Measuring contact angles and absorption processes on wettable and non-wettable powders

The wetting properties of powders have attracted increasing attention, because they are essential parameters in various application fields, like ceramics, clays, pharmaceutical products, cosmetics, and a huge range of 'technical' applications. Ferrosilicon (FeSi) powder, for example, is used to produce steel as well as silicon for solar panels and computer chips. The Washburn method is one of the most commonly used methods to analyse the wetting behaviour of powders with a liquid. However, this method is limited to hydrophilic, i.e. ‚wettable, samples with contact angles below 90°.

Using the optical contact angle and contour analysis system OCA (Fig. 2) from DataPhysics Instruments, the wetting behaviour of hydrophobic or non-wettable powders with a contact angle above 90° can also be analysed easily and reliably. In this application note, the wetting behaviour of wettable and non-wettable powders were studied using the example of FeSi powders.

Fig. 1: Ferrosilicon powder is used in the production of steel.

Keywords: OCA ▪ Contact Angle ▪ Wettability ▪ Wettable & Non-Wettable Powders ▪ Absorption ▪ Ferrosilicon

Technique and Method

The optical contact angle measuring and contour analysis systems of the OCA series (Fig. 2) combine high resolution optics, exact liquid dosing and precise sample positioning into powerful and reliable measuring systems.

The contact angle of a liquid, dosed on a solid surface, characterises the wetting behaviour of this specific solid-liquid-combination. A reliable and robust measurement of contact angles can help in the development of surface coatings, composite materials, paint and varnishes, as well as cleaning agents. Thus, the measurement of contact angles using an OCA is a versatile method for a wide field of real-life-applications. In addition, systems of the OCA series are suitable for determining the wettability of powder samples.

Fig. 2: Optical contact angle measuring and contour analysis system of the OCA series.

Experiment

In the present study, four kinds of Ferrosilicon powders (A, B, C, D) were tested on their wettability and wetting behaviour with distilled water. For the measurement, an OCA from DataPhysics Instruments was used. It was reported in advance that samples A & B would be hydrophobic and non-wettable. Whereas samples C & D would be hydrophilic and therefore wettable.

To ensure the purity of the distilled water and cleanness of the syringe, a preliminary test was carried out. In it, the surface tension of the water used for the later measurements was verified tree times using the pendant drop method. The measurements yielded a surface tension of 72.26 ± 0.32 mN/m which is in good agreement with literature values[1].

Using a laboratory scoop to pick up a pre-defined quantity of each sample, the powders were filled into the round cavities of a sample container for powders (ST-P). The ST-P was designed especially for optical contact angle measurements on porous materials like powders (Fig. 3).

The samples were placed carefully on the device without touching the test area. A droplet of 3 µL was suspended at the end of the syringe needle of the OCA. The sample table was raised slowly until the powder touched the drop. Then the sample table was moved down carefully to complete the transfer of the droplet to the powder's surface.

Using the ST-P, it was possible to place a water droplet on the powder's surface and to measure its contact angle. Using the automatic evaluation features of the

Fig. 3: The sample container for powders ST-P.

software, the mean static contact angles of the four samples were obtained. Additionally, absorption processes were recorded in movie clips.

To ensure the accuracy and reproducibility of the results, the measurement was conducted three times per sample.

Results

Measurements on the Ferrosilicon powder samples A & B confirmed their non-wetting properties resulting in high contact angles larger than 148° (see Table 1). Fig. 4 shows an exemplary water droplet on a hydrophobic powder.

In contrast to the non-wettable samples, sessile drop measurements on samples C & D showed lower contact angle values around 90°.

Thanks to the high frame-rate camera of the OCA, absorption processes could be observed and confirmed the wettability of the samples. The drops on the hydrophilic samples absorbed into the powder. The contact angle of sample C changed from an initial value of 92° (Fig. 5 I) to a final detectable value of 15° (Fig. 5 II). The contact angle on sample D decreased from an initial value of 94° to a final value of 11°.

During the absorption process the drop age is being tracked in addition to the contact angle. Hence, the time dependency of the absorption process can be analysed. Fig. 6 shows the absorption process on sample D. The contact angle decreased quickly within just 300 ms. This behaviour was observed for samples D & C.

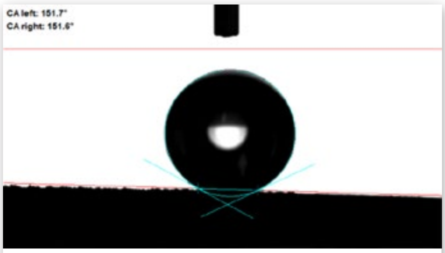

Fig. 4: Sessile water droplet on non-wettable powder.

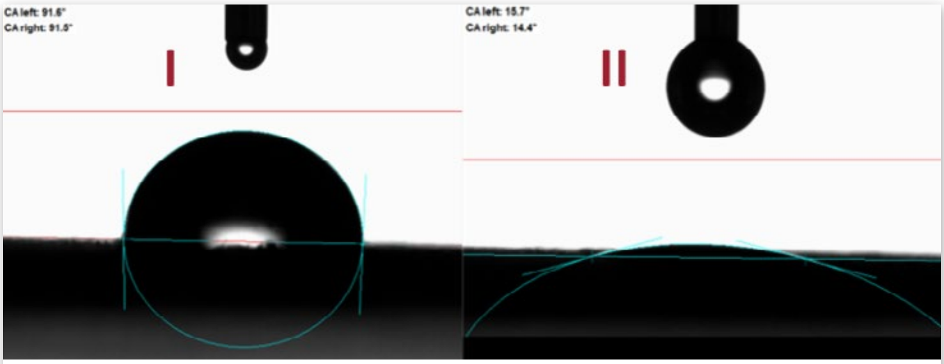

Fig. 5: Initial water drop (I) and final water drop (II) on sample C.

Summary

Using an optical contact angle measuring and contour analysis system of the OCA series the wetting behaviour of wettable and non-wettable powders has been studied.

It could be confirmed that samples A & B were non-wettable by water, resulting in contact angles larger than 148°. In contrast, samples C & D showed lower contact angle values around 90°. Absorption processes confirmed the wettability properties of samples C & D as hydrophilic.

Hence, the OCA series can be used to easily and reliably study the wettability of powders.

Table 1: Initial contact angles of water on FeSi powder samples.

Sample	Mean contact angle [°]
Powder A	148.94 ± 3.2
Powder B	148.28 ± 0.23
Powder C	91.47 ± 2.04
Powder D	91.16 ± 3.94

References

[1] N. B. Vargaftik, B. N. Volkov, and L. D. Voljak , “International Tables of the Surface Tension of Water”, Journal of Physical and Chemical Reference Data 12, 817-820 (1983), DOI: 10.1063/1.555688

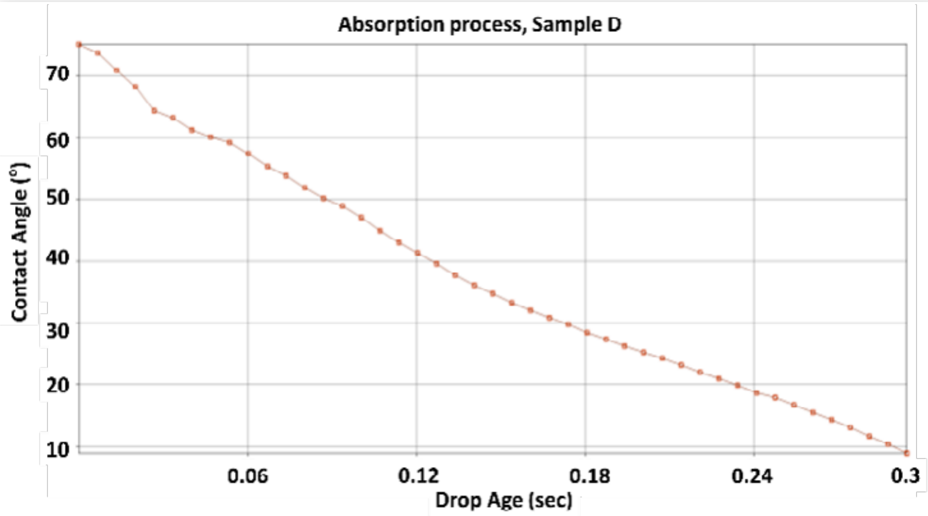

Fig. 6: Absorption process on sample D.

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