Fully Automated Methods for Pump-Conveyance of Problematical Sludges

Lijao Sewage Treatment Plant in Guangzhou, China

ABEL develops and manufactures reciprocating positive displacement pumps for abrasive, aggressive and shear-sensitive media. ABEL is recognised around the world as a technological leader in diaphragm pumps. Solids handling pumps (for dewatered sludge, paste-like and non-Newtonian media) and high pressure plunger pumps complete the range of products. Filter press feed and transfer of dewatered municipal sludge from belt presses, centrifuges and chamber or membrane type filter presses to silos, barges or incinerators are typical applications in waste water treatment plants.

In addition to the “classical” use of belt conveyers and troughed chain conveyors, increasing importance is also being attached to the handling and transportation of high-viscosity and high solids sludges via pipelines since these permit more flexible routing and avoid the nuisances caused by odours and fouling.

In addition, a high level of automation is also demanded, i.e., the sludge has to be conveyed from the treatment site to its destination with as little difficulty as is possible using a centrifugal or displacement pump with a Newtonian liquid.

It is obvious that such sludge can cause major disturbances during conveyance, both at start-up and shut-down of the system: such disturbances, if they are not prevented by means of automatic early detection and immediate regulation and control reactions, can result in failure of the system. The unpleasant result would then be the necessity of opening individual elements of the system and manual removal of the sludge blockages, inevitably using “mining” methods in some cases.

Partially dried sludge is generally destined for incineration. The sludge is either injected directly into a fluidised-bed incinerator or fed via a sprinkler-type stoker at the end of the pipeline onto domestic waste awaiting incineration, for instance, or pumped into a silo for temporary storage.

The pump-conveying system is shown in Figure 1 and consists of a hopper above the twin shaft screw conveyor, into which the extracting screw of the dryer discharges the partially dried sludge. The hopper has vertical walls or, preferably, walls sloping...
at a negative angle, in order to prevent bridging of the sludge in the hopper. The hopper is also equipped with a level probe.

In addition to an open area into which the sludge drops, the twin shaft screw conveyor also has a closed tubular section, within which the helical screws generate the feed pressure and force the sludge via a connecting bend into the solids pump.

The solids handling pump (shown again separately in Figure 2) takes the form of a hydrostatically-driven, twin-cylinder single-action positive displacement pump with automatically operated valves, which ultimately pumps the sludge into the downstream pipeline. A slip injection unit is located immediately downstream of the pump. A similar unit, adapted to the external contour, is also installed at the inlet to or outlet from the connecting bend. These injection points are coupled to a metering station.

The solids pump, including the pre-press screw, hydraulic unit, metering station and the level probe in the feed hopper, are controlled and monitored by means of a PLC. This PLC is itself connected to the control system for the overall drying plant.

The solids pump cylinder and the hydraulic drive motor for the screw conveyor are driven by means of flow- and pressure-compensated hydraulic pumps. This permits variable-stroke and variable-speed operation up to and including safe stopping of the solids pump and/or the pre-press screw with a simultaneous maintenance of the maximum limit pressures, without heating up the hydraulic fluid and without dissipating energy.

The mass flow of sludge is controlled either by altering the incineration temperature (the solids pump must then be fed using the level probe by altering the speed of the dryer discharge screw) or, in the case of silo feeding, by regulating the speed of the solids pump itself, again using the level probe in the feed hopper.

It is quite clear that the pump’s screw conveyor and, in particular, its connecting bend to the solids handling pump are the weak points in this processing line. On the one hand, the thrust of the screw feeder is limited and on the other, it cannot build up pressure with a liquid such as water, i.e., it will never be able to clear the bend of sludge in the direction of flow.

In the arrangement explained above, which is also the most common set-up, it must twice divert the sludge through 90° on its path into the cylinder of the solids handling pump.

A new inlet-valve housing design in which the screw can be installed immediately upstream of the pump will thus become increasingly popular in future (Figure 3). Only a straight transition piece between the pre-press screw outlet and the now horizontal inlet valve will then be needed instead of the 90° bend. The sludge will therefore be forced almost directly into the sludge cylinder, undergoing in the process only a slight change of direction of flow of less than 32°.

This solution not only eliminates the weak point of the 90° connecting bend and the 90° bend in the valve housing, both susceptible to blockage, but also greatly increases the filling level of the solids pump’s sludge cylinder, thus significantly improving the pump’s overall efficiency.

In individual cases this may even enable the use of smaller hydraulic drive systems or the installation of a smaller solids handling pump.

More common than the transfer of semi-dried sludge is the transfer of dewatered sewage sludge with solids handling pumps. Depending upon the solids content dewatered sewage sludge can be pumped over several hundred meters with solids handling pumps (Figure 4–6).
At the Lijao Sewage Treatment Plant in Guangzhou, China, dewatered centrifuge cake with 20–25% solids concentration must be pumped by two solids handling pumps to barges through a 300 m long pipeline. The capacity of each pump is 40 m³/h and the design pressure is 10 MPa.

The first phase of this sewage plant located in Guangzhou city, southern China, treats 400,000 tons/day of sludge. During the design of this new plant, it was decided by the local Design Institute to use piston pumps to transfer the dewatered centrifuge cake to barges at the quay. For a 300 m long pipeline, the choice of piston pumps was easy as it offers many advantages over other conveying technologies.

The design institute and end user decided to use ABEL SH pumps due to their high performance in many installations for similar applications around the world. The technical advantages over other hydraulically driven piston pumps was also a deciding factor.

The plant was commissioned at the end of 2005 and the ABEL SH pumps have continued to perform well, requirement of spare parts is low and downtime is minimal.

ABEL supply mainly consists of SH pump, double screw feeder, hydraulic power pack, control and power cabinets and injection system. The sludge is stored in two silos, the discharge screw of silo feeds the double screw feeder of the ABEL pump. The control cabinet and its PLC controls the hydraulic power pack, the SH pump, the screw feeder, the silo sliding frame and the gate valve (installed between silo and screw feeder). Control of the pump is also possible with an operator panel installed near the SH pumps. The PLC software is programmed in-house and according to the system requirements.

The ABEL slip injection system consists of the dosing pump (triplex plunger type) and three slip injection rings installed along the pipeline. The function of this system is to lubricate the piping with a thin film of water to reduce the friction losses thus reducing the required discharge pressure and power consumption.

The ABEL advantages

Sludge transport in a closed pipe avoids bad or harmful odors and contamination of the environment. Pipes allow a flexible layout, are space saving and easier for a system design. The pump performance itself (flow rate) is not affected by varying sludge solids concentration. The suction & discharge cone valves in the ABEL pumps prevent backflow. Backflow (recirculation) of sludge from pump discharge to suction is experienced with valveless pumps at higher pressure. Therefore, with the ABEL valve design, the SH pump is more efficient and runs more smoothly than valveless piston pumps. An external grease lubricating system for the piston seals is not necessary for ABEL’s solids handling pumps. The piston seals are of single acting (single lip) cooling and lubrication is ensured through the water filled cylinder box. A special feature are ABEL’s cone valves with extended valve rods which avoids cross-contamination of the hydraulic system, even with worn valve rod seals.

Summary

Due to the more favourable energy balance and the reduction of nitrogen oxide emissions via residual moisture, the incineration of partially dried sludges offers an advantage over the incineration of only mechanically dewatered or totally dried sludges.

The measures explained can quite easily eliminate the problems which, on the other hand, such sludges cause during pipe-based conveying.

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