Use of Double Hose-Diaphragm Pumps in the Bayer Process for Alumina Production

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Abstract

In alumina production processes, highly caustic bauxite slurries are pumped at high pressure into tubes or autoclaves for digestion at high temperature. Even today, production of alumina is based on the conventional Bayer process. Within this process, MULTISAFE® double hose-diaphragm pumps are involved at several stages and reliably pump bauxite slurry, red mud and lime milk. FELUWA pumps provide for environmentally friendly transportation of critical media at solids concentrations of up to 70 % with associated high efficiency as well as low wear and tear. The special design of the double hose-diaphragm pumps offers decisive advantages compared to traditional diaphragm pumps. At the heart of MULTISAFE® pumps are two hose-diaphragms which are arranged one inside the other. They fully enclose the product and provide double hermetic sealing from the hydraulic drive end. Thus, the slurry is in contact with the inside of the hose-diaphragm and check valves only, so that the heavy pump casings can be made from standard materials, which means considerable cost savings.

Keywords: Hose-diaphragms, energy efficiency, bauxite slurry, red mud disposal, alumina production

1. Introduction

Whereas bauxite mining is generally characterized by relatively low energy consumption, the further processes for transforming bauxite into alumina and further to aluminium are associated with a considerably higher energy demand. Nevertheless, the alumina industry has succeeded in an almost 10 % improvement in global refining energy efficiency in the course of the past years. The saving of energy is a consequence of the implementation of advanced technologies and equipment with improved energy efficiency.

The actual energy requirement of the Bayer process is to a great extent dependent on the quality of the feedstock. It uses a recirculating volume of concentrated caustic solution to dissolve the alumina minerals, separate them from still solid impurities, and then re-precipitate alumina tri-hydrate. Calcining completes the transformation of the tri-hydrate to alumina. Beyond process technology improvements to energy consumption, additional improvement is achieved by the implementation of energy-efficient equipment. Given that up to 30 % of the electricity consumption of alumina processing facilities is used by the high-pressure digestion pumping system and by motors of the ball mills, energy-efficient equipment is indispensable for such key positions within the system. Positive displacement pumps are typically employed to pump the bauxite slurry into the digesters under high pressure.

2. Digester Feed Pumps and Double Hose-Diaphragm Pumps

Hydraulically actuated piston diaphragm pumps are typically applied for digester feeding. However, the suitability of traditional piston diaphragm pumps is limited when it comes to the handling of aggressive or abrasive products, because not only the diaphragms but also entire pump chambers are in contact with the product. Aggressive fluid pumping, for example,

requires wet ends made of high grade stainless or even duplex steels. Solids, which are carried by fluids, tend to settle in the lower pump area between diaphragm and clamping ring and often lead to premature diaphragm failure. In the event of a diaphragm failure with such pump types, the product automatically contaminates the hydraulic system, where it comes in contact with the sliding seals and cylinder surface. This can lead to considerable destruction and consequential damage and create significant man power and cost for cleaning and subsequent repair of pump and gearbox.

Combined hose diaphragm piston pumps offer substantial advantages compared to traditional piston diaphragm pumps. MULTISAFE® double hose-diaphragm pumps (see Figure 1) represent the highest level of diaphragm pump technology with numerous strong features.

Figure 1. Seven sets of double hose-diaphragm pumps.

At the heart of MULTISAFE® pumps are two hose-diaphragms which are arranged one inside the other (see Figure 2) and fully enclose the linear flow path of the conveyed fluid. Simultaneously, they create a double hermetic sealing from the hydraulic drive end of the unit. Both hose diaphragms are actuated by the piston by means of hydraulic fluid. In step with the piston stroke, they are subject to pulsing action, comparable with that of a human vein. The cylindrical shape of the diaphragm favors the flow behavior and avoids the settling of solids.

Figure 2. Arrangement of double hose-diaphragms.

Similar to the traditional piston diaphragm pump, double hose-diaphragms are likewise actuated by a hydraulic fluid and provide for the displacement action. One of the major advantages of this design is its linear flow path, so that it is especially beneficial to the handling of aggressive,

resonance conditions. As is generally known, machines with an unbalanced mass interact in terms of vibration, if they are set up on the same floor or in the same building. After a certain period of time, this results in a consolidated rhythm and an accordingly increased pulsation rate. This phenomenon can be counteracted by means of the included PLC (programmable logic control) with the latest Multiple Pump Control System.

In accordance with their design, double hose-diaphragm pumps generate pulsating discharge curves. They usually do not cause problems in piping systems of process industry, provided that efficient pulsation dampeners are applied or minimum pulsation is ensured by the pump design, such as quintuplex configuration. The encoder provides for out-of-phase operation with angular synchronism and reduces the risk of damage to components or problems in associated processes due to possible fluid system dynamics. To utilize this system each of the driving motors has to be provided with an encoder. Single units discharging into a piping system do not require encoders, since the direct torque control (DTC) is capable of determining the nominal torque of the driving motor with a high degree of accuracy. However, the provision of an encoder does not only ensure out-of-phase operation of multiple pumps discharging into common piping. The reduced residual pulsation likewise contributes to an accordingly reduced wear rate of the check valves for the benefit of “mean time between repairs” (MTBR) and “mean time between failures” (MTBF) figures.

3. Conclusions

Beyond process technology developments to reduce energy consumption, additional improvement is achieved by the implementation of energy-efficient equipment, such as digester feed pumps, which rank among the highest energy consuming equipment of alumina facilities. Double hose-diaphragm pumps are especially conducive to handle aggressive, abrasive and highly viscous fluids as used in the Bayer process. The redundant hose-diaphragm provides for a linear flow path without sedimentations and ensures double hermetic sealing from the drive end. Check valves are considered the sole real wearing parts of double hose-diaphragm pumps. Ball valves are preferable, because valve balls have a considerably higher lifespan than valve cones. Valve balls are continuously rotating and thus changing the sealing area against the valve seat. Permanent condition monitoring of check valves avoids loss of energy, because any decrease in output resulting from valve wear is usually automatically compensated by the variable speed drive through the necessity of increased pump speed. Single-acting quintuplex configuration provides lowest pulsation by means of five plungers actuated by a common crankshaft. This pump can handle up to 1000 m^3/h. The pumps are equipped with the latest Condition Monitoring System, especially designed to monitor smallest valve leakage, temperatures and diaphragm condition. Where several pumps operate in parallel and discharge at independent speeds into a common pipe, pump synchronization controls phase shift and eliminates excitation of resonances significantly.