

Ultimate precision

Dr Graham Rideal of Whitehouse Scientific gives an insight into the latest developments in sieving technology

With so many so many particle sizing instruments on the market these days, sieving, the father of them all dating back to ancient Egyptian times, tends to be overlooked.

One of the problems has been the perception that sieving is old fashioned and inaccurate. This brief review looks at all elements in the analytical process from sieve cloth, through sieve frames to shaking methods to see how sieving has moved with the times.

Quality sieve cloth

It goes without saying that the quality of sieve analysis results is determined fundamentally by to the quality of the sieving medium. With industry striving to become more competitive, there is a danger of cost savings eclipsing quality. But this is false accounting, because without the confidence of having good quality meshes, the associated uncertainties can cause losses of millions, either in production or litigation, as in the case of the pharmaceutical industry.

By way of example, sieves used to be, and still are sold in some parts of the world, according to the mesh count. This is simply the number of wires per inch. The problem with this measure of quality is that we assume, quite wrongly, that the wires are uniformly spaced giving regular apertures. This is exemplified in figure 1 showing a comparison between two sieve meshes of identical mesh count. These two meshes of the 'same' specification will obviously give quite different results in a sieve analysis. For accurate work therefore, sieve cloth should be specified by the aperture size not the mesh count.

In terms of material of construction, brass wire was the first material to be used but these days stainless steel wire is the preferred material both for mechanical strength and resistance to a wide range of chemicals.

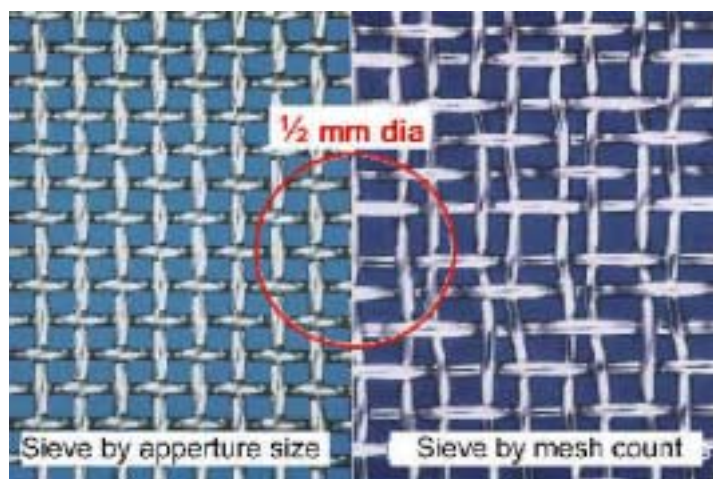


Figure 1: Measuring a sieve cloth by mesh count rather than aperture size gives a false impression of quality (Courtesy of G Bopp)

Sieve aperture calibration

Historically, sieve meshes have been calibrated by microscopy (see ISO 3310-1). Here wire spacing in the X and Y directions are measured as well as wire thickness. One of the problems of this method is that it produces rather a large number of parameters, for example: mean wire spacing, standard deviation, maximum single spacing, wire thickness. When applied to both directions, up to eight parameters need to be compared so matching sieves can be a real problem.

An alternative method is to use glass calibration microspheres. In this method specially graded microspheres are shaken over the sieve surface and the effective aperture size determined from the weight of beads passing. The process only takes about one minute and the results are traceable to international standards such as NIST. Furthermore the test can be performed in the analyst's own laboratory so the sieves do not need to be sent away for re-calibration. Having just one parameter, the effective cut point of the sieve, also facilitates sieve matching.

Wire weaving

It must be said that the technology of wire weaving has improved in leaps and bounds in the past few years. It seems incredible that the looms, little changed in concept for hundreds of years when they were initially designed to weave cotton, can now weave stainless steel wire to tolerance of about 5 microns.

The current minimum size for test sieves is 20 microns, although some of the best weavers claim to go down to 17 microns. Indeed, the standards set in ISO 3310 are now easily surpassed by the best European weavers.

There are still applications however, where even higher specifications are required. Electroformed or photo-etched

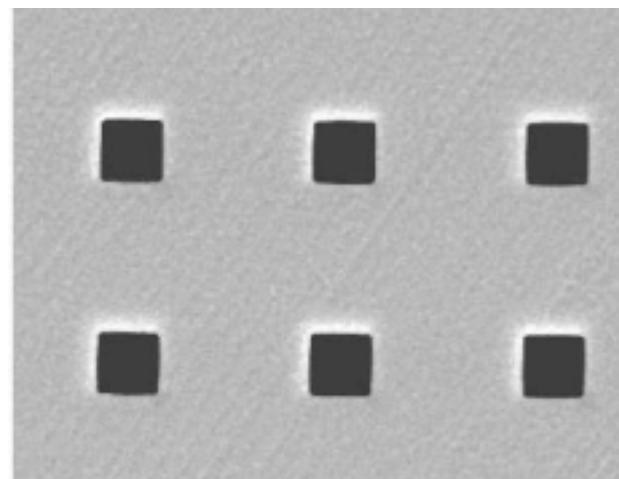


Figure 2: The precision of a 7 micron electroformed sieve (Courtesy of Tecan)

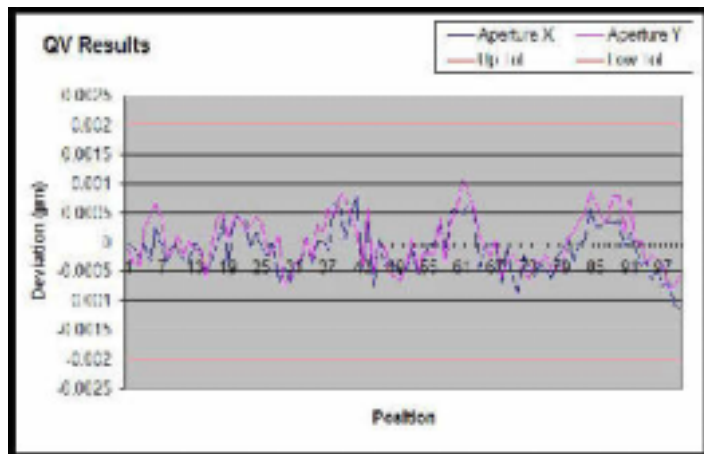


Figure 3: An electroformed sieve can be manufactured to tolerances of 1 micron

sieves must then be used. These sieve membranes represent the ultimate in precision sieving where apertures from millimetres to a few microns are achievable with tolerances down to 1 micron, figures 2 and 3.

Sieve frames

Sieve frames have traditionally been constructed in two component parts, between which the wire mesh is stretched and fixed in position, usually by soldering. In the latest so-called 'new generation' test sieves, a one-piece construction is used where the mesh is welded to the frame after stretching, figure 4. This enables the entire sieve structure to be made out of one material, for example, pharmaceutical grade stainless steel, so minimising the possibility of metal (lead) contamination of the product. A further advantage is that there are no crevices for particles or liquid to be trapped enabling a speedier and more efficient washing process.

Other options for sieve frames are brass, although these are not so popular these days and clear plastic. Perspex frames are useful in some of the latest shaking devices where the process can be visually monitored.



Figure 4: A new generation sieve frame (Courtesy of Retsch)

Sieve shakers

Very few people actually shake sieves by hand these days although it is still perfectly acceptable provided a standard and repeatable method can be used. If the technician is just looking for large particles in the product after milling for example, it is still one of the fastest methods in particle sizing, with the additional advantage of being able to see the particles in question.

In most cases however, some form of mechanical shaker is used. These tend to be electro-mechanical in operation because precise control of amplitude is possible through electronic feedback of the shaking operation. Highly reproducible shaking can then be performed irrespective of the weight of powder or number of sieves used.

As the particle size decreases, the shaking operation has to compete increasingly with inter-particle attractive forces, which begin to dominate below about 50 microns thus preventing individual particles passing the sieve.

In such cases, a liquid carrier must be used to break down the particle clusters. Although most sieve shaker manufacturers offer wet sieving attachments for the sieve shaker, the process is more complicated and time consuming.

A solution to breaking down the particle clusters without resorting to wet sieving is to apply the energy to the particles directly. In other words, the particles are shaken not the sieves. This is done by high velocity air currents, either through air jet sieving or sonic sieving.

In the air jet process, a jet of air from a rotating sweeper is blown on the underside of a sieve containing the powder to be analysed. The force of the blast breaks down the particle clusters, which are lifted above the sieve surface. Before they have time to reform, a negative pressure on the remaining part of the sieve not in contact with the jet sweeper rapidly draws them through the sieve, figure 5. Air jet sieves can measure down to 10 microns by using electroformed sieves.



Figure 5: Hozokawa Air Jet Sieve

The original form of the air jet sieve used just one 200mm diameter sieve and so a complete particle size analysis took some time. More recent versions can accommodate six or seven sieves although they must be smaller in diameter if the instrument is not to exceed the size of the bench!

A more elegant solution is to use sonic forces to generate the air currents. This is done by hermetically sealing the sieve stack between a sonic driver (a HiFi speaker) and a flexible reaction diaphragm. Simply controlling the 'volume' of the speaker then controls the amplitude of oscillation.

The energy applied is so intense that inter-particle forces are easily broken down so extending the lower limit of particle sizing to 5 microns. As the air current pulses at 3600 oscillations per minute, it is also one of the fastest methods of sieve analysis. Having an on-board computer also minimises operator error during an analysis.



Figure 6: A Gilson Sonic Siever for 200mm diameter sieves

A sonic sifter for 200mm diameter sieves is shown in figure 6 although very small footprint instruments are available for 75mm diameter sieves.

Conclusion

While the latest techniques of laser diffraction or image analysis may look impressive on the bench, unless they are used sensibly and operated in accordance with the manufacturers instructions, false results can be obtained. For example, when analysing a suspension of particles, if the stirrer speed is too high, air bubbles rather than real particles will be measured.

Even though sieve analysis may be perceived as old fashioned, most manufacturers of the latest sophisticated instruments recommend that the laboratories use sieves as a back up to confirm the results in difficult cases.

There is also the question of cost effectiveness. A developing business may not be able to afford tens of thousands of pounds for the latest particle sizing instrumentation. A simple sieve under a hundred pounds shaken by hand may well be all that is required for process control to begin with. As the business develops more sieves, sieve shakers and particle sizing software can be added to give impressive displays of the results.

But the biggest advantage of all in sieve analysis over most other methods is that you can see whether particle pass the sieve or not so the results are totally unambiguous.

For more information please contact Dr Graham Rideal at Whitehouse Scientific on tel: +44 1244 33 26 26. You can email; info@whitehousescientific.com, or visit www.WhitehouseScientific.com