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Backfilling of pastes and long distance transport of high density slurries with double piston pumps

Peter Peschken *Putzmeister Solid Pumps GmbH, Germany*

Dirk Hoevemeyer *Putzmeister Solid Pumps GmbH, Germany*

Abstract

Filling chambers with pastes in underground mines to increase the safety, climate and cut-off grade is state of the art. By adding gravel the strength is increased and the cement content can be reduced. This results in reduced costs for the backfill process. The results will be shown by examples from different mines.

High density slurries are pumped over long distances. At the Polish power plant of Belchatow flyashes are pumped over a distance of 8000 m. After more than 2 years of operation a first resume can be given.

1 Introduction

The economy and the environment are subject to continuous pressure. Paste pumping will consume a low amount of water and energy compared to slurry transport.

Why should material be pumped?

(1) Conveyance of large quantities in pipelines

Due to the constant transport process several hundred m³/h of material can be pumped 8000 hours per year through a pipeline by one system. If the volumes increase a second or third system can be placed easily beside the first system. Due to this pumps are used for the transport of tailings slurries on mines, milled ore transport, water hoisting of mine water and ash transport of power plants.

(2) Closed system

Due to the closed pipeline system, pumping is very environmentally friendly. No material can spoil into the environment during transport because a right pipeline is hermetically sealed, provided it is well maintained. If the material creates an odour people are not affected by this.

(3) Transport over great distances

In most of the cases the pumping distance is only several hundred meters. Of cause powerful pumps can convey materials over long distances like several kilometers or very good pumpable high density slurries even over very long distances of tens of kilometers.

(4) Horizontal and / or vertical transport

A pipeline can be placed horizontal or up and down a shaft or just follow the possible transport direction in a building.

(5) Material mostly taken up only once

The material is fed into the pipeline and it stays in the pipeline until the end of the pipeline. There is no need to double handle materials using different systems to get it to its destination, such as extraction of ore from a shaft. If you have e.g. a conveyor belt or a truck you deliver the material up to a bunker at the shaft and

then you have to hoist it by another system.

(6) Independent of weather

In cold areas the pipelines can be placed underground or they can be insulated or heated. This makes pumping transport independent of weather.

(7) No environmental influence

Pumps, driven by electric power packs, do not create exhaust fumes. If hundreds of trucks have to drive through a community it will receive negative acceptance of the mine operation. A pipeline, placed underground, will not disturb anybody.

(8) Low operator cost

Pump systems can work nearly automatically. Only a small number of skilled operators are needed to drive a pump system.

(9) Very safe transport

Nobody gets in contact with the material while it is in the pipeline. A pipeline has no moving parts. Transport of ore by conveyor belt or even more by truck can be dangerous. The presence of exhaust fumes from trucks in a mine can be eliminated by using pump systems.

2 Projects

2.1 Backfilling of fine grained cemented paste – Example Goldstrike

Goldstrike is located on the Carlin Trend, the most prolific gold mining district in the Western Hemisphere, about 60 km northwest of Elko, Nevada. The operation includes the Betze-Post open pit mine – a truck and shovel operation – and the Meikle and Rodeo underground mines.

The fine grained tailings slurry (maximum grain size is 200 µm approximately.) is pumped to a thickener.

Figure 1 Disc-filter. Material flow from thickener to a the disk filter

The thickener underflow is then pumped to a disc-filter. The material from the disc-filter is transported by belt to a continuous mixer where cement, fly ash and water are added to create a paste which fulfils the needs and can be used for backfilling. The paste has a slump of 8 inch with a solid concentration of approximately 73% by weight. The cemented backfill is transported to the stopes by means of hydraulic piston pumps.

HSP series – (Hydraulic Seat valve Pump)

The HSP pump has a pump head with hydraulic driven seat valves. The appropriate cyclical opening and closing of the valves controls the material flow from its intake up to its introduction into the delivery line.

Figure 2 HSP 25100 HPS head with hopper with hydraulic driven seat valves. The output of this pump system is 95 m³/h at 120 bar simultaneously

The wear plate and seat are available in different material pairings and geometric designs to be selected in accordance with the pumped medium to achieve long service lives.

Double piston pumps of this type are available up to outputs of 400 m³/h and delivery pressure up to 150 bar.

Pulsation damping

This pump system is equipped with the proven PCF (Putzmeister Constant Flow) system to reduce pressure peaks in the pipeline and to guarantee a continuous flow.

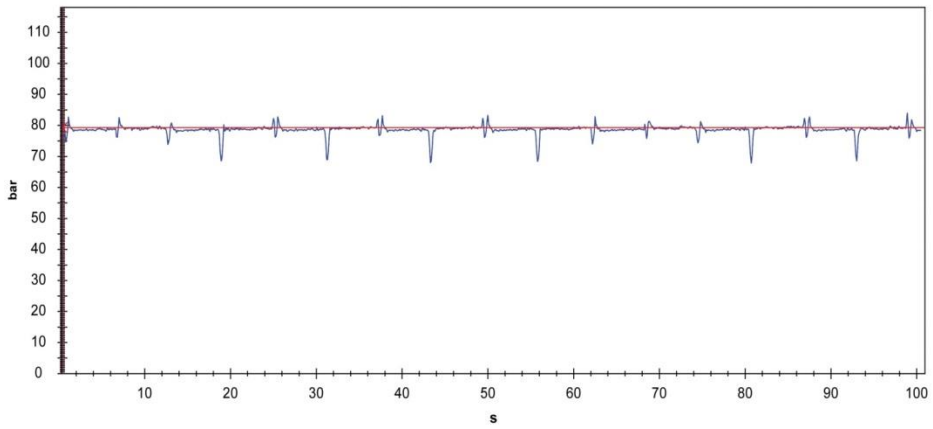

Figure 3 Delivery pressure curve with PCF system

The two delivery cylinders are driven separately from each other via their own hydraulic system and a constant output flow rate with very low residual pulsation (maximum +/- 8%) is achieved by means of an appropriate control sequence (Figure 3). This reduces the transmission of power and the dynamic load of the delivery line and its mounting, which contributes to a lower risk of plant failure. If the requirements of pulsation damping are not quite so high, pulsation dampers which work in accordance to the air vessel principle can be used.

At Goldstrike after the mixer the paste falls into a hopper where the HSP 25100 HPS, driven by a HA 250+250 E SP power pack, sucks the paste out and pumps the paste through an 8 inch pipeline 15 m above ground, then 500 m down and underground over a distance of 2400 m to 4800 m.

Approximately 8% of cement has to be added to achieve the requested strength.

The gold mine tailings have a solid concentration of 73% by weight, a specific gravity of the paste of 1.86 t/m³, a d80 of 150 µm, a d50 of 74 µm and a d20 of 23 µm.

By commingling stones into the paste the amount of cement can be reduced. This has to be calculated economically from case to case.

2.2 Backfilling of paste commingled with stones – Example Bad Ground

Figure 4 Stiff plastic mix – concrete like

KOS series – S-transfer tube pump

In cases where coarse particles are added, up to 60 mm grain size are possible to handle, a double piston pump of type KOS has to be chosen (Figure 5). This enables many possibilities for paste composition and improves cost-effectiveness.

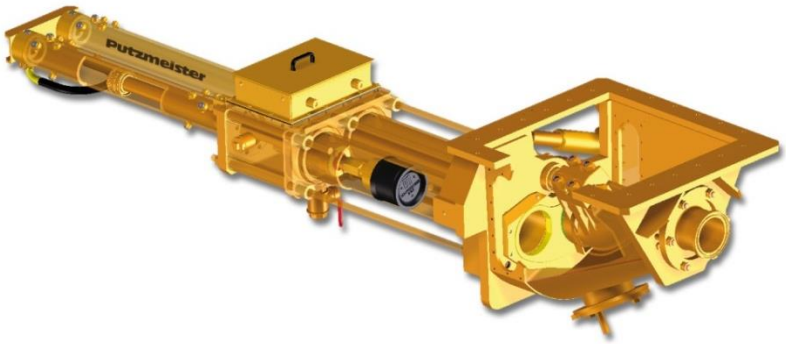

Figure 5 KOS Piston pump with S-tube

The paste is placed in the hopper of the pump and, from there, sucked into the delivery cylinder during the intake stroke. The delivery piston pushes the paste into the delivery line through an S-transfer tube. At the end of each stroke the S-transfer tube is switched over within 0.5 seconds by means of powerful plunger cylinders so that the next stroke can start. The fast change over time of the S-transfer tube means that there are only short interruptions in the output flow rate, which is advantageous with regard to pulsation.

Thanks to its special design the pump works without valves or other narrowed sections. For the conveyed medium this results in a constantly clear passage over the entire cross section of the pipe. This means that the machine is not sensitive to relatively large foreign bodies and obstructions. Foreign bodies can be up to 70% of the diameter of the pump`s pressure connection. This prevents blockages thus providing a high level of machine availability and minimizing downtime.

The advantage of also being able to pump larger particle sizes may be relevant when, for example, conveying coarse grained ore for further processing. Fine ore and finely ground material can also be pumped.

In the power plant sector fly ash can be pumped together with coarse bottom ash together.

Figure 6 This is the plant 1979 for 25 m³/h

Figure 7 This is how it looks 2017 for 250 m³/h

Table 1 Features of KOS solid pump

Pump type	KOS 25200 HP
Output	400 m³/h
Delivery pressure	100 bar
Del. cyl. Length	2500 mm
Del. cyl. Diameter	560 mm
Driven by a hydraulic power pack with maximum 2 x 800 kW	

Figure 8 Putzmeister KOS 25200 – Mammoth Pump

2.3 Europes largest brown coal station – Belchatow

Figure 9 The Belchatow Plant – 5420 MW

Table 2 Application data Belchatow

Medium to be conveyed	Fly ash
Maximum grain size	10 mm
Dry solids content	52wt%
Maximum Temperature	35°C
Pumping distance	8000 m
Ø of pipeline	200 mm

Belchatow produces 28 TWh of electrical energy are produced every year. In former times they used centrifugal pumps for the transport of the ash to the deposit. For 1 ton of ash 10 tons of water were required, with a piston pump the mixture is 1:1, so only a 10th of the water is needed. Previously the 420 t of fly ash per hour had to be mixed with 4200 t of water, today only 420 t/hr of water are needed. The amount of energy is reduced to 50% which reduces the operating costs drastically.

This power plant produces a hugh amount of fly ash and the construction materials industry has only a few customers for this project. The fly ash from brown coal is lower grade than from hard coal. Most of it is used for landfill or as backfill material.

If the landfill site is full it is re-cultivated.

Figure 10 Ash deposit is 8000 m from the power plant

Because failure of the pumps, and hence removal of the fly ash would cause the power plant to shut down they chose reliable piston pumps for this task.

In 2013, a total of six HSP 25150 HP seat valve pumps featuring the Putzmeister PCF system, each driven by an 800 kW hydraulic unit, were installed for transporting the fly ash of the entire power station. Currently, there are three pump lines in operation and three on stand-by. Some 600 m³ of fly ash slurry are pumped every hour.

Figure 11 Delivery scope 6 x HSP 25150 HP, HA 400+400 E and PCF

Six individual DN 200 PN 100 delivery lines (maximum 100 bar), each 8 km long, lead from the pumps to the landfill site. Each pump can be connected to each of the pipelines via coupling station – a kind of "shunting yard". Pressures may vary in the delivery lines, since the fly ash itself has different compositions – depending on the seam from which the coal comes. In order to protect the long pipelines from wear PCF controls are installed at the pumps. The so-called PCF control reduces the pressure differences that occur during the pumping switchover process and creates a more consistent flow in the pipeline. This is extremely important, since the long conveyor line could experience vibrations if the pressure were to vary constantly. In this case, the pipeline would be at risk of blocking and even breaking. The plan is to expand the power station in 2016 by a new modern unit with a capacity of approximately 800 MW. This is to have two further identical pump lines for transporting the fly ash.

The pump systems are equipped with the PCF system to protect this piping system.

Figure 12 Pipeline, DN 200/PN 100, length 8000 m, no heating

2.4 Pumping of high density slurry and pumping of paste – Example Lai Steel

At the Lai Steel plant are two different pumping stations. At the first pumping station 2 pumps of type HSP 25100 HPS, each one driven by a HA 630 E SP are in operation. The maximum output of each pump is 120 m³/h and the maximum delivery pressure is 150 bar.

Figure 13 2 x HSP 25100 HPS driven by 2 x HA 630 E-SP

Figure 14 Material

Pump system 1: At this plant slurry is thickened to a paste in a 1500 m³ paste thickener designed by Lai Steel. This paste is mixed by a constant flow through mixer with cement and fed into the HSP 25100 HPS double piston pump. The paste is very fine grained with 50% smaller than 37 µm.

The paste is pumped through a 148 mm diameter pipeline down into the mine and then over a maximum distance of 2400 m.

The second HSP 25100 HPS of pump system 1 is pumping the tailings slurry over a distance of 8000 m to the second backfill plant. To avoid sedimentation the pipeline diameter is 117 mm. While pumping 100 m³/h the slurry speed in the pipeline is 2.58 m/s. The complete pipeline is buried underground.

Figure 15 Long distance pipeline

Pump system 2: At the second backfill station the slurry is thickened in a thickener of the same type like at plant 1. The process is the same like at plant one.

3 Conclusions

This paper shows the advantages of transport by piston pumps through pipelines.

- Piston pumps can convey paste and coarse-grained material over long distances.
- Piston pumps have the advantage of pumping material with low water and high dry solid content.
- Piston pumps in connection with closed pipelines have proven to be the best suitable system for backfilling and landfilling projects.
- Horizontal or vertical direction shifts do not pose any issues.
- Piston pumps can work under any kind of weather and are not hazardous to the environment

Acknowledgement

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Bibiography

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