Calibrated discrete element modelling (DEM)
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Meridian... correct weight for Fortescue
Handling toxic dust during unloading in fluoridisation plant

Australian authorities have been slowly installing water-fluoridation plants over the years, endeavouring to promote dental health. Queensland's determination to give 90% of its population access to fluoridated water by 2012 has seen the pace of plant installations rise markedly.

ProMinent Fluid Controls has supplied more than 60 fluoridation systems over the past 25 years. Many earlier installations were for rural water supplies in relatively small water treatment plants.

Initially, 25kg bags of sodium silico-fluoride powder (Na2SiF6) were manually loaded into a hopper. Later, installations used a vacuum loader designed by ProMinent. A dry chemical feeder meters the Na2SiF6 into a mixing tank of water, where it is dissolved before being added to the water supply (other chemicals used for fluoridation are sodium fluoride powder and hydrofluosilicic acid).

Toxic dust control
More recently, however, the company has supplied equipment for much larger plants, including five that started up in Queensland around the end of 2008. The plants range in size from approximately 125 MLD to 750 MLD and serve more than 50% of Queensland's population of approximately 4.5 million, according to ProMinent sales manager, Neville McKee.

For plants of this size, ProMinent has designed a fully automated process in which the Na2SiF6 is completely contained in a scaled transfer system from the time it is received until the moment it is put into the mixing tank.

Sealing is important for dust control because the plants use up to 875 kg/d of Na2SiF6, which is toxic and subject to strict regulatory control. Bulk bags of Na2SiF6 are unloaded into a transition or floor hopper, from which a flexible screw conveyor transfers the material to a storage hopper that feeds the mixing tank.

The transition hopper is small, with a capacity of only 60l. In contrast, storage hoppers may be as large as 8,750l or more for a 750 MLD plant and designed to hold up to seven days' supply of Na2SiF6.

The major pieces of equipment are the bulk bag discharger, a dust containment system, and the flexible screw conveyor, all supplied by Flexicon. Bulk bags of 1,000kg are lifted into place on the discharger frame by an electric hoist and trolley on a cantilevered I-beam.

Powder is discharged from the bag into the transition hopper through a double-wall Tele Tube telescoping tube. The tube is secured to the bag spout by a patented Spout-Lock clamp ring that creates a dust-tight seal, while the bottom of the tube is connected to a collar in the lid of the sealed hopper.

The clamp ring, in the open position, is raised pneumatically to the bag spout. The spout is pulled over the rim of the tube's inner wall and the ring is locked in place over it. At this point the pneumatic pressure that raised the tube is released, causing the telescoping tube assembly to exert downward pressure on the spout.

The continuous downward pressure on the bag keeps the spout taut at all times and helps maintain a steady flow by preventing excess material in the spout from bulging outward and creating dead spots or falling inward and restricting the flow.

The double-wall telescoping tube is a key element in the entire system, says McKee.

"In this design, errant particles are drawn into the dust collector through an annular gap that encircles the bag spout seal.
This is the only way to go to obtain extra protection against dust leakage."

Flexicon's Bag-Vac dust collection system is activated prior to connecting the telescoping tube to the bag. The system attached to the discharger frame, conveys dust pneumatically to a water trap tank. Once the clamp ring has been secured, the dust extractor is turned off and the spout drawstring is untied, allowing the powder to flow into the transition hopper.

The dust extractor remains inactive throughout the unloading process. However, air displaced by the flow of material exits via the dust collection system. A filler prevents Na2SIP6 from being entrained in the outflowing air.

**Stopping the flow is a cinch**
A special feature of the unloader unit is a pneumatic Power Cincher flow control valve that can close the bag at any time, so that a partially empty bag can remain in place until more material is needed. This is important for the flocculation plants, which use approximately 120 kg/d of Na2SIP6 per 100 MLD of water. The cincher also helps to keep moisture out of the bag and can isolate the bag in the case of an emergency.

Promoting flow are Flow Flexer bag activators - two pneumatically driven plates that rhythmically raise and lower opposing bottom edges of the bag to direct material to the outlet. As the bag empties, the stroke of the plates lengthens, forming the
bag into a steep V shape and promoting total evacuation. An adjustable timer controls the frequency of the strokes.

The dust tight system is vented to a BagVac dust collector that removes residual powder and collapses the empty bag prior to tie off, preventing dust generated when empty bags are flattened manually.

As mentioned earlier, a flexible screw conveyor transports the Na2SIF6 from the floor hopper to a storage hopper that feeds the mixing tank. The conveyor consists of a rotating, stainless steel spiral screw, housed in a 65mm diameter polymer tube. The lower end of the roughly 5m long tube passes through the wall of the floor hopper, near the bottom, and the top end discharges the powder through a chute into the top of the storage hopper some 4.5m above the plant floor.

Fluorate powder flows from double outlet hopper through sealed connections to the two flexible screw conveyors that move it to the two storage hoppers.

A self-centred conveyor

As the screw rotates, it self-centres within the tube, providing ample clearance between the screw and the tube wall to prevent grinding of the product. A 4kW electric motor, located above the discharge point, rotates the screw at a variable rate up to 6,000rpm. The flexible screw conveyor is inherently enclosed throughout its length to avoid airborne dust.

As the bags contents empty into the floor hopper, the conveyor is activated. The transfer of powder to the storage hopper continues until either the transition hopper is empty or the weight of the storage hopper reaches a pre-set high level, as indicated by four load cells underneath the hopper. The control system signals the conveyor to stop when the high level is reached.

From the storage hopper, a dry chemical feeder metres the fluoride powder into a mixing tank through a sealed unit that prevents the escape of dust. The flow of powder is automatically matched to the inflow of water to the tank in a ratio that results in a 0.2% Na2SIF6 saturated solution. The tank has a high-speed mixer and a retention time of 10min.

Finally, the solution is carefully metered into the flowing water supply by a peristaltic pump or a progressive cavity standy pump. The dosage rate varies from 0.6mg/l to 1mg/l, depending on local requirements.

In rare cases, a water treatment plant may have two independent pipelines, each with its own dosing system. This situation occurs when a town or city has grown and added more treatment capacity.

These cases require separate storage hoppers and dosing systems for each pipeline, McKee says. However, a single bulk bag discharger and one transition hopper can feed two storage hoppers by incorporating two separate flexible screw conveyors into the single common transition hopper.

Feeding two storage hoppers is well within the capacity of the system. McKee points out that a single conveyor delivers material at a rate of around 5,000kg/h, while the seven-day storage capacity of a large hopper is only about 8,750kg.

The Flexicon system is the only one that ProMinent uses for fluoridation plants, McKee says.

“We have only ever promoted Flexicon bulk bag unloaders with double-wall telescoping tubes for fluoride, as we found it to be the best available to handle a toxic powder with minimum risk of dust.

‘I think it would be a brave water supply authority to try a different brand at the moment, as we have promoted this since the application arose for bigger bulk type fluoride installations, about three years ago.’

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