A comparison between various pump systems for high flow rate tailing pipelines

H. Krimpenfort [1], T. Rassmann [2], A. Pavlov [3], Ralf Scherer [4]
1. Key Account Manager
FELUWA Pumpen GmbH, Germany
2. Thoralf Rassmann
Regional Director Russia
FELUWA Pumpen GmbH Representative Office, Moscow, Russia
3. Alexander Pavlov
Area Sales Manager
FELUWA Pumpen GmbH, Germany
4. Sales and Marketing Director
FELUWA Pumpen GmbH Representative Office, Moscow, Russia
Corresponding author: a.pavlov@feluwa.ru

Abstract

Large mines produce tailings in high volumes. As suitable large tailings storage facilities are becoming scarce and difficult to find, tailings need to be transferred over longer distances than before. These longer distances, especially when a high positive static head and an extended transfer length have to be covered, require high discharge pressures. For this purpose, a number of alternative pumping systems are available. The first and most traditional method is to use centrifugal pump systems with multiple pumps in series. Over the last several years however, piston diaphragm pumps have also been successfully used for many such applications, especially at high and very high discharge pressures. Centrifugal pumps installed in series are usually applied at high flow rates at system pressures up to a maximum of 45-55 bar. Piston diaphragm pumps find application at lower flow rates and at pressures above 35 bar. In this paper, a train of centrifugal pumps will be compared with conventional (medium flow rate) piston diaphragm pumps and with high flow rate piston diaphragm pumps, which have recently become available and operate successfully. The comparison is based on an undefined type of tailings at a flow rate of 5,000 m^3/hr. The selected discharge pressure is 50 bar, for which traditionally centrifugal pumps are used. This paper will show that at these lower discharge pressures and higher flow rates, piston diaphragm pumps offer a very feasible alternative. All key figures of CAPEX and OPEX parameters are compared, resulting in a payback period calculation, accompanied by a sensitivity calculation with different OPEX parameters. In addition to the commercial differences between the various systems, technical aspects will also be discussed. This paper will show that high-capacity piston diaphragm pumps are the most feasible solution for high flow tailings applications.

Keywords: tailings slurry, pipeline transfer, pump systems, hydrotransport, comparison.

1. Introduction

Mineral resources are becoming more difficult to find and less-accessible locations need to be explored and exploited to mine these minerals. In addition, environmental and safety conditions are becoming stricter, especially regarding tailings storage facilities (TSFs). Suitable TSFs are therefore also more difficult to find and need to be constructed at more remote locations and at higher costs. This also applies especially to existing mines at which the existing TSF capacity has reached its limit. In such cases, a new TSF needs to be built at a location further from the processing plant, which requires higher pressures. Also, in many cases, tailing flows of different mine sites need to be combined and transferred to a common TSF. The combination of remote locations and combined tailings flow results in elevated discharge pressures and high flow rates.

2. Methodology and Options

For the transfer of high flow rates at elevated discharge pressures, a number of pumping alternatives are available.

2.1. Centrifugal Slurry Pumps

The first and most commonly used method is the application of centrifugal pumps in series. In order to reach an elevated discharge pressure, typically, trains often consisting of up to five or eight such pumps in series need to be installed per station. In cases where more pumps are required, a booster station along the pipeline may be required. Although the initial investment costs of these systems are low, the operating costs are usually quite high. A large part of this higher cost is due to the relatively low efficiency of centrifugal slurry pumps when compared to diaphragm pumps (PD) pumps. When averaged over a complete wear cycle of the centrifugal pump, efficiency in most cases will fall in the range of 50-70%. Another factor which results in high OPEX is the consumption of high-wear parts and associated down time and costs. The abrasive slurry flows through the pump typically at an impeller tip speed of up to 25 m/s. As the slurry is in direct contact with the pump volute, wear plate and impeller, these components have to be replaced at regular intervals. Consequently, the availability of each individual pump is rather low. Since a pump train consists of multiple pump sets, the availability of a complete pump train, which is critical to ensure a reliable operation, is very low. Another fact which contributes to the low availability of multiple pump trains, is that the shaft of centrifugal pumps needs to be flushed by a gland seal water system. The pressure of this system needs to increase at every stage in the train by 4 or 5 bar, which is difficult to control and makes the system vulnerable and potentially less unreliable. The low availability of each pump set in combination with the vulnerability of the gland water system results in a very low system availability. In order to guarantee a satisfactory availability, the majority of tailings pipelines are therefore equipped with at least one train of similar configuration. Some operators even prefer to have a third train of pumps to their disposal: one operating, one standby and one under repair. The capacity of a centrifugal pump is dependent on its discharge pressure (further explained in Chapter 6 of this paper). Whenever pressure increases/capacity decreases, the possibility of settling of solids and the risk of a plug is considerable. For this reason, a positive displacement pump is often installed for deblocking purposes, which increases the total CAPEX of the entire system.

2.2. Medium-Capacity Piston Diaphragm Pumps

An alternative for such centrifugal pumps in series is the use of piston diaphragm pumps of which the discharge pressure is, in principle, nearly unlimited, but in practice usually does not exceed 250 bar.

Therefore, booster stations along the pipeline are rarely required. Traditionally, the capacity of such pumps is rather limited (typically 650-700 m^3/hr). In order to reach a high capacity, a number of such pumps need to be installed in parallel. Obviously, the CAPEX of piston diaphragm pumps, when compared to centrifugal pumps, is relatively high. This is especially the case with conventional low to medium-capacity PD pumps of which many units need to be used in parallel. These high CAPEX costs are however, depending on certain conditions, offset by low OPEX costs. The mechanical efficiency of piston diaphragm pumps lies in the range of 85-90%. The difference with centrifugal pump systems is therefore at least 20%. This difference, especially when tailings pipelines are being used continuously and at high energy prices, leads to significantly lower annual energy costs for the piston diaphragm pump. Furthermore, the consumption of parts that wear in piston diaphragm pumps is much lower than for centrifugal piston diaphragm pumps varies from 6.7-2 years for medium-capacity piston diaphragm pumps, depending on consumption of parts that wear, and the price of power. For high-capacity piston diaphragm pumps, this period is reduced to three years to one year, which makes this type of pump the most feasible option for high flow rate slurry pipelines. In addition to commercial advantages, piston diaphragm pumps offer the operational advantage that the risk of a blocked pipeline with these pumps is considerably less than with centrifugal pumps.