Sieving – still an essential tool for particle sizing

In the second part of our series on sieving techniques, Graham Rideal tells us why, in an age where technology rules, the humble sieve is still as vital as ever for particle size analysis

The last 10 years has seen tremendous advances in the field of particle size analysis. From the earliest form of size analysis, the humble sieve, it is now possible to accurately measure particles by sedimentation, microscopy, Coulter counting, light blocking, laser diffraction, ultrasonic spectroscopy, dynamic light scattering, precision photography, elutriation, field flow fractionation, zeta potential, electrostatic migration, even oscillating springs. The list seems to increase every year.

The advance in technology, however comes at a cost, both literally and in terms of performance of the instruments Not that they are unreliable or prone to breakdown but just as a first class chisel in the hands of a second class carpenter will not produce good results, so the operators of advanced particle sizing instruments can compromise performance by using poor work practices. Measuring air bubbles caused by excessive stirring is a classic example. This is one of the main reasons for the enormous increase in the use of quality audit standards in recent years.

A second opinion

In addition to certified reference materials, any laboratory serious about particle size analysis should have a back up method to confirm any anomalous results. Two techniques that fulfil this role and are conceptually easy to understand are microscopy and sieve analysis, both of which have also seen such major technological advances that they are now powerful tools in their own right.

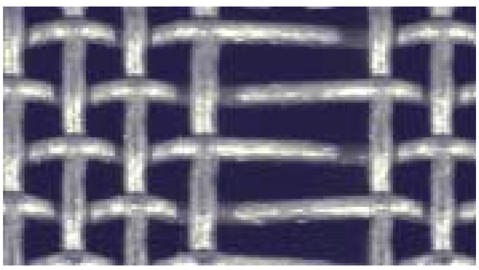

Figure 1: Counting sieve wires per inch belies quality by disguising aperture size

At one time, sieve meshes were sold by their mesh number - the number of wires per inch. This is a very poor definition because the pitch of the wires and their thickness could vary significantly resulting in a distorted mesh that still conforms to the ‘mesh number’ specification, figure 1. With products like this, it is not surprising that sieve analysis started to lose its popularity.

Precision wire meshes

Anyone who sells sieve mesh by its mesh count alone is certain to be producing an inferior product and disguising it with a poor specification. One of the highest precision weavers, G Bopp of Switzerland, for example, draws their own stainless steel wire down to 18µm with a tolerance of less than 1µm, which is then woven into 20µm apertures with a precision of +/-3µm. This is remarkable considering that over 10,000 wires have to be individually and manually spaced on a loom prior to weaving.

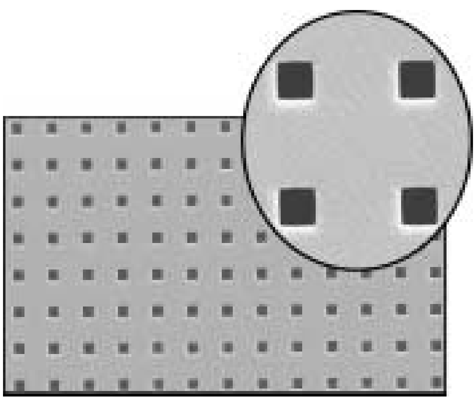

Figure 2: A 7µm Electroformed sieve foil (courtesy of Tecan)

It is not possible to produce a plain weave mesh with an aperture size below 20µm for particle size analysis because the wire diameter needed would be too small to have the necessary strength to survive the rigours of the weaving process.

Electroformed sieves

To extend the range of sieve analysis below 20µm, photomasking and electrolytic deposition processes must be employed to accurately control the aperture size. Nickel is usually the preferred substrate. It is then possible to improve tolerances to better than 1µm. Although aperture sizes down to 3µm have been reported, even a 0.5µm tolerance, in percentage terms is too great for precision work. At 7µm however, Tecan has succeeded in producing one of the highest specification electroformed sieve, figure 2.

Advances in sieve shaking

Producing an accurate sieve is only the first stage in performing a sieve analysis. In the next stage, the particles must be encouraged to pass through the apertures. As particle sizes decrease, their mutually interactive forces exponentially increase, so dry sieving is not recommended below about 50µm. Simply shaking the particles on the sieve surface will not introduce sufficient energy to break up the loose agglomerates.

In order to sieve below about 50µm therefore, the agglomerates must be energised to release the individual particles and enable them to pass the sieve. The two most common approaches are ultrasonics and pulsed air.

In the former, an ultrasonic transducer attached to the sieve mesh produces high frequency impulses through the wires to energise the powder. Pulsing the air to fluidise the particles can be achieved either by an air jet, as in the case of the Alpine Air Jet sieve or through high frequency air pulses generated sonically, as in the case of the Gilsonic Autosiever, figure 3. The advantage of the latter is that up to seven sieves can be used simultaneously.

Figure 3: A new Gilson 200mm diameter sonic sieve shaker sieves down to 5µm

Some of the latest sieve shakers now have sophisticated software packages to identify and monitor sieve usage, flag when recalibration is required and calculate the results, see large picture on page 1.

Calibration and traceablility

One of the biggest question marks hanging over the quality of the results from a sieve analysis has been the calibration of the sieves. There are several sources of uncertainty.

The variation in the apertures resulting from the weaving process is something that is often overlooked. It is surprising how many people believe that a wire woven 250µm sieve, for example contains only 250µm apertures. The ISO specification in fact, allows the average aperture size to range from 240 - 260µm with a maximum tolerance for a single aperture of 308µm. In theory, this means that if 300µm monosized beads were left on the sieve long enough, they would all pass through.

Another more worrying prospect is that the sieve manufacturer has put the wrong mesh in the frame. This has happened on many occasions in the past.

Aggressive or excessive use can also introduce wear. For example, in certain applications involving abrasive materials, the aperture size can increase with use as the particles pass through.

One of the biggest sources of error is sieve abuse by the operator, for example using a spatula or wire brush to ‘encourage’ particles to pass.

So, although the most advanced sieve shaking machine may be employed, unless the size of the sieve is known, and good operating procedures are used, the results are meaningless.

For all these reasons, the calibration of sieves has increased enormously in the past year, especially in sensitive industries such as pharmaceuticals. Sieves can be calibrated microscopically by the manufacturer or, by the increasingly popular method of certified glass microspheres. The advantage of the latter is one of speed and convenience because the sieves do not need to be sent back to the manufacture.

Unrivalled repeatability

In addition to its simplicity, one of the biggest advantages of particle size analysis by sieving is repeatability. The Bureau of Certified Reference (BCR) has produced both quartz and spherical glass standards over the last 20 years and in both cases, it is a little known fact that when the sieves were calibrated and used under prescribed conditions, the spread of results between the certifying laboratories was much narrower than any other technique used. So, although even if a laboratory has the most advanced particle sizing instrumentation, it is comforting to have the unequivocal backing of sieve analysis in the background.

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