SIZE REDUCTION UNIT operations, especially milling, are widely used throughout the solids handling industries. Product performance typically depends on particle size, with continuous real-time measurement being the best option for optimal control. This article looks at how USA-based Sturtevant Inc., an established manufacturer of materials processing equipment, is using the Insitec online particle size analyser from UK technology supplier Malvern Instruments Ltd, to optimise milling solutions for specific customer applications.

Sturtevant Inc. based in Massachusetts, USA, manufactures materials processing equipment for an array of industrial applications. The product offering ranges from crushers and grinders for the coarse break-up of hard and soft materials, to the Micronizer for the production of very fine powders, and includes air classifiers for particle separation. These units are used to process materials as diverse as pharmaceuticals, fly ash and ceramics. In each case the aim is to reduce particle size to a specified value that delivers the required performance.

Sturtevant has a testing facility where the company’s teams develop solutions specifically tailored to individual applications. It also offers field services, in situ support at a customer site, as and when required. For in-house trials, technicians have historically used off-line laser diffraction particle size analysis to monitor processes producing material in the sub-2,000 micron size range.

This approach is relatively successful but cannot achieve real-time monitoring and is especially limited when process response times are very short. Early in 2008 Sturtevant started to investigate the potential benefits of online particle size measurement.

Online measurement
Sturtevant elected to take advantage of a consultancy service from Malvern to evaluate the impact of online particle size analysis. This service includes: setup of a particle size analyser at the customer’s facility, the measurement of process material, and a written report summarising technical performance and the findings of the study. The installed Insitec particle size analyser proved valuable for monitoring various different units (Figure 1).

With an off-line measurement regime samples are extracted regularly from a process line or unit for analysis in a laboratory. In the process environment practicalities dictate that this type of measurement is usually conducted once per hour at most, and there is often a considerable delay between sample extraction and receiving results.

At the pilot facility, analysis frequency varies from application to application as the more flexible analytical schedule is closely tailored to the demands of individual development programmes.

The company’s off-line laser diffraction system, Malvern’s Mastersizer 2000, has a broad dynamic range and provides fast automated measurement making it valuable for many applications. However, online analysis offered Sturtevant real-time monitoring and a continuous data stream for detailed process characterisation, with minimal manual effort.

The Insitec system measures up to four complete particle size distributions every second. All stages of the analytical process are fully automated from sample extraction through to results presentation.

The system aspirates material from a sample loop on the process line using a J-probe (Figure 2), taking a fraction of the stream for analysis and returning it after measurement. A Vortab flow conditioner upstream of the probe homogenises material flow in the line thereby ensuring that extracted samples are representative of the bulk.

This solution allows Sturtevant to rapidly investigate new process options.

Figure 1: Insitec particle size analyser monitors real-time output

Real time Trona
Developing optimal milling solutions for FGD-grade trona can reduce injection levels and increase fly ash recycling, as Steve Coulombe of Sturtevant and Alon Vaisman of Malvern explain.
The performance of modified equipment or a new application is quickly and easily characterised and the impact of changing process variables is visible in real-time. The data the instrument provides, therefore, both accelerates and improves process optimisation and product development.

Late in 2008 Sturtevant used online analysis to develop and demonstrate a highly successful solution for the grinding of trona, sodium bicarbonate carbonate (sodium sesquicarbonate) for flue gas treatment.

**Flue gas desulphurisation**

A coal fired power plant operator requested a mill to grind trona to a suitable particle size for the removal of SOx from flue gas. Coal combustion produces a variety of nitrogen- and sulphur-based oxides that are potentially damaging to the environment.

Selective catalytic reduction removes nitrogen oxides but increases the amount of SOx in the flue gas. Trona injection is an effective way of reducing SOx levels in the stack emissions, preventing the formation of unsightly blue plumes and reducing acid rain levels.

Sodium sesquicarbonate is an excellent reactive sorbent for flue gases, but particle size is critical; finer materials provide a greater specific surface area for more rapid sorption.

A **Dv50** of around 10 to 20 microns minimises the amount of material required for treatment. This is important from the perspective of variable cost reduction and waste disposal, because the reacted sorbent ends up in a fly ash waste stream.

When trona is used predominantly for absorption of SO2, rather than SOx, a fine particle size can reduce the amount of spent sorbent in the fly ash to a sufficiently low level to allow incorporation into cement. This is an appealing, cost effective alternative to waste disposal options.

**Trona processing**

For this power plant trona is supplied by two different companies. One source is coarser than the other with a **Dv50** of several hundred microns as opposed to less than a hundred. The operator required a milling solution capable of handling both feeds. A Simpactor was selected for the duty but with a specially designed rotor to ensure effective processing of both materials.

Material enters the Simpactor and is deposited on a horizontal high RPM Rotor Plate. The Rotor Plate accelerates the material through a set of multiple Impact Pins where most of the size reduction takes place.

Additional grinding taking place as it hits the Impact Wall Liner. In operation, particle size is controlled mostly by changing the Rotor RPM. Initial set of the Rotor, as to Impact Pin quantity and placement, and Impact Wall Liner type also have an effect on the final particle size achieved and throughput (production capacity) of the Simpactor mill."

At the test facility the performance of a new aggressive rotor was investigated. Online particle sizing data confirmed the ability of the mill to process both the coarse and fine trona feed materials; the coarser feed requiring higher rotational speeds to increase grinding intensity. Tests were conducted with two different rotors to confirm the optimal solution. Having proven a solution at the test facility, experts from both companies transferred the technology to the customer site for in situ trials.

The online data recorded as flow rate through the mill increased from 500 lbs/hr to 1,000 lbs/hr to 1,500 lbs/hr and then back to the original condition. The analyser extracts a set fraction of the process stream, so the amount of material passing through it increases with flow rate.

Step changes in transmission (dark blue line) – the amount of light penetrating the sample – track the process flow rate. It is important to note that these changes do not affect the accuracy of particle size measurement. The Insitec reliably characterises even relatively concentrated streams, thanks to a patented multiple scattering algorithm, and easily handles changes in load.

The particle size data demonstrate the ability of the instrument to monitor performance in real time and indicate that the product becomes coarser as flow rate increases. Changes in **Dv90** are more pronounced than for **Dv50** and, with this rotor, particle size is generally coarser than is optimal (Figure 3); **Dv50** is around 35 to 40 microns rather than 10 to 20 microns.

Figure 4 shows results from a second run with the more aggressive rotor. With this hardware the **Dv50** is around 10 microns, the optimal value. Real-time
analysis proved to the customer that the trona being injected was sufficiently fine regardless of the feed source, demonstrating the suitability of the developed solution.

The trial resulted in an order for four Simpactors. The finely milled material removes SO$_3$, very effectively so injection levels are low, meeting the design intent; the waste material is acceptable for cement production. Reducing injection levels and disposing of waste via the cement incorporation route has a beneficial impact on the bottom line for the power plant operator.

Currently the installed mills run without real-time analysis but online measurement at the power plant could prove beneficial in the long run. Often milling circuits grind a consistent feed to differently sized products but in this application the situation is reversed, with two very different feeds and a constant product specification.

Optimal rotor speeds have been defined for each supply, the coarse feed requiring operation of the mill at its limit. However, with the finer material there is the scope to change speed of rotation in response to changes in feed particle size. If the feed is constant then clearly this is unnecessary but finer materials are prone to segregation a potential source of variability.

Continuous monitoring of the mill outlet would provide data for the manual or automated manipulation of rotation speed in response to any feed changes, giving the system greater stability.

**Conclusions**

As a supplier of size reduction and separation solutions Sturtevant has a strong interest in developing optimal systems that fully meet customer requirements. Laser diffraction particle size analysis is a valuable tool for product characterisation and is routinely used in its off-line form during development.

The installation of an online laser diffraction system, the Insitec from Malvern, has highlighted the benefits of real-time monitoring and the potential it offers for better, faster process and product optimisation.

Using online technology Sturtevant has successfully supplied an optimal pin mill for grinding trona, a dry sorbent for FGD. This solution produces consistently fine material that is highly effective for the removal of SO$_x$ from flue gas, and is fast becoming an industry standard. It reduces trona injection to very low levels that permit the incorporation of the fly ash waste into cement (SO$_3$ removal) and/or significantly reduce associated waste disposal costs (SO$_2$ removal).

This application highlights the ability of online analysis to provide benefits at every stage – from equipment design and development through to routine operation and troubleshooting. Monitoring a process in real-time gives insight that is invaluable for comprehensive process optimisation and minimising production costs.

**References**


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