Advantages of AODD Pumps in Sludge Drying and Thickening Applications

Ensuring proper sludge formation in filter-press operations is a critical - and potentially lucrative - stage in the surface finishing, waste-handling and wastewater industries. Therefore, it is imperative that the correct pump technology be chosen to optimize the operation of the centrifuges and evaporators that are central to sludge-formation processes. While piston pumps have been a popular technology for these applications, in-the-field results indicate that a much better choice is the air-operated double-diaphragm (AODD) pump. AODD pumps excel in these applications because they are capable of the high-pressure operation necessary for filter-press processes, along with being dry-run capable, self-priming and self-regulating.

In many industrial processes, substances occur in aqueous or "muddy" form, where the liquid portion must be removed. This may take place during production processes - for example in the filtration of edible oils or yeast solutions - but more frequently occurs at the end of a process in waste sludge from various industries from surface finishes to wastewater treatment.

Since the disposal of such sludges is calculated based on weight and volume, thickening and drying is particularly lucrative. During the process, the sludges are treated using chemicals and/or physical processes so that the substances in it form flake-like solids. After pH-adjustment to neutral or alkaline using milk of lime, the dewatering process separates out water for disposal and the remaining volume of sludge is significantly reduced.

The simplest technology for this process involves collection and thickening of the sludge via gravity. However, it is significantly more effective to use technical drying methods via processes such as centrifuges and evaporators, or more commonly, chamber filter presses (Figure 1).

The principle of a chamber filter press includes a number of plastic frames that are pressed together under high pressure. Inside the frames are hollow chambers - from which the press gets its name - that are surrounded by filter cloth. When the sludge is fed into the chambers using pressure, a "filter cake" forms inside the chambers and the filtrate flows through the filter cloths into drainage channels. When all the chambers are completely filled, the sludge feed stops. The press can now be opened and the solid filter cake removed. After closing, the press is ready for a new pressing process.

To fill these presses, filter material and pressure is required. The pressure — usually between 8 and 15 bar at its peak - should be even in order not to destroy the flocs during feeding. The flocs should also have enough free space in the feed area. In addition to the constantly increasing counter-pressure that occurs until the end of the pressing, a further constraint is the eventuality that an empty-running sludge tank can lead to dry running of the pump being used to generate pressure.

Figure 1: Chamber filter press with an Almatec air-operated double-diaphragm pump

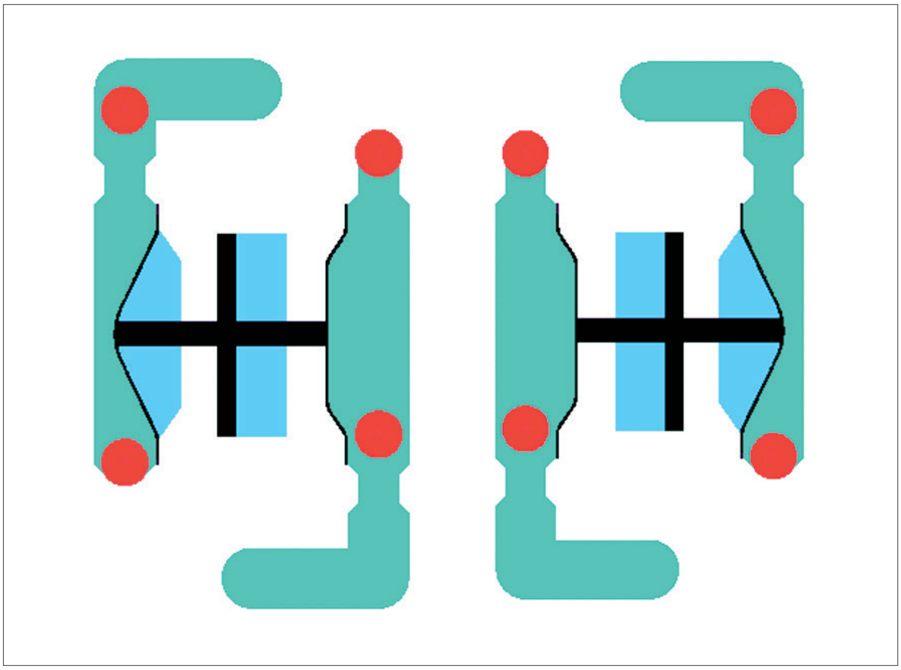

Figure 2: Functional principle of an air-operated double diaphragm pump with a feed pressure of 15 bar (Almatec AHD Series).

To build pressure, different variations of displacement pumps are frequently used, including piston diaphragm pumps, which are applied most frequently for large presses. In these large and costly units, one or two diaphragms are hydraulically actuated and feed the sludge into the press via valves. These pumps require large overhead costs even for small plants, such as an air pressure vessel to equalize the feed rate and a maximum pressure monitor or bypass. Eccentric screw pumps are also used, either as self-regulating pumps (with motors that are electronically controlled via a frequency converter) or as cyclical systems (where an air pressure vessel is “charged” by the pump). This valve-free procedure is advantageous when processing large sludge quantities and when long fibers prevent the use of valves. However, there are constraints in small- and medium-sized plants due to their sensitivity to abrasion and dry running. The space required to use this system is also considerable.

This list of pumps also includes hose-diaphragm piston pumps, which function in a similar way to piston diaphragm pumps but with crimped hoses rather than diaphragms and piston pumps. The latter piston pumps typically generate strong pulsation and require constant lubrication. Both of these pumps are characterized by their simple electrical operation, with fairly high installation and maintenance costs.

By comparison, it is much easier to use an air-operated double-diaphragm (AODD) pump; they are resistant to dry running, virtually maintenance-free, self-priming, self-regulating and highly compact. Without the control or intervention of an operator or electronic system, the counter-pressure of the chamber filter press regulates the feed rate automatically. The feed rate decreases continuously as counter-pressure increases simultaneously to the degree of filling. This effect can be used to detect when the chamber filter press is full. When this is reached, the pump virtually stops - zero feed rate - or only occasionally makes a delivery stroke. In addition, the use of compressed air as drive power to move the diaphragms, results in a highly efficient, regular and gentle cyclic drive that allows the medium to be fed smoothly.

A standard AODD pump is typically limited to the pressure of the supplied air, which is often insufficient to fill the press. For this reason, it is often necessary to increase the pressure, for which there are three very different technical solutions:

- The first variant uses one of the diaphragms on a standard pump to generate additional pressure. The force of this diaphragm, which is surrounded only by air and compressed air, is transferred to the feed diaphragm via the internal diaphragm connection, enabling the feed diaphragm to work with double the pressure. This method is rarely used anymore, as it leads to high pulsation, low feed rates and high air requirements. It also commands high service costs as the diaphragm on the air side is very sensitive and breaks quickly.
- Another variant is to operate a standard pump with an air pressure amplifier, which drives the pump with increased air pressure. This process is limited by the fact that a standard pump is used most of the times. Although these pumps are equipped with external reinforcements, from a technical perspective the standard pumps in question are designed and built for significantly lower pressures and as a result only have limited resistance to the increased strain. Additionally, the increased pressure resulting from these air pressure amplifiers or “boosters” pulsates strongly, which can influence the flow of the product. Boosters also seem to reach their limits in maintaining pressure, ie, during repressing. This is because the devices used are almost always too small. These devices yield the required end pressure, but may require a longer filling time.

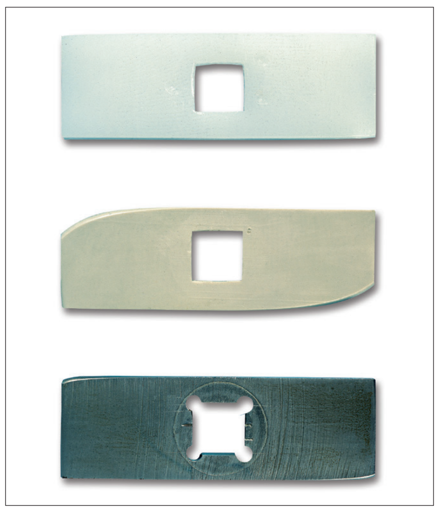

Figure 3: Wear factors based on the sand-slurry process - PE UHMW = 1 (top); PP = 7 (middle); steel = 1.6 (bottom).

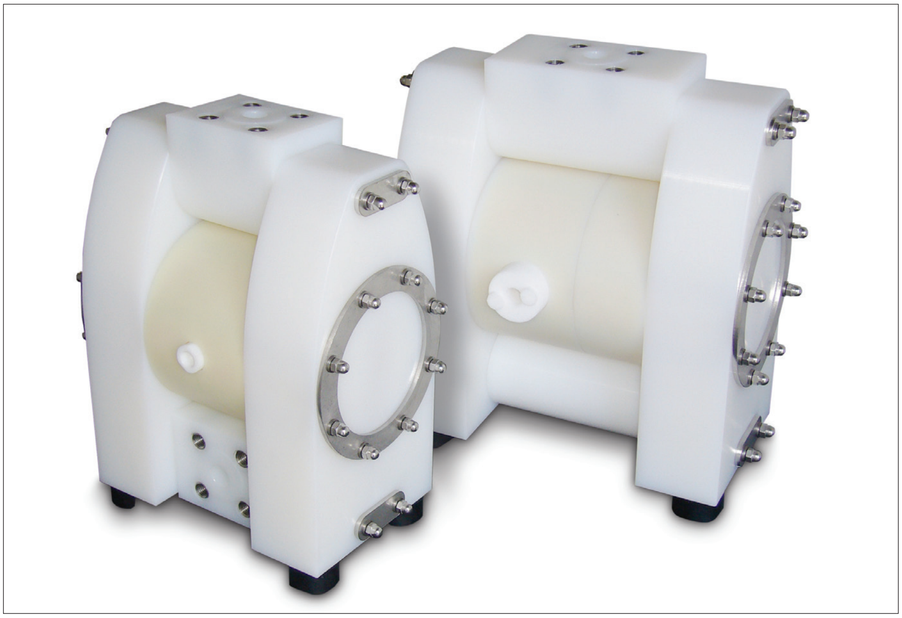

Figure 4: High pressure air-operated double-diaphragm pumps in the Series, with internal pressure conversion (Almatec AHD Series), as well as the variant for use with an external booster (Almatec AHS Series).

- The third variant is a pump with internal pressure conversion. Figure 2 shows how this technical solution applies compressed air to a differential piston along with the diaphragms. The increased surface area - typically twice as large or more - causes the compressed air to generate a corresponding amount of increased force. This converted force acts on the feed diaphragms with increased (double) pressure. The entire construction is designed for the high strain caused by the maximum amount of pressure, as well as the strain caused by the typically abrasive sludge. For this reason, the pump housing is built from materials such as stainless steel or polyethylene (PE-UHMW). This tough material is a decisive factor in the durability of the pump (see Figure 3 abrasion test).

Using compressed air to power a pump is very effective thanks to constructive measures. The pump operates with minimal dead space, ie, the space inside the pump that must be filled without serving the actual feed process. As a result, the pump always has sufficient power reserves to handle large volumes of wastewater.

With the introduction of a new generation of high-pressure AODD pumps, there is now an additional variant that combines the highly robust housing of the pressure-converting pump with an air section where no conversion takes place (Figure 4). This version is therefore suitable for all applications under heavy load conditions, ranging from low-feed pressures to high-pressure applications of up to 15 bar (218 psig). If the user operates a pump at such high air pressure - whether it is from an external booster or directly from the compressor - they can do so secure in the knowledge that the pump is structurally designed for such pressure ranges and need not be held together by external reinforcements.

On these new pumps, the diaphragms are equipped with specially developed heavy-duty diaphragms with an integrated metal core providing a long service life and the ability to handle heavy loads. The vulcanized core of the diaphragm supports extremely thick layers of elastomer. To transfer the suction forces, the core is also reinforced with a special textile that is barely flexible in any direction.

In addition, these pumps can be combined with the optional use of a sensor that responds to the movements of the diaphragm and allows the cycle to be easily monitored. Accordingly, the slow stroke frequency that accompanies a full press rarely triggers a signal. If a PLC is used to program a time window within which a stroke should take place, a full chamber filter press is indicated by the fact that these rare signals no longer occur within this time window.

The compressed air can be switched off and a signal can be set for the operator to empty the press. This method functions purely by physical means and is independent of sensitive pressure gauges and contaminating sensors in the wastewater current.

In conclusion, when selecting pumps for filter press operations, AODD pumps are the clear solution, incorporating a number of characteristic advantages. Conventional displacement pumps with electric drive and control elements do not have these properties which are specific to the design of the pumps, including run dry capability, good controllability and a gasket-less mechanical design to mention but a few.

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