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ANALYSIS OF PERISTALTIC PUMPING TECHNOLOGY IN THE MINING INDUSTRY

Adding value, minimising costs

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Key conclusions

There are a number of key benefits associated with using peristaltic pump technology in the mining sector with respect to added value and cost reduction

i. Significantly reduced water use means significantly less cost. On average, water savings of 71% can be achieved in comparison with common centrifugal pumps.

ii. The treatment of less water ensures less chemicals and equipment are required.

iii. The number of filters after thickening applications can be reduced. With disc filters costing around $100,000 each (filter capacity can be reduced by 1/4), the savings are substantial.

iv. No mechanical seal flush water is required: some centrifugal pumps need approximately 72 litres of water per minute, this excludes any spill water from damaged seals.

v. Less storage is needed for tailings – the number of basins can be reduced.

vi. Lower environmental risk – consider the toxic sludge disaster in Hungary in October 2010 which led to a national state of emergency. The failure of a tailings dam polluted the environment and nearby rivers. The tail was still very aqueous due to the low dry solid content – with use of a hose pump it should have been more like a mud consistency which might have resulted in more stable conditions.

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I Mining industry faces up to water management responsibilities

In a recent paper prepared for the ICMM, the Centre for Water in the Minerals Industry (CWiMi) suggested that water access, quality, use and environmental impact directly affect the ability of the industry to operate worldwide. Yet despite these challenges, mine operators face ever increasing obligations to reduce water consumption and operate within a framework that cuts overall environmental and water footprints.

The importance of water cannot be underestimated, and consequently all mines must carefully assess the impact of mining on local and regional water quantity and quality in order to retain a social licence to operate. With this in mind, best practise water management is the new trend that defines credibility for the mining industry while negating the potential impact of additional costs.

II The mining process

Broadly speaking, the extraction of precious metals can be based upon two techniques; leaching or filtration-based methods, although hybrids of both techniques are also used.

The focus on water consumption within filtration-based mining is very strong because high volumes of water are used inherently in the process. Here, the first stage involves the crushing and grinding of the ore, after which the fine ore is mixed with water at the froth floatation cells in order to extract the mineral. The resulting tail froth will be thickened in a sedimentation tank, where the overflow is water and the underflow contains the concentrated ore or tail. This paste-like substance is called the thickener underflow.

Following the thickener there is usually a filtering stage to dry the sludge for further processing. It is desirable to have a thickener underflow with a high dry solid content: the less water involved, the higher the efficiency of the filter. The pump installed underneath the thickener determines the maximum allowable dry solid content – therefore the pump technology is the limiting factor.

III Less water equals fewer costs

Among the key drivers for water reduction and greater water re-use in the mining sector are:

- Increasing price of water.
- The limited availability of water at mines located in desert areas or at altitude. The Antofagasta region in Chile is the driest place on earth, and here several mines are located at high altitudes.
- Intake water needs to be conditioned i.e. alum dosing, pH control, etc.
- Effluent water of operation needs to be treated.
- Environmental responsibility. For instance, the Pascau Lama project on the Chilean-Argentinean border was delayed by a decade because of possible environmental impact.

In order to increase production and, at the same time, minimise rising costs, companies need to adopt new approaches, which means optimising their mining procedures.
The less time a mine requires to pump, add or remove water in the course of processes usually translates into reduced operating costs. However, the taut relationship between maintaining a

reliable supply of water to support mineral processing, and using as little water as possible in order to have the smallest volume on hand at any time, means that mine water inventories must be managed carefully.

Here pumps have a vital role to play, and peristaltic pumps specifically can be considered water-saving devices, not simply because they can accommodate very high solids-content materials found commonly in mining operations, but because they do not require seal gland water, thus eliminating the requirements to either treat process wastewater or provide pump service water. Pumps such as these can play a key role in new management trends like water balance modelling.

IV Benefits of peristaltic pump technology for mining applications

All peristaltic pumps supplied by Watson-Marlow Pumps Group can be considered as inherent metering pumps offering repeatability of 99.5%. Furthermore, many models include integral digital drives with Profibus or SCADA control. Easy system integration with new or existing controls is coupled with operator friendly-use. Often, there is no need for separate VFDs or complex control devices, while a wash-down NEMA 4X corrosion-resistant enclosure suits arduous mining environments.

The pursuit of ever-more cost efficient pump technology is of ongoing interest to mine operators. Pumps such as Watson-Marlow's Bredel SPX series, for instance, accommodate continuous flow rates up to 80m³/hr and are extremely durable (pressures up to 16 bar). There are no internal universal joints, valves, dead corners or glands to impede flow, and they are reversible for back-flushing.

Bredel SPX pumps such as this one at Buxton Lime in the UK, have a corrosion-resistant enclosure which suits arduous mining environments.

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V Handling thicker slurry flows

Although one main goal of mine operators is to use less water in the transportation process, doing so creates thicker, more paste-like slurries, which in turn creates other issues. More product can be transferred at lower velocities, but pump and hoses must be designed to handle thicker flows.

Bredel SPX high pressure hose pumps can handle undiluted tailings and thickener underflow up to 80% solids. No seal water flush systems, strainers, dampeners, in-line check valves, run-dry protection devices or other ancillary equipment is needed. The entire family of pumps are self priming to 9m, can run dry safely and can meter accurately to ±1%.

This innovative technology fits with wider current research into more efficient modes of high concentration slurry transport. The ultimate aim is to reduce water use, energy consumption and capital costs, as well as improve slurry transport reliability by establishing a more fundamental understanding of slurry flow behaviour and design.

According to Dr Jie Wu of Australian research organisation, CSIRO, there are errors up to 600% associated with conventional designs of high concentration flows, which can result in pipeline transport failures or the inability to pump the desired quantity of solids. It is clear that being able to make more accurate predictions will help the industry optimise design and achieve a far better outcome.

VI Optimising the transfer of paste backfill

One of the most commonly pumped materials in mining operations is paste backfill, a cementitious composite that is similar to concrete. It consists primarily of mine tailings mixed with hydraulic binders, which are typically Portland cement and some form of supplementary cementing materials, and water.

Residues, slimes or 'tailings' are the materials left over after the process of separating the valuable fraction from the worthless fraction (gangue) of an ore or mineral. It is increasingly common for mine operators to store tailings below ground in previously excavated voids. As well as being more environmentally friendly than storing above ground in traditional tailing dams, it also serves the dual purpose of reducing costs and supporting mine structures.

Paste technology is introduced to make the backfill quicker, easier and more cost effective to transport, deposit and cure. The goal for the high density paste formulations is to produce a pumpable material that does not segregate when placed – the fines content should be a minimum of 15% by weight of the paste. Naturally, choosing the right pump technology for the task is vital.

Bredel SPX2100 handles paste backfill @74% solids and 4% cement at Turmalina Mine, Brazil.

VII

Accommodating high solids content

While pumping applications in the mining sector frequently involve abrasive, corrosive, shear sensitive and viscous liquid products, solids present the real challenge. Solids such as rocks, sand and ore comprise different mineral contents and pump systems must be able to accommodate these variations.

Mining slurries often feature sub-micron solid contents of 80% by weight, with specific gravity often greater than 2.0. In addition to offering abrasion resistant slurry pumping performance in arduous conditions for extended periods, the selected pump must be capable of high operating pressures and flow rates to ensure a smooth liquid passage and deny the opportunity for the product to settle.

Other required features should include repeatable and reliable delivery performance, self-priming functionality and low and easy maintenance. However, with so many pump types available it is little wonder mines frequently end up employing technology unsuitable for the task in hand. Ultimately this leads to inefficiency and increased costs, typically due to excessive wear and downtime.

The mining of slurries does not pose a problem to rugged Bredel SPX hose pumps.

This paste backfill application at Jaguar Mining in Brazil requires a Bredel SPX2100. The pump is operating at 50m^3/h and at a pumping distance of 420m. Density is 2.8 through a 100mm line.

VIII

Limitations of centrifugal and membrane pumps

While centrifugal and membrane pumps have traditionally dominated the mining sector, particularly for operations such as thickener underflow applications, they are not without their shortcomings. For instance, the amount of dry solids which can be handled by centrifugals is limited. In several applications, rotors or impellers on slurry pumps last only weeks and membrane pumps clog, leak or fail due to factors such as strong acidity in a matter of months. Attempting to overcome these problems, some mine operators previously purchased special pumps constructed from acid-resistant materials rather than put up with frequent, costly pump maintenance or replacement. But this is an extremely expensive alternative.

Bredel hose pumps offer significant benefits over other pump technologies.

For these reasons, the latest peristaltic (hose) pumps are today taking ever greater slices of market share. Among the many benefits of peristaltic pumps are:

- No mechanical seals
- No requirement for seal gland water
- No seal water flush systems
- No moving parts in the product zone
- Low and easy maintenance – just one wearing part; the hose
- Almost all materials can be pumped, including slurries
- Backflow and siphoning are prevented without the need for valves
- Wear-free performance

For the mining sector this last point is arguably the most advantageous. Obviously, the longer a pump can operate without maintenance or failure, the better. The wear-free performance of peristaltic pumps is an attribute that results from a unique operating principle. Unlike other pumps, the abrasive nature of the product has no bearing on pump life and the need for routine maintenance and spare parts is reduced greatly.

Unlike other pumps, the performance of SPX pumps is not affected by the abrasive nature of slurries and chemicals.

IX

Hose is at the heart of peristaltic operations

In a peristaltic pump such as a Bredel high pressure hose pump nothing but the hose touches the fluid, eliminating the fluid contaminating the pump. Fluid is drawn in and trapped between two shoes before being expelled. The complete closure of the hose, which is squeezed between a shoe and the track, gives the pump its positive displacement action. The result is a pump ideally suited for the transport of typical mining slurries including pyrite, copper, zinc, uranium, nickel, cobalt, silver, platinum, lime and gold concentrate.

Pumps like the Bredel SPX range are virtually maintenance-free as there are no impellers, liners or mechanical seals to replace, no check valves to clog and no rotors or stators to wear out. The only wear-part is the hose, which can be replaced in a matter of minutes with no special tools.

The hose is the secret at the centre of peristaltic technology. This is the part in direct contact with the slurry – so it needs to be both flexible and tough. At the heart of all Bredel pumps is a

composite hose constructed from compounded rubbers reinforced with four individual layers of braided nylon, and finished by precision machining for enhanced suction, pressure and flow performance over its expected lifetime.

Design features such as these are important because over-occlusion of the hose stresses both the pump and hose, reduces hose life and places unplanned loads on the pump bearings. Similarly, under-occlusion results in loss of pump efficiency and damaging back-flow, which also reduces hose life.

The hose is the secret at the centre of peristaltic technology.

A Bredel hose offers nylon reinforcement.

X

Calculating the benefits

In a thickener underflow application, consider an example of copper extraction based on froth flotation. Using a hose pump, higher slurry densities can be achieved compared to centrifugal alternatives. This ultimately introduces savings against process water and filtration equipment.

A typical slurry density goes up to a maximum of 3100kg/m^3: Based on 1m^3 of slurry, and assuming that the ore is chalcopyrite ($CuFeS_2$) at a density of 4300kg/m^3, it is possible to calculate volumetric solid content of 63%.

Based on published data for centrifugal pumps, it is known that the maximum dry solid content (by weight) will be 27-29% before efficiency begins to drop. Thus, assuming a maximum dry solid content of 30% by weight for a centrifugal pump, it can be shown that for the transfer of 70 tons of ore per hour (for example), a centrifugal pump will require a flow rate capacity of 181m^3/h, some seven times greater than that of a Bredel SPX100 to perform the same task, which offers 26m^3/h.

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EXAMPLE

Every installation and application will be different, but here is a possible comparison of a rubber-lined centrifugal pump's performance and that of a peristaltic hose pump doing the same job.

Let us assume that every hour we want to move slurry containing 70 tons of solids. The maximum concentration by weight for a centrifugal pump is less than 30%: being generous, at 30% concentration the slurry must include 163 tons of water (giving an hourly slurry weight of 233 tons). If the pump runs 24/7, 1,426,880 tons of water will be needed each year: 1,294,444m^3 – plus 1,653m^3 of seal water (at 189 litres/hr). Total annual water use: 1,296,097m^3.

The peristaltic pump can handle much thicker slurries – up to 80% solids. Let us assume a lower concentration by weight of only 60%, which allows a wide margin for safety. The slurry must include 46.7 tons of water for each hour's pumping, (giving a total slurry weight each hour of 116.67 tons). In a year, that is 407,680 tons of water, or 369,841m^3.

In this example, the water used where a peristaltic pump is in service is 28.7% of the water required by a centrifugal pump system.

	Rubber Lined Centrifugal Pump	**Bredel Hose Pump**	
	Centrifugal	**Peristaltic**	
	Q	**Q**	**units**
Sludge concentration (Concentration by Weight)	30.0	60.0	% (Cw)
Specific Gravity of solids	1.65	1.65	
Weight of solids in slurry	70.00	70.00	Ton
Weight of water in slurry	163.3	46.7	Ton
Total weight of slurry mixture	233.3	116.67	Ton
Flow Rate of slurry	**187**	**81**	**m^3/hr**
Specific Gravity of slurry	1.13	1.31	
Concentration of solids by volume	20.6	47.6	% (Cv)
Water Consumption – Yearly (based 24/7)	1,426,880	407,680	Ton/year
Water Consumption – Yearly (based 24/7)	1,294,444	369,841	m^3/year
Seal Water Consumption (7.6-189 litres/hr) @ 189 litres/hr	1,653	0	m^3/year
TOTAL	**1,296,097**	**369,841**	**m^3/year**
Peristaltic saving		**924,603**	**m^3/year**
		71.3	**% water saving**

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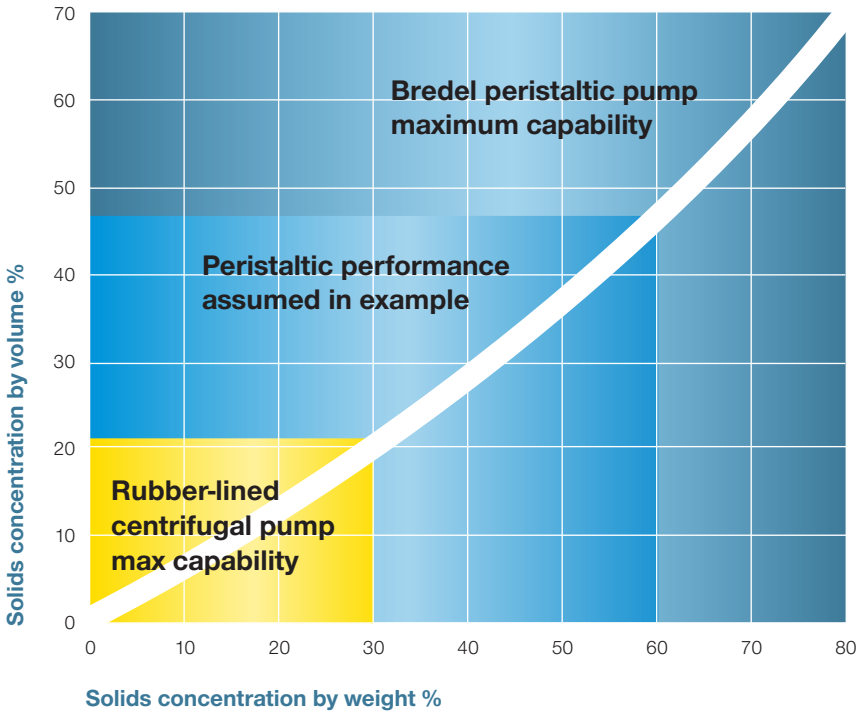
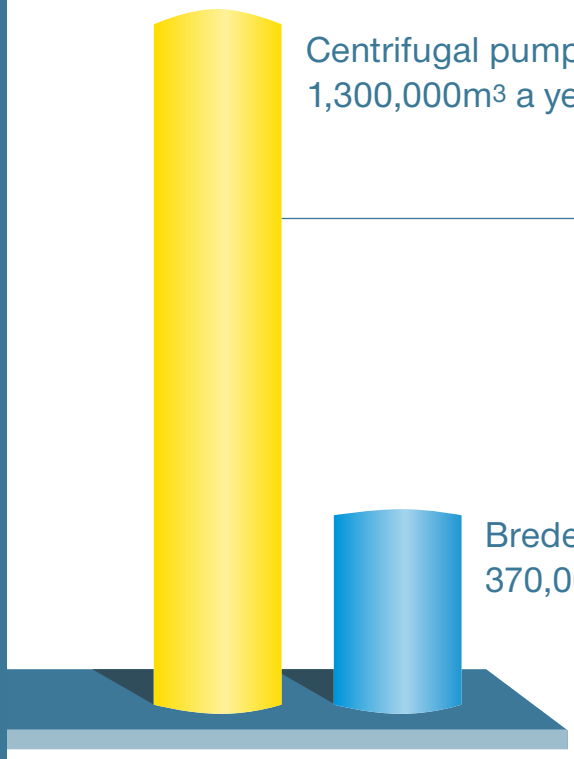
Solids concentration and pump capability





Centrifugal pump:
1,300,000m3 a year

Bredel peristaltic pump:
370,000m3 a year

Peristaltic pumps give a 71% saving

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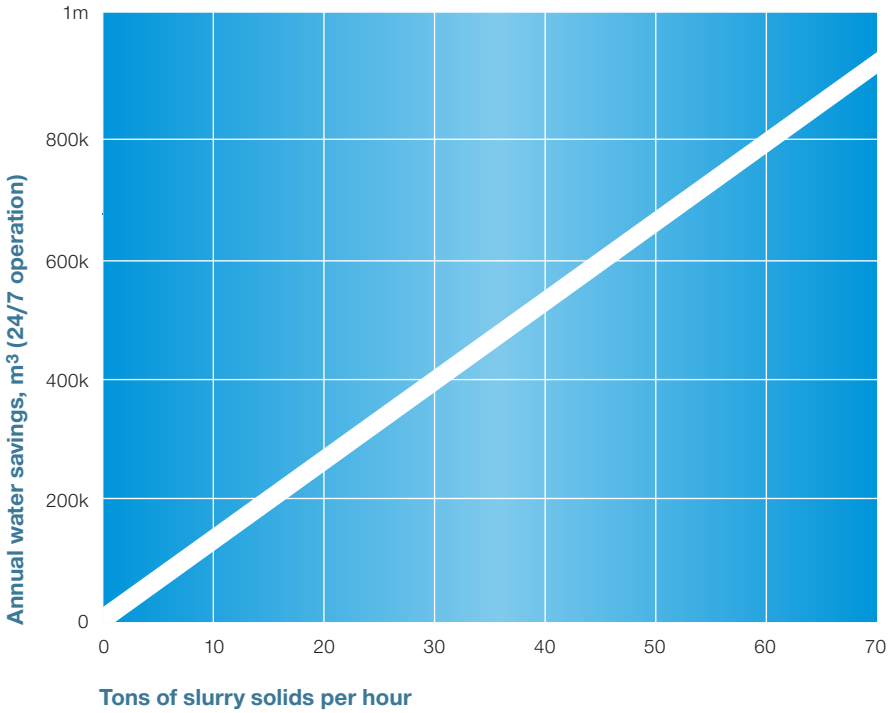
Typical annual water savings achievable with a peristaltic slurry pump instead of a rubber-lined centrifugal pump



XI

Evidence of growing uptake

More and more mining industry customers are turning to peristaltic technology to solve solutions to specific problems. This is because peristaltic pumps can help mine operators face up to key challenges, which include:

- Reducing downtime
- Reducing operating costs
- Managing and reducing water inventories
- Reducing chemical usage
- Lowering maintenance costs
- Conforming to environmental regulations

A recent beneficiary of peristaltic technology is a large copper and gold mining company in Arizona which had to frequently replace components on hard chrome iron centrifugal pumps used in a difficult tailings slurry application. The pump impellers were wearing out every two weeks, causing significant downtime and costly repairs. The mine considered several different pump technologies, finally selecting Bredel SPX100 hose pumps. In this application, the hose pumps transfer tailings slurry 670m to a separate plant. With no seals to flush and the ability to pump tailings with a high solids concentration (80%) the mine uses much less water with SPX pumps, achieving considerable savings in both maintenance costs and water usage.

Another example can be seen at Jaguar Mining Inc, which operates four gold mines in Brazil. The company first adopted Bredel SPX pumps at its Turmalina mine when it was faced with pumping paste backfill comprising 4% cement and 69% solids. No centrifugal pump could handle the task.

Eight Bredel SPX50 installed at Jaguar Mining, Brazil.

To overcome the challenge presented by paste backfill, the mine operator installed a Bredel SPX100D on a trial basis and the results were so impressive that it subsequently purchased the pump, which is now transferring the mix with an S.G of 2.8 at a rate of 50m^3/hr over a distance of 420m.

Today, the Turmalina site has no less than five Bredel SPX100D pumps for backfill operations; six Bredel SPX100D and two SPX100 models for floatation processes; eight SPX50, two SPX65 and two SPX100D pumps for leaching processes; two SPX100D for reject pumping; and ten SPX65 models for working with reagents. The total number of pumps at the Turmalina site is 37.

The story of success is similar at a large mine in New Brunswick, Canada, which has replaced centrifugal slurry pumps with Bredel SPX hose pumps. Here, the 65% solids of the zinc and lead thickener underflow slurries was too high to allow the centrifugal pumps to deliver the desired flow rate, while abrasive wear was causing an unacceptable frequency of costly repair. Because the abrasives in the slurry do not affect Bredel pump life the mine is now able to minimise downtime and achieve reliability at the desired flow rate.

XII Accurate chemical metering

Another potential area of saving is through accurate chemical metering. The range of chemicals used in mining processes is vast and includes copper sulphate, xanthate, SIBX/MIBX, GUAR, cyanide, sulphuric acid, lime, flocculants, zinc sulphate, aerophine, sodium silicate, BIOX, surfactants and sulphides to name but a few. However, by using microprocessor-controlled brushless DC drive technology, Bredel pumps will properly maintain the floatation rates of ore extracts to ensure economical use of expensive chemicals and create significant process efficiencies.

Bredel SPX65 on reagent dosing at Jaguar Mining, Brazil.

Bredel Hose Pumps are capable of handling abrasive and corrosive chemicals.

The upshot is that Bredel pumps have become first choice in mines throughout the world for applications that include dosing process reagents and pumping shear-sensitive polymers for flocculation and coagulation, abrasive lime slurries for pH control, or corrosive chemicals like cyanide for gold recovery.

Ores of course, have different mineral contents and pumps must consistently vary their dosing rates to optimise chemical usage and maintain plant throughput. Additionally, process reagents such as cyanides and acids are often highly corrosive but as the chemically resistive hose of a Bredel peristaltic pump is the only part in contact with the pumped product then there are no working parts exposed to the chemical.

To help demonstrate the potential benefits, the world's largest trona soda ash mine in Wyoming was experiencing problems with its diaphragm metering pumps used for dosing flocculant (defoamer) into the trona processing lines. Unfortunately the diaphragm pumps would last only five to six months due to the highly corrosive nature of the flocculant. Even after trying to add large amounts of water to the flocculants, which subsequently had to be removed from the process, the diaphragm pumps would still fail.

The mine was eager to find a way to cut the costs being created by the diaphragm metering pumps and Watson-Marlow had the solution. The mine purchased several Bredel SPX10 and SPX15 hose pumps to address both pump maintenance and flocculant wastage problems. The hose pumps' inherent corrosion resistance allows the mine to pump pure flocculant into the discharge lines and holding tanks. With no need to add water the mine is saving money in downtime and maintenance costs.

In another example, Minera Fresnillo SA, a subsidiary of Peñoles Group, located in northwest Mexico, was experiencing endless headaches with its diaphragm pumps. Minera doses aerophine, xanthate, sodium cyanide and copper sulphate into flotation tanks. Unfortunately the diaphragm pumps were in need of constant and costly maintenance due to the obstruction of the valves, damaged diaphragms and leaks, which led to a reduction in productivity. However, after purchasing a total of 17 Watson-Marlow high accuracy 521CC and 621CC pumps, Minera has seen substantial savings in chemical usage. Furthermore, since the pumps have no valves to get blocked, and virtually eliminate hazardous chemical leaks to the environment, the mine is very pleased.

High accuracy 520 series pumps can deliver substantial savings in chemical usage.

XIII Conclusion

Moving ores, concentrates and residues in slurry form are essential parts of industrial mining processes. In an effort to reduce water, energy and chemical consumption, and improve slurry transportation reliability, more and more mining operators are discovering the simplicity and benefits of peristaltic hose pumps. With thousands of Bredel pumps already at work around the world, there is little doubt that hose pumps are the future.

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FOR MORE INFORMATION ON ANY OF THE CHALLENGES, PRODUCTS OR TECHNOLOGIES RAISED IN THIS PAPER, PLEASE CONTACT:

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