

Particle & Powder Density, Hausner Index and Carr Ratio

Introduction

The measurement of individual particle and bulk powder density is a process critical measurement for many industrial sectors. This short note presents details about two commonly used techniques.

Bulk Density

The density of a powder is often determined using a jolting volumeter. A known weight of sample is placed into a measuring cylinder and 'tapped' (mechanically raised and lowered a set distance) until a consistent volume is reached which corresponds to the maximum packing density of the material. By measuring both the untapped volume and the tapped volume the following can be determined:

Pour (or Bulk) density = mass / untapped volume

Tapped density = mass / tapped volume

Hausner ratio = tapped density / pour density

Carr's Index = (tapped density – bulk density) x 100 / tapped density

It is well known that particle size influences flowability. For example fine particles (< 100µm) tend to be more cohesive and therefore less free-flowing, whereas larger denser particles tend to be free flowing.

The Hausner ratio and Carr's index are both measures of the flow properties of powders. A Hausner ratio of <1.25 indicates a powder that is free flowing whereas >1.25 indicates poor flow ability.

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The smaller the Carr's Index the better the flow properties. For example 5-15 indicates excellent, 12-16 good, 18-21 fair and > 23 poor flow.

Examples

Data measured and determined for a range of household products are shown in Table I. It can be seen from the Hausner ratio and the Carr's Index that the bath salts and washing powder are free flowing, whereas the talcs are cohesive.

Material	Bulk Density	Tapped Density	Hausner Ratio	Carr's Index
Blue Bath Salts	1.100	1.175	1.068	6.383
Peach Bath Salts	0.713	0.723	1.014	1.351
Washing Powder	0.666	0.730	1.097	8.824
Own Brand Talc	0.673	0.886	1.316	24.000
Brand Talc	0.585	0.843	1.440	30.556

Table I: Typical density and flowability data determined for household products.

Pycnometry

Pycnometry is used to measure the skeletal (or true) density of solids (and some liquids) by measuring changes in pressure with gas displacement. Helium is typically used as it is a small inert molecule that easily permeates the smallest of voids and open pores (but does not permeate any closed porosity). It is an ideal technique to measure particle density.

A pycnometer contains two chambers. In the first chamber the volume is calibrated and then filled with a known weight of sample. Prior to analysis the sample chamber is purged with helium to remove any water and gases. During the analysis helium is filled into the second chamber (known as the reference chamber) to a specified pressure. From here the helium flows into the sample chamber and when the pressure has stabilised the change in pressure is recorded. The analysis is repeated until consistent results are obtained and the volume of the sample is then calculated. From the volume the density can then be determined, and typical values are shown in figure 1.

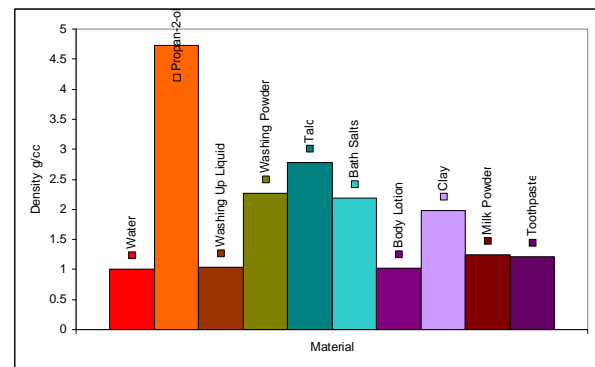


Figure 2: Pycnometer density results for a range of samples

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