SIZE AND SHAPE ANALYSIS OF SALT USING DYNAMIC IMAGE ANALYSIS

The particle size distribution (PSD) of salt is an important physical characteristic used for quality assurance and grading product. The historic technique for measuring the PSD of salt has been sieve analysis. Many salt producing facilities have now switched to dynamic image analysis (the CAMSIZER), which is quicker, more efficient, and provides additional information about the shape of the salt crystals. This application note describes how the CAMSIZER has been successfully used to characterize salt size and shape.

Introduction

The chemical term “salt” refers to an ionic compound of anions and cations in general. This document will refer to the two most common forms of salt, sodium chloride (NaCl) and potash (KCl, potassium chloride). Salt is a dietary mineral that is essential for animal life, but can be toxic to many land plants. Salt flavor is one of the basic tastes, making salt one of the oldest, most ubiquitous food seasoning. Salt is used mainly in the chemical industry (85%), but also in the production of food, washing powder, de-icing salt and organic and inorganic fertilizer (for example KCl), and can be either liquid or granular.

Salt can be recovered in different ways; either by getting it out of the earth (dry mining) or by extracting it from sea water (wet mining). Deep-shaft mining is much like mining for any other mineral. Typically, salt exists as deposits in ancient underground seabeds. Many salt mines use the "room and pillar" system of mining. Shafts are sunk down to the floor of the mine, and rooms are carefully constructed by drilling, cutting and blasting between the shafts, creating a checkerboard pattern. After the salt is removed and crushed, a conveyor belt hauls it to the surface.

Salt is also harvested through solar evaporation from seawater or salt lakes. Wind and the sun evaporate the water from shallow pools, leaving the salt behind. It is usually harvested once a year when the salt has a specific thickness. After harvest, the salt is washed, drained, cleaned and refined. This method yields the purest salt, often resulting in nearly 100 percent sodium chloride. Only areas

with low annual rainfall and high evaporation rates – such as the Mediterranean countries or Australia (for example) - can have effective solar evaporation plants. Usually machines perform this harvest, although it is still done by hand in some areas.

Quality testing

Salt producers carry out quality control on the mined product during production and on outgoing goods. Some companies use particle measurement systems in the quality lab, some use them at-line or on-line. A basic requirement for most applications is that the salt grains/granules have a defined particle size distribution. Some types of salt require a cubic shape (which can be achieved by doping with boron) to improve the handling.

Problems and requirements associated with measuring the particle size distribution of salt include:

- A minimum control frequency must be ensured due to the importance of particle size.
- Salt plants need more efficient measuring methods to reduce personnel in the quality labs.
- Since salt products are mostly specified by sieve analysis, the results of an alternative measurement system have to match sieve results.
- A shape measurement system is required for measuring the cubic shape or elongation of certain types of salt.

Using Dynamic Image Analysis

The CAMSIZER dynamic image analysis system has successfully been used to measure both the size and shape of salt in laboratories around the world. A fitting procedure in the CAMSIZER software can be used to obtain results for cubic or angular particles which are closer to sieve results than they would be without fitting, as seen in figures 1 and 2.

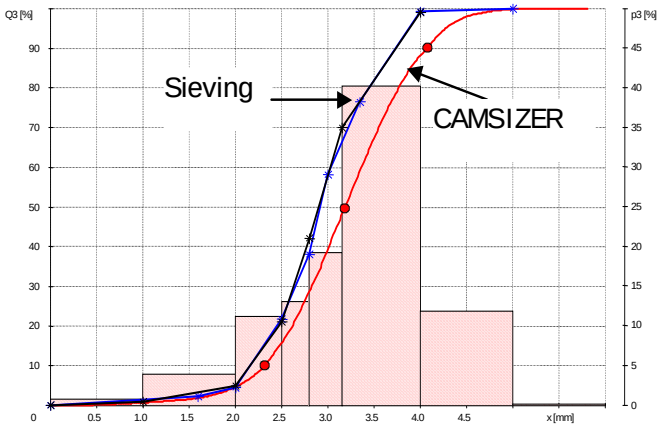

Figure 1: angular granulate – CAMSIZER result vs. sieving without fitting.

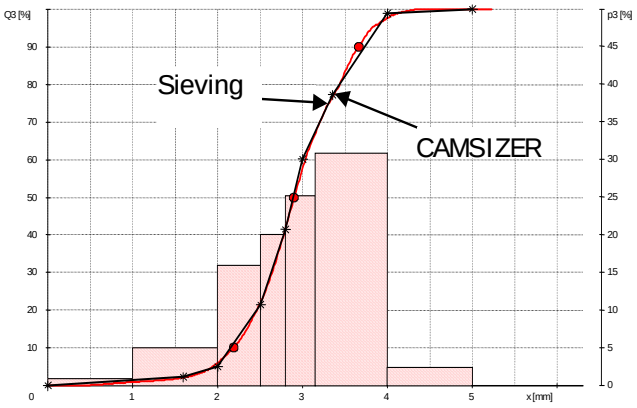

Figure 2: angular granulate – CAMSIZER result vs. sieving with fitting

The CAMSIZER data can match sieve results for narrow and wide distributions, ranging from 30 micron to 30 mm. This is an essential point when replacing the traditional sieving technique with a faster and more precise method, but without changing the product specifications. Figure 3 shows a comparison of CAMSIZER and sieve results across a broad dynamic range of sizes.

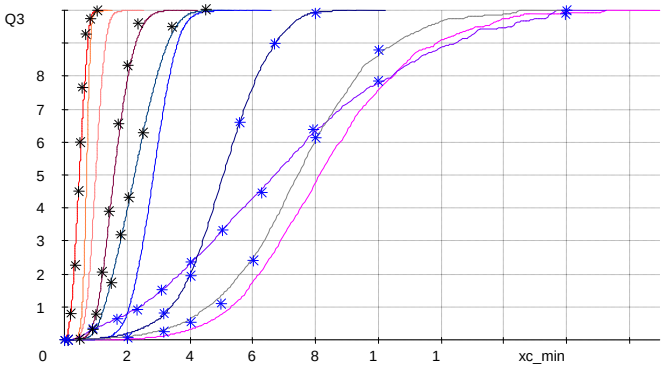

Figure 3: Comparison of sieving results and CAMSIZER measurement. Curves: CAMSIZER Dots: sieving results

The ability to analyse the particle shape is important for the detection of aggregates.
It is also required for the quality control of some types of salt which must consist of cubic or elongated particles. Figure 4 shows a plot of particle shape as described by the aspect ratio calculation (x-axis) vs. % under on the y-axis. The graph in Figure 4 shows four repeated measurements of the same sample (red), and 3 measurements of different batches (green,

blue, violet). The reproducibility is proven to be excellent.

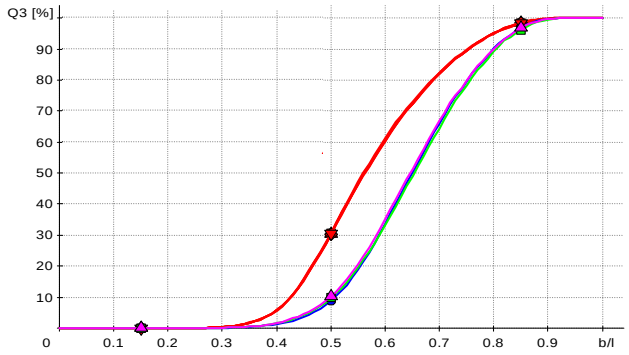

Figure 4: Aspect ratio (width divided by length) for two different salt products.

This shape information is also supported by the images of the particles measured, shown in Figure 5. The advanced image processing routines of the CAMSIZER software allow the simultaneous detection of a few 100 particles in every image in real time (60 images per second). Even very transparent particles are detected accurately.

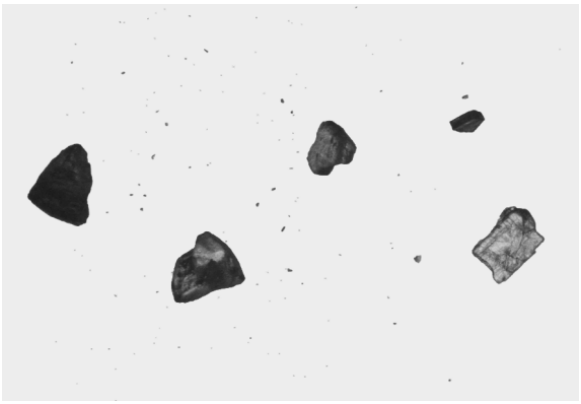

Figure 5: Images of blue salt sample from Figure 4.

It is also possible to display the particle size distribution as a histogram including the upper and lower specification ranges, as shown in Figure 6.

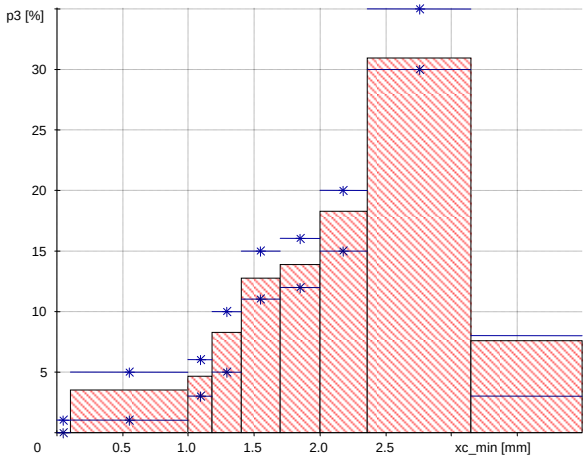

Figure 6: Particle size distribution including specification range for each histogram band.

Conclusions

The CAMSIZER dynamic image analyzer can replace sieve analysis over a broad range of salt sizes. The benefits to upgrading to this advanced technology include:

- Reduction of sample analysis time.
- Analysis costs, manpower, and workload can be reduced.
- Perfect matching of sieve results, i.e. identical product specifications.
- More information on each sample (i.e. size and shape, higher resolution, etc.).
- Higher resolution of the size distribution => more precise adjustment of the process parameters => higher output (less recycling).
- Results are available faster and at higher frequency.
- Results saved in 1,000 sizes classes => ability to simulate any sieve stack configuration.
- More frequent and better calibration.
- Similar and accurate results in absolute size at different locations due to low instrument to instrument variability.

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