HORIBA Scientific

Application Note

Particle Size and Shape Analysis of Fertilizers using Digital Image Analysis

AN172

Fertilizers are organic or inorganic plant foods which may be either liquid or solid. They are used to enrich soil in order to improve the quality and/or quantity of growth. The particle size distribution (PSD) of many fertilizer products must be measured and controlled for quality and industrial hygiene reasons. The CAMSIZER digital image analyzer provides accurate, reproducible PSD results quicker than older techniques and also reports particle shape information.

Introduction

Fertilizers are chemical compounds given to plants to promote growth. Fertilizers can be organic (composed of organic matter), or inorganic (made of simple, inorganic chemicals or minerals). They can be naturally occurring compounds such as peat or mineral deposits, or manufactured through natural processes (such as composting) or chemical processes (such as the Haber process). Fertilizers typically provide the three major plant nutrients (nitrogen, phosphorus, potassium: N-P-K) in varying proportions, secondary plant nutrients (calcium, sulfur, magnesium) and sometimes trace elements (or micronutrients).

Naturally occurring organic fertilizers include manure, slurry, worm castings, peat, seaweed, sewage, and guano. Green manure crops are also grown to add nutrients to the soil. Manufactured organic fertilizers include compost, bone meal and seaweed extracts.

Inorganic fertilizers are typically synthesized materials containing the three primary ingredients N-P-K. They are named or labeled according to the content of these three elements, which are macronutrients. Examples of inorganic fertilizers include:

- Potassium chloride, potassium sulphate, potash special grades, magnesium fertilizers.
- Nutrient salts and liquid fertilizers.
- Special mineral fertilizers, ENTEC fertilizers.
- Water-soluble salts, liquid fertilizers.
- Controlled release fertilizers.
- Complex fertilizers, nitrogenous fertilizers.
- Ammonium nitrate, ammonium sulphate.

Manufacturing

Because of occupational health and safety (respirability of fertilizer powder) and environmental aspects (formation of dust) fertilizer manufacturers are forced to granulate the fertilizer powders and crystals. This improves the handling and does not affect the molecular structure of the product in any way.

Pressed, crushed and classified (angular particles):
When the raw material is very fine (powders), the powders are pressed between two rollers to produce a 1-2 cm film of hardened fertilizer. This film is crushed and the produced particles are classified by production sieves. Only 50%-80% of the final product has the desirable size distribution. Smaller particles have to be pressed again, whereas too big particles have to be crushed again.

Granulated (round particles):
When the raw material consists of crystals, a roll granulation process produces bigger granules of fertilizer particles. When the particles have a certain size they are taken out of the granulation process.

Coated (round particles):
Some granulated fertilizers are coated for better handling and a longer effective period (action time). These larger, misshapen particles can cause problems when the coating produces undesirable agglomerates/aggregates.

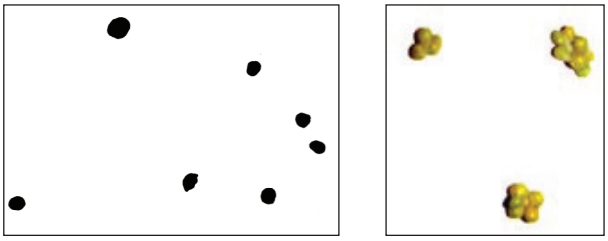

Figure 1: (left) CAMSIZER image of a good coated product, (right) digital image of agglomerates

Fertilizer producers need quality control for incoming goods, production and for outgoing products. Some companies use particle measurement systems in the quality lab, some use them at-line or on-line. Many fertilizer producers, such as bulk blending companies, mix different fertilizers to obtain a specific nutrient content of the soil.

A basic requirement for most applications is that the fertilizer granules have a defined particle size distribution and shape in order to obtain a certain dilution rate and action time. For fertilizers consisting of coated beads, it is also necessary to be able to detect agglomerates. For some types of salt, a cubic shape (achievable with boron doping) is required to improve the handling.

Particle Characterization

Particle size analysis is so important in the fertilizer industry that a minimum frequency of measurements must be made to assure proper quality. The fertilizer industry's traditional technique for particle size analysis has been sieving, but companies are now looking for more efficient measurement tools. Any technique considered for replacing sieving must have the ability to match the historic sieve results, but provide gains in speed, ease of use and long term cost.

As previously noted, some types of salts require a cubic or elongated shape. Sieve analysis is influenced by the shape of the particles but does not provide any quantifiable shape information.

Digital Image Analysis

The CAMSIZER digital image analysis system has successfully replaced sieve analysis in fertilizer plants around the world. CAMSIZER results can match historic sieve results while providing several additional benefits.

Figure 2: The CAMSIZER with Autosampler

Some fertilizer granules are round (more or less spherical) or egg-shaped (like particles in Figure 3 and Figure 4). For these products a comparison between sieve analysis and CAMSIZER is very easy by using the width of the particle projection $x_{c\,min}$ or $x_{Ma\,min}$. Almost identical results in these cases are achieved without any fitting, as shown below.

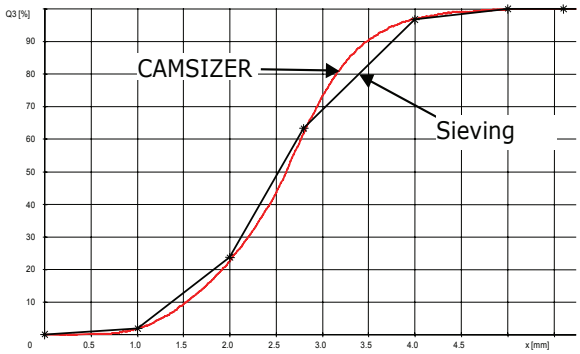

Figure 3: CAMSIZER vs. sieve results for round granulate without fitting

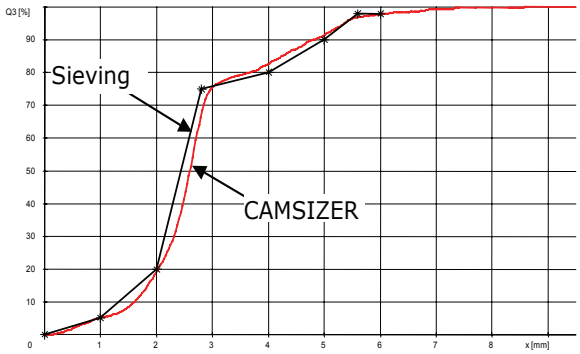

Figure 4: CAMSIZER vs. sieve results for egg-shaped granulate without fitting

For angular and flat particles, a fitting procedure can be used to get results, which are closer to sieve results than without fitting.

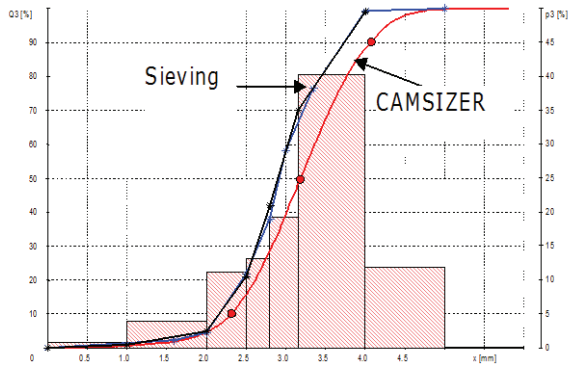

Figure 5: CAMSIZER vs. sieve results for angular granulate *without fitting*

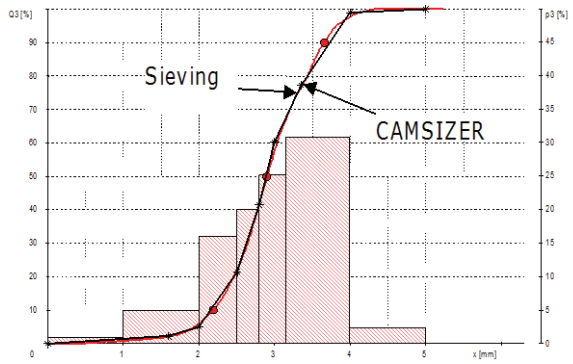

Figure 6: CAMSIZER vs. sieve results for angular granulate *with fitting*

Using the CAMSIZER provides the additional benefit of particle shape information, a valuable improvement for many products. Other benefits of measuring fertilizer with the CAMSIZER include:

- Reduction in sample analysis time.
- Reduced analysis costs and workload.
- More information on each sample (i.e. shape information such as sphericity).
- Higher resolution of the size distribution.
    - o More precise adjustment of the process parameters.
    - o Higher output yields 50% → 80% (less recycling).
- Results are available in higher frequency because of faster measurement.
    - o Save on scrap and labor during the night shift.
- Results saved in 1000 size classes gives the ability to simulate any sieve stack configuration.
- The CAMSIZER software allows for the export of an EXCEL-readable file to provide the results of at-line and lab analyses to the quality computer system.
- More frequent and more accurate calibration.
    - o No need to use low-quality sieves with questionable accuracy giving low confidence data.
- Excellent instrument-to-instrument reproducibility allows different CAMSIZERs at different locations to report the exact same result.