Replace sieves analysis with laser diffraction in particle sizing

INTRODUCTION

Particulate materials are the raw ingredients, intermediates or the end products in an enormous range of manufacturing processes. Common particulate materials include powders, granules, suspensions, emulsions, slurries, aerosols and sprays. Various physical properties affect the behaviour of these materials, and one of the most important is particle size.

Sieving remains in use across the manufacturing industry due to its low cost, simplicity, and ability to measure relatively coarse particles up to several centimetres in size. However, the technique has pronounced drawbacks which make it unsuitable for supporting high productivity, modern manufacturing. These disadvantages can be overcome by a move to laser diffraction technology, which delivers reliable, faster, simpler analysis along with a wider measurement range, better resolution and easier maintenance. Here we explain why a switch from sieving to laser diffraction should be a priority for manufacturers looking to optimize analytical productivity and increase efficiency.

Reason 1. Better data quality
Data quality in particle sizing is crucial in R&D, process and quality control. The repeatability and reproducibility of results with diffraction is markedly better than with sieving.

Typical laser diffraction measurements feature reproducibility of better than 1% and repeatability of better than 0.5%, with little variability contributed from the operator. This is in stark contrast to sieving methods, where reproducibility can vary strongly with operator and even the age of the sieve stack. The statistical advantages of laser diffraction offer one of the most important arguments in moving to an analytical method from sieves.

Reason 2: Higher measurement resolution for improved product quality

Laser diffraction reports 100 size classes over the full measurement range, compared to 5–8 size classes reported by sieving analysis.

More detailed resolution of a sample gives more informative particle size distribution data, enabling:

- Faster detection and resolution of production issues
- Improved understanding of the relationship between particle size and product performance
- Better control over product quality, enabling access to premium markets

A typical sieve stack contains only five to eight sieves, principally to ensure that measurement times do not become unmanageable. This means that size classes across the measurement range are few and wide, leaving the technique blind to subtle differences in particle size. This is particularly problematic when there are changes in the amount of material at the extremes of the size distribution - the very coarse or very fine particle fractions. Laser diffraction reports 100 size classes over the full measurement range, delivering far more precise resolution than sieving and detecting even the smallest changes in particle size distribution. In manufacturing, this makes it easier to spot a process change at an early stage and take corrective action before a major problem develops. It also enables rapid and sensitive detection of out of specification material for both feeds and products.

Reason 3: Faster analysis

In modern material testing, especially for process monitoring, speed is the single most important factor in selecting an analysis method. The difference between a few seconds and a few minutes can often be measured in thousands of dollars in wasted material due to suboptimal process conditions. Laser diffraction experiments take seconds, compared to 5 -10 minutes for sieve testing.

Faster analysis means:

- Increased throughput/productivity
- Quicker product release
- More responsive and effective process control

Preparation for sieve analysis is time-consuming, requiring each sieve to be weighed before construction of the sieve stack. The sample must also be weighed prior to loading into the top sieve. The stack is then shaken for a typical minimum time of at least five minutes, with polydisperse samples often requiring much longer. Following shaking, each sieve and its contents must be weighed. Often, these steps must be repeated multiple times as part of method development or to check the ongoing effectiveness of the measurement method.

Laser diffraction is much more automated. Once a standard operating procedure (SOP) is defined, routine analysis is as simple as adding the sample and starting the measurement. Sample dispersion and measurement are then performed without further manual intervention. The whole measurement is typically complete in less than a minute, enabling rapid reporting of key quality control data and, as a result, improved product consistency.

Reason 4: Increased measurement range, including very fine particles

Laser diffraction measures particles from 20 nm to several mm in a single measurement, while sieving fails below 100 µm.

A broader measurement range delivers:

- Versatility of application, maximizing return on investment for the analytical system
- Improved product differentiation, by enabling the development and quality control of materials which benefit from properties associated with finer particle sizes
- Futureproofing: broader capabilities can tackle evolving analytical requirements

Sieving is not a suitable technique for measuring fine particles. This is due to the force of adhesion between particles, which increases rapidly as the particle size decreases in the sub-100 micron region. This can lead to particle size changes during sieving, caused by particle agglomeration, resulting in poor measurement reproducibility and/or sieve blocking. Wet sieving is a potential solution but increases equipment set-up times.

In laser diffraction, rapid dry powder dispersion can be achieved for samples containing very fine or even sub-micron particles. Liquid-based dispersion further extends the measurement range to around 20 nm, enabling the routine analysis of nanomaterials. Both fine and coarse material can be analysed within a single automated measurement, enabling reproducible characterization of different product grades, even those with very broad particle size distributions.

Reason 5: Simpler operation and analysis
Analytical procedures and manual interventions needed for laser diffraction are fewer and less complex than those for sieving.

Simpler analytical procedures:

- Reduce training requirements for new analysts
- Increase analytical productivity, freeing up time for higher value tasks
- Minimize the potential for erroneous results

As previously described, sieve analysis is a multi-step procedure requiring various manual interventions and numerous weighing steps. The sample and sieve weighing data must then be processed to calculate the particle size distribution.

Modern laser diffraction systems virtually eliminate the need for manual intervention during routine analysis. Collection of the light scattering data required for laser diffraction particle size calculations begins automatically as soon as the sample enters the laser diffraction measurement zone. These data are then instantaneously analysed to provide particle size data and distributions. The measurement process can be followed in real time, providing immediate feedback on the repeatability of analysis, and instantly identifying product quality issues.

Reason 6: Trouble-free maintenance
Routine maintenance of modern laser diffraction systems is minimal compared with that needed to keep sieves 'fit for purpose'.

Routine maintenance requirements have a major impact on:

- Lifetime cost of ownership
- Analyst productivity
- Equipment utilization and need for downtime

After each sieve analysis, the sieve stack must be dismantled and each sieve carefully cleaned with a fine brush. This is most critical when working with fine powders, which often agglomerate and block the sieve mesh. Rigorous, routine examination of the sieves is also required to detect damage to the sieve mesh, a major source of poor-quality analysis.

Following a dry powder laser diffraction measurement, a quick brush down to remove any residual sample is the only routine maintenance needed. After a wet measurement, a simple flush with clean liquid fulfils the same requirement. Modern systems incorporate automated cleaning procedures, rapidly returning the instrument to operational readiness. Such systems are specifically designed to fulfil the requirement for 'workhorse' instruments relied upon by multiple, relatively non-expert users. Minimal cleaning requirements enable rapid switching from one sample type to another, while occasional maintenance tasks are made easier by improving the accessibility of key components, such as measurement cell windows.

Next steps
If any of these reasons have led you to consider switching from sieving analysis to laser diffraction, or have prompted further questions, please visit https://www.omecinstruments.com/technology/laser-diffraction