Sieve Analysis in Quality Control

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We all know the term ‘quality’. It is widely used to describe a product of particularly high value. However, the exact definition of quality is as follows: Quality is the compliance of defined properties with the detected properties of a product as determined by performing tests.

A product can be described as high-quality if a test measurement ascertains that the desired properties lie within a given tolerance. If the measured values deviate too much, the quality is lower.

Many materials, whether natural or artificial, occur in dispersed form (material which does not form a consistent unity but is divided into elements which can be separated from each other, e.g. a pile of sand). The particle sizes and their distribution within a material quantity - i.e. the fractions of particles of different sizes – have a crucial influence on physical and chemical properties.

A few examples of properties which can be influenced by the particle size distribution:

- the strength of concrete
- the taste of chocolate
- the dissolution properties of tablets
- the pourability and solubility of washing powders
- the surface activity of filter materials

These examples clearly show how important it is to know the particle size distribution, particularly within the context of quality assurance of bulk goods for production processes. If the particle size distribution changes during the production process, the quality of the product will change as well.

Some examples taken from everyday life show how closely the particle size distribution is linked with product properties:

- If the particles of ground filter coffee are too coarse, the contained flavours cannot dissolve completely in hot water. This is due to the fact that only the flavours contained in the particle surface are washed out. Thus, the taste of the coffee cannot fully develop. Moreover, the water runs too quickly through the spaces between the particles and the filter. If the coffee is ground too fine, too many flavours, acids and bitter aromas are dissolved which impair the taste. Another disadvantage is the blocking of the fine-pored filter paper by ultra-fine particles which can even cause overflowing of the filter.
- Abrasive papers and grinding pastes need abrasive agents with a very narrow particle size distribution. Consequently, the particle sizes should not vary too much. Substantial deviations from the required size range may result in uneven surfaces: if the particles are too coarse, the paper/paste can leave deep grooves in the treated surface; if the particles are too fine, the grinding effect is reduced.
- Activated carbon filters in respiratory masks need a large reaction surface to efficiently absorb hazardous organic solvents from the air. The surface area is particularly influenced by the particle size. If the particles in the filter are too coarse, an efficient neutralisation of the harmful vapours is not possible. If the particles are too fine, the person wearing the mask will have difficulties to breathe because the fine pores prevent sufficient amounts of air from passing.

Sieving Methods

During sieving the sample is subjected to vertical movement (vibratory sieving) or horizontal motion (horizontal sieving). With tap sieve shakers both movements are superimposed. During this process the particles are compared with the apertures of every single sieve. The probability of a particle passing through the sieve mesh is determined by the ratio of the particle size to the sieve openings, the orientation of the particle and the number of encounters between the particle and the mesh openings.

Single sieving is carried out with one test sieve of a defined mesh size and is used to determine the percentages of undersize and oversize. It is used to get a general idea of the sample characteristics (sieve cut). A particle size distribution in the actual sense is not obtained with this method.

If more fractions are required, a set of sieves is used. The sieves are arranged in a stack with the mesh size increasing from bottom to top. The sample is then placed on the top sieve.

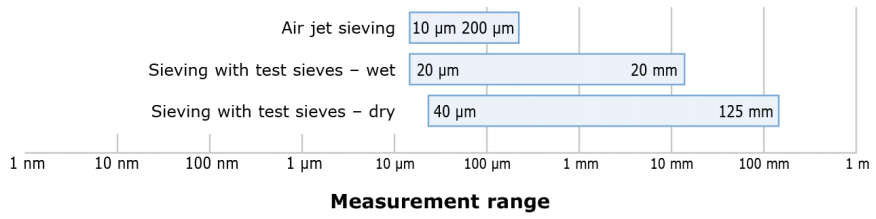

Figure 1

The appropriate sieving method depends on the degree of fineness of the sample material (*Figure 1*). Dry sieving is the preferred method for the size range between 40 µm and 125 mm. Wet sieving extends the measurement range to 20 µm. If wet sieving is not permitted, air jet sieving is an alternative which provides acceptable results down to 10 µm.

Vibratory Sieving

The sample is thrown upwards by the vibrations of the sieve bottom and falls back down due to gravitation forces. The amplitude indicates the vertical oscillation height of the sieve bottom.

Figure 2

With vibratory sieving, the sample is subjected to a 3-dimensional movement, i.e. a circular motion superimposes the vertical throwing motion (*Figure 2*, left).

Due to this combined motion, the sample material is spread uniformly across the whole sieve area. The particles are accelerated in vertical direction, rotate freely and then fall back statistically oriented. In Retsch sieve shakers, an electromagnetic drive sets a spring/mass system in motion and transfers the oscillations to the sieve stack. The amplitude can be adjusted continuously to a few millimeters.

‘Control’ sieve shakers allow the digital setting of amplitude and sieving time. During the sieving process, a built-in measuring system and control unit performs a continuous comparison between the set and actual amplitude values which ensures a high degree of reproducibility.

Horizontal Sieving

In a horizontal sieve shaker the sieves move in horizontal circles in a plane (*Figure 2*, middle). Horizontal sieve shakers are preferably used for needle-shaped, flat, long or fibrous samples. Due to the horizontal sieving motion, hardly any particles change their orientation on the sieve.

Tap Sieving

In a tap sieve shaker a horizontal, circular movement is superimposed by a vertical motion generated by a tapping impulse (*Figure 2*, right). Tap sieve shakers are specified in various standards for particle size analysis.

The number of comparisons between particles and sieve apertures is substantially lower in tap sieve shakers than in vibratory sieve shakers (2.5 s-1 as compared to ~50 s-1) which results in longer sieving times. On the other hand, the tapping motion gives the particles a greater impulse, therefore, with some materials, such as abrasives, the fraction of fine particles is usually higher. With light materials such as talcum or flour however, the fraction of fine particles is lower.

Air Jet Sieving

The air jet sieve is a sieving machine for single sieving, i.e. for each sieving process only one sieve is used. The sieve itself is not moved during the process.

The material on the sieve is moved by a rotating jet of air: A vacuum cleaner which is connected to the sieving machine generates a vacuum inside the sieving chamber and sucks in fresh air through a rotating slit nozzle. When passing the narrow slit of the nozzle the air stream is accelerated and blown against the sieve mesh, dispersing the particles. Above the mesh, the air jet is distributed over the complete sieve surface and is sucked in with low speed through the sieve mesh. Thus the finer particles are transported through the mesh openings into the vacuum cleaner or, optionally, into a cyclone.

The sieve analysis starts with the smallest mesh size; the undersize is determined by weighing the material before and after sieving. If a size distribution curve is required, this procedure is continued with increasing mesh sizes. The oversize on the finer sieve is put on the sieve next in size and is sieved again.

Air jet sieving is used, for example, for the continuous and quick control of classifying processes.

Option: Wet Sieving

Most sieve analyses are carried out with dry materials. However, there are many applications in which wet sieving cannot be avoided, e.g. if the material to be tested is a suspension or if a very fine sample (< 45 µm) that tends to agglomerate has to be sieved. Dry sieving would lead to blockage of the sieve.

As in dry sieving, a sieve stack is assembled on a sieve shaker. The sample is placed on the top sieve in the form of a suspension. The sieving process is supported by water from a spray nozzle located above the uppermost sieve. Rinsing is carried out until the sieving liquid leaving the sieve stack outlet is no longer clouded with solid particles. If this finest fraction is required for analysis, it has to be recovered with the help of a very fine filter and can be weighed after drying.

Important note: The water should not alter the sample in any way, i.e. the particles should not swell, dissolve or react with the liquid.

During wet sieving it may occur that air cushions are formed between the sieves. This effect is caused by the fact that the sieves form a dust- and liquid-tight stack which helps to avoid material loss and cross-contamination. The mesh sizes below 100 microns are particularly affected by this. By placing venting rings between the sieves, this effect can be avoided.