Particle Size and Shape Analysis of Cement Samples

Introduction

Cement is the most frequently used material in construction today. Slightly more than a ton of concrete is produced every year for each person on the planet, approximately 6 billion tons per year. It is a versatile material and can be molded to just about any shape. Cement is also strong, inexpensive, and easy to make. Cement is a complex mixture of calcium silicates and aluminates that is made by heating a mixture of clay and limestone to ~ 1500^{o}C in a kiln. The detailed physicochemical processes involved in the hydration and setting of cement slurries are very complex, and a clearly defined quantitative account is still lacking; even the precise composition of the cement powder is unknown. Cement is a material that is used in every city in the world, and little is known about its chemistry.

The cements particle size is now seen as critical for the determination of the quality of the cement. As finer particle size will result in a greater surface area, cement manufactures control particle size as this parameter directly affects the cement's compressive strength and curing speed. Particles larger than 50 micron cannot be fully hydrated, while particles smaller than 2 micron cause exothermal setting in the final product. As the grinding and crushing process is very energy intensive, manufactures require accurate data on the particle size of their product in order to be able to save time and energy and not to grind too finely.

Particle shape also affects cement properties. Cement that has been ground into particles of a more regular (spherical) shape has a lower surface area than cement that is irregularly shaped. Differences in particle surface area will lead to variations of water demand in batches of differently shaped cement. Particle shape analysis will further enable the understanding of the effect of different grinding aids and grinding time on particle shapes, and how these shapes are distributed with respect to size. Shape analysis will also provide information on parameters such as equivalent shape factor and aspect ratio, both of which determine the cements flow-ability.

The Solution

The CIS-100 system can measure both the size and shape of the cement particle, so as to help control the product quality. The laser channel employs the Time-Of-Transition (TOT) technique and measures the particle size distribution of cement. The TOT principle is independent of optical properties; therefore the difference in optical properties between the silicates, aluminates and clay do not affect the measurement.

The video channel employs CCD camera technology and dedicated shape software to perform Dynamic Shape Analysis.

Instrument configuration

1. Ankersmid CIS-100S Particle Size and Shape Analyzer
2. Flow Cell Module ACM-104A
3. Liquid Flow Controller LFC-101
4. Lens B100 (in measurement range 2~600µ)
5. Lens CW, DW（for shape analysis）

Sample preparation:

The cement samples were prepared for analysis by suspending the sample in ethanol. The suspension was then sonicated for thirty seconds to break down any agglomerates that may be present in the sample.

Analysis procedure:

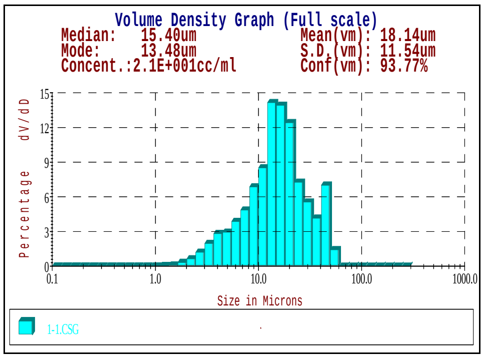
A certain amount of the suspension was added to the reservoir of the LFC-101 and pumped through the ACM-104A cell and cycled back to the reservoir in a continuous flow manner.

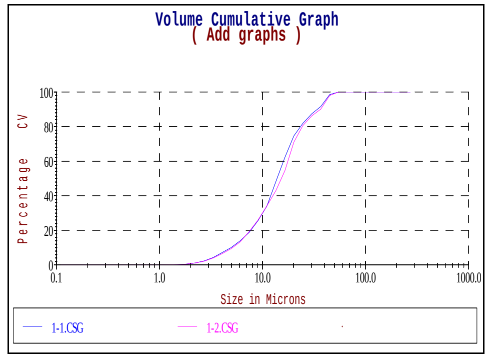
Laser Channel: Every sample was measured by the Laser Channel using the repetitive mode 3 times to illustrate the reproducibility of the results.

Video Channel: Every sample was measured using the Ankersmid WShape analysis software. The macro included removal of out-of-focus particles.

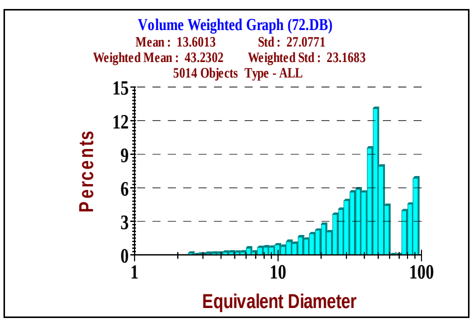
Results

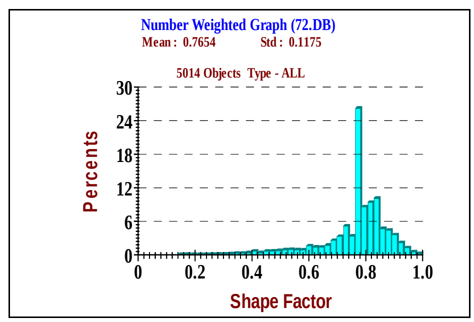
Particle Size Results using Laser Channel



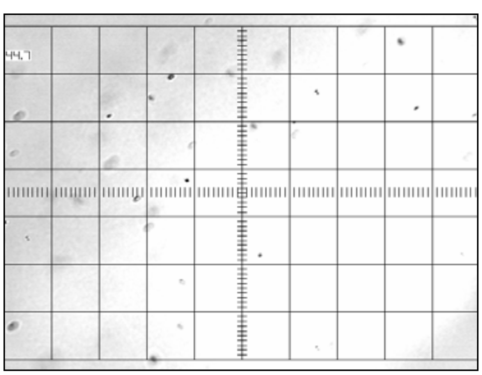


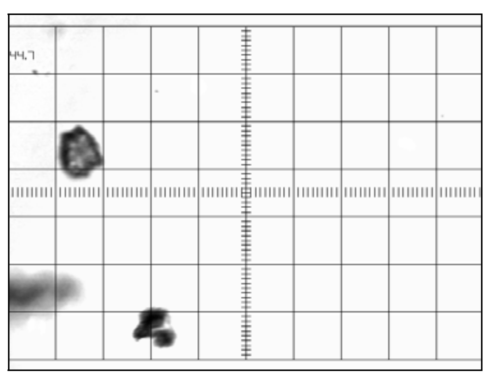
Shape Results using the Video Channel





Video Images





Conclusion

The Ankersmid CIS-100 Particle Size and Shape Analyzer is a powerful tool for the characterization of the size and shape of cement. The laser measurement is direct and not influenced by the samples optical properties. This means that no correction of the results to account for the difference in refractive and absorption properties of the different particle components that make up the cement is required, as is needed in laser diffraction instruments. Accurate data on particle size will lead to optimization of the grinding process and reduce energy consumption. The shape analysis is fully automated and provides critical information on particle shape.