Bulk density is also known as loose density, loose packing density, loose bulk density and volumetric density.

Tapped density is the ratio of the mass of particles to the total volume of powders that are filled into container after tapping under specific conditions. The total volume is the sum of true volume of particles, the pore volume of open and closed pores in powders, and interstitial volume between the packed particles after vibration.

Scott bulk density tester



Tapped density meter (fixed volume)

Tapped density meter (fixed mass)

8: What is powder flowability?

Flowability is a weighted sum of angle of repose, compressibility, angle of spatula, uniformity or cohesion. It is used to evaluate the flowability of powders comprehensively. Flowability is mainly used to describe the flowing characteristics of powders under gravity, with a range of 0~100.

Flowability Evaluation	Flowability Index	Flowability Evaluation	Flowability Index
Very Good	90 – 100	Not Good	40 – 59
Fairly Good	80 – 89	Bad	20 – 29
Good	70 – 79	Very Bad	0 – 19
Normal	60 – 69		

9: What is powder floodability?

Floodability is a weighted sum of flowability, angle of fall, angle of difference and dispersibility. It is used to evaluate the floodability of powders comprehensively. Floodability is mainly used to describe the splashing characteristics of powders under gravity, with a range of 0~100.

Flowability Evaluation	Flowability Index	Flowability Evaluation	Flowability Index
Very High	80 – 100	May Flush	25 – 39
Fairly High	60 – 79	Won't Flush	0 – 24
Tends to Flush	40 – 59		

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Further information can be found at

https://www.bettersizeinstruments.com

Email: info@bettersize.com

Address: No. 9, Ganquan Road, Jinquan Industrial Park, Dandong, Liaoning, China

Postcode: 118009

Tel: +86-415-6163800

Fax: +86-415-6170645