Piped slurry

John Chadwick looks at some of the latest mineral slurry pipelines and new products used in such projects

Paterson & Cooke is a leader in slurry pipelines. Angus Paterson notes the industry's "increasing focus on developing large, high quality orebodies in remote regions. These remote projects have many unique challenges, not least poor infrastructure and inaccessible terrain that make conventional bulk transport of the mineral to port challenging. Mining companies are increasingly looking to slurry pipeline technology as a viable and competitive option to rail and road transport, as demonstrated by recently commissioned projects such as Minas-Rio's 529 km iron ore pipeline in Brazil and OCP's 187 km phosphate pipeline in Morocco. Both these project represent significant milestones in the advancement of slurry pipeline technology.

"The Minas Rio pipeline, commissioned in 2014, is one of the longest iron ore concentrate pipelines in the world capable of transporting 26.5 Mt/y of iron ore concentrate from the mine site in Minas Gerais to the pelletising and export terminal at the coast near Rio de Janeiro." The pipeline diameter varies from 610 to 660 mm and includes a main pump station and one booster station, together with pressure monitoring stations and choke stations to control the system. At the concentrator, the main pump station, at some 650 m above sea level (masl), comprises seven operating and one standby Weir Minerals Geho high pressure piston diaphragm pumps, each with 1,950 kW drives and a pump discharge capacity of ± 18.4 MPa at 300.7 m^3/h. The slurry is pumped 247 km to the booster station that has eight operating and two standby piston diaphragm pumps that transfer the slurry to the terminal. These pumps have 1,950 kW drives and produce up to 20.6 MPa at 263 m^3/h each. Main high pressure slurry valves up to 610 mm were supplied by ValvTechnologies. A choke station is installed upstream of the booster pump station to control slack flow between the concentrator and the booster station and a second choke station is required between the booster pump station and the terminal.

A comparable pipeline, also commissioned in 2014, is the 914 mm diameter, 187 km Jorf Lasfar phosphate slurry pipeline of Office Cherifien des Phosphates (OCP) in Morocco. This system has the capacity to transport 26 to 38 Mt/y of phosphate ore, making it one of the world's largest capacity ore slurry pipelines. The head station at Khouribga, at 645 masl, receives varying grades of phosphate slurry from several wash plants, the furthest of which is 22 km away. The different grades of phosphate slurry are stored in dedicated agitated slurry tanks before being pumped in batches separated by water to the terminal station at Jorf Lasfar. As these batches of phosphate slurry arrive at the terminal station they are diverted to feed separate process streams in the refinery.

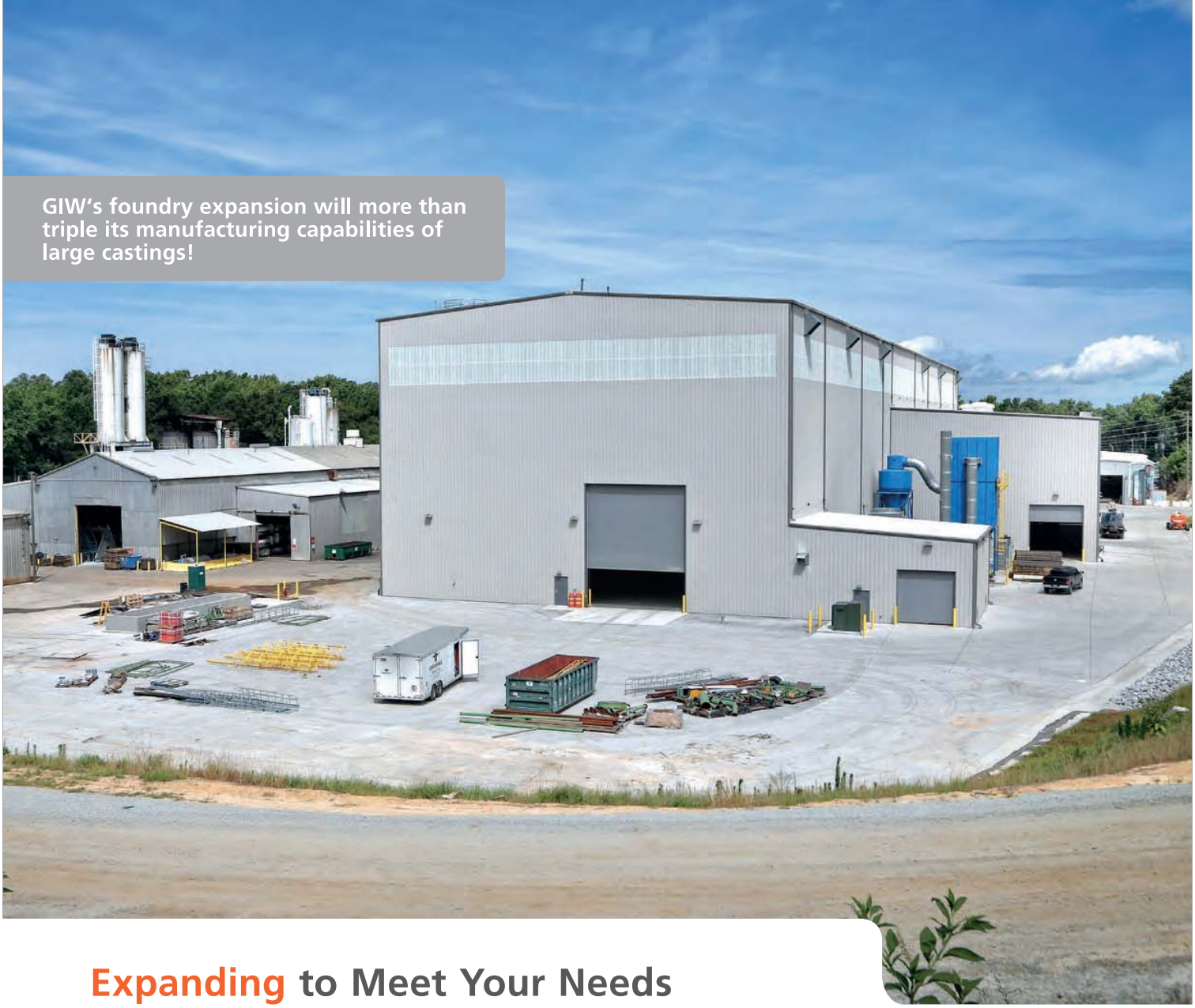
Office Cherifien des Phosphates' 187 km Jorf Lasfar phosphate slurry pipeline in Morocco is one of the world's largest capacity ore slurry pipelines

Paterson explains that "the requirement to transport varying grades of ore in intermittent batches, each with different flow properties, means that the design must cater for a wide range of operating conditions. This is done by controlling the pipeline operation by varying the pumping pressure based on feedback from a series of pressure monitoring stations and a variable choke station at the terminal that ensures the pipeline remains fully pressurised. The pipeline initially rises over the first 20 km to a high point of ± 766 masl and then continues to the refinery at the coast."

Paterson & Cooke provided detailed design, engineering and commissioning support. Tefken Construction installed the pipeline.

"Due to the high volumes and moderate pressure requirements, the single pump station consists of two trains of six centrifugal pumps in series (one operating train, and one standby). Each pump is fitted with a 1,850 kW motor and the pump station discharge pressure is maintained by varying the speed of several of the pumps. The centrifugal pumps are equipped with separate, wear resistant, volute liners and

Volvo CE's intelligent pipelayers were used for the Jorf Lasfar pipeline installation and were well received by the operators on the site, particularly when used for tie-ins



Expanding to Meet Your Needs

GIW Industries, Inc., the leader in the design, manufacture, and application of heavy-duty, centrifugal slurry pumps, is proud to announce its foundry grand opening. The current expansion of our Grovetown Foundry will ensure that KSB's GIW® Minerals products will be ready for growing market demands. This investment in large casting capacity will make our foundry more efficient in handling sizable castings while continuing to uphold our world class quality and safety standards. This is all just one step in a path of continuous investment to provide the most efficient slurry equipment products to our valued customers.

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have casing pressure limits of 6.2 MPa."

Weir Minerals won an £8.6 million contract to supply Warman centrifugal high-pressure pumps for this pipeline project. The pumps are designed for use in series transporting applications and are deployed at three pumping stations along the pipeline's route.

There are several 500 U-HTPP high-pressure transport pumps in series at the start of the route and these pumps are fed by booster stations, with additional 12/10 T-AHPP pumps also positioned in series. Weir Minerals also supplied standby pumps.

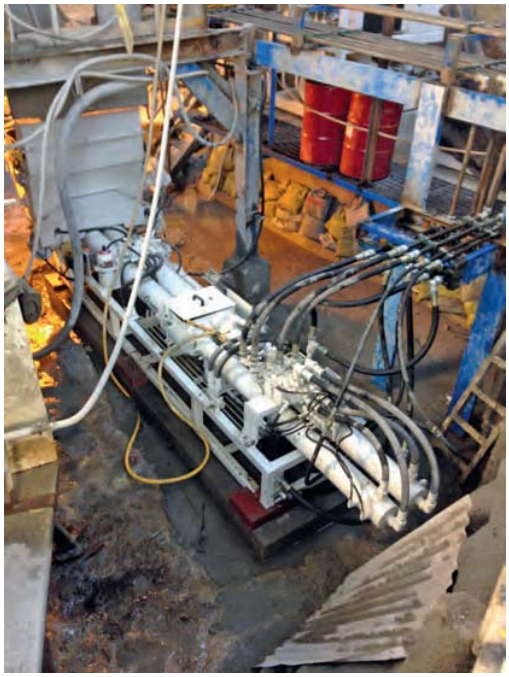
Such slurry pipelines are often exposed to high internal abrasion of the pipe wall caused by the movement of mineral slurry through the line. Different pipeline coating materials are available, at different costs, to enhance the lifetime of the slurry pump. The pipes of the Khouribga project are internally coated with different coating materials, depending on product phase to be transported and position of the spool. A portion of the pipes has been coated with a polyurethane with high performance material properties.

Rosen says its RoCoat 3000 was the only material available that complied with all client specifications. Rosen was invited by Tip Top Oberflächenschutz, responsible for all rubber and polyurethane lining of the project, to submit a quote and won the supply contract for the internal coating of pipes. RoCoat 3000 is specifically designed for high abrasive slurry applications.

In total, 704 m of pipes have been coated with a 12 mm thick polyurethane coating; 194 coated pipes with diameters ranging from 305 to 914 mm left the Rosen production site. Some of the pipes were installed with flanges and weldolets with different sizes.

Paterson explains that both the Minas Rio and OCP systems "start at similar elevations and so require choke stations to ensure that the flow is fully pressurised at all times. The major difference between them is that the Minas Rio pipeline terrain profile requires two pump stations fitted with high pressure positive displacement pumps, compared to the OCP pipeline that requires a single pump station fitted with centrifugal pumps. The capacity of these systems is very different from some of the early long distance coal slurry pipelines, such as the well-known Black Mesa coal pipeline that pumped 4.8 Mt/y of coal for more than 30 years. The advances in pump and pipeline technology make it possible to transport large volumes of ore reliably and efficiently using slurry pipelines."

BHR Group, an expert in fluid engineering, is another specialist consultancy. It offers various services critical to the effective operation of pipelines:



Commissioning of the first KSP65 HPR at Andaychagua in July 2015 by Schwing Bioset

- Pipeline design for 'non-settling', fine particle, pseudo homogeneous slurries, including pipe sizing and total pressure loss estimation
- Pipeline design for settling slurries, including estimates of deposition velocity and total pressure loss
- Open channel flow of Newtonian and non-Newtonian slurries
- Selection and sizing, including deration, of both centrifugal and positive displacement pumps
- Estimation of pump power imparted to slurry and motor sizing
- Estimation of specific energy consumption for hydraulic conveying of solids
- Selection of instrumentation for on-line measurement of slurry, pulp and tailings properties (flow, concentration, density, viscosity)
- Viscosity/flow curve measurement of non-Newtonian materials
- Mixer selection and storage tank design
- Troubleshooting of the operation of existing slurry feed/receiving tanks
- Slurry storage vessel design and operation.

Backfill applications

Turning to pipelines for backfill underground, Schwing Bioset recently commissioned pumps for a backfill application at Volcan Compañía Minera's Andaychagua mine in the Ticlio area high in the Peruvian Andes at over 4,800 m above sea level. Andaychagua employs a descending cut and fill mining method. This requires the use of cemented tailings filled with crushed waste rock and large amounts of steel rebar, creating strong roof support slabs to protect the miners and the mining process below.

Andaychagua has relied on this mining method for many years using Schwing pumps, which have provided reliable service for over 10 years. To keep operations running smoothly, Schwing Bioset recently supplied a new pair of KSP 65 HPR industrial pumping units with 300 kW power units to replace the trailer mounted pumps used previously. These new industrial grade pumps will allow Andaychagua to extend the replacement interval of the pumps in the backfill operation. The first unit was commissioned last July and the second was installed during October. Each of these units has been set-up for dual purpose flow ranges of 46 m^3/h @ 147 bar or 70 m^3/h @ 94 bar.

Another recent Schwing Bioset application is for OCI Chemical Corp's Big Island mine which has been in operation since 1962 and produces over 3 Mt/y. The trona is mined by the room and pillar method and it is then conveyed to surface where it is refined into dense soda ash. The waste material is pumped back underground as far as 1.7 km. The tailings range from 50-63% solids.

OCI needed to replace aging piston pumps at the mine near Green River, Wyoming, and chose to install Schwing Bioset equipment to pump the tailings underground or to surface storage facilities - on a 24/7 basis. Because of this continuous demand, OCI spent a great deal of time and research in choosing a product and partner, and during this process they visited Schwing Bioset operations, among others. In the end, several factors drove the decision to choose Schwing Bioset piston pumps, and OCI has installed two model KSP 220 pumps with XL poppet valves.

According to OCI Project Manager, Jim Spurrier, the most compelling factors included Schwing Bioset's resume of satisfied mining clients, the ability to customise programming and electrical design to integrate into OCI's existing controls and computers, and the open loop hydraulics and hydraulic signalling incorporated in the product design. The other important factor was that Schwing Bioset is based out of Wisconsin. The ability to get parts stocked in North America and shipped within one business day was critical, as well as having service technicians in the US.

Engineering Dobersek has significant experience in this field, such as the installation in north Siberia requiring four, heavy-duty slurry pumps with a capacity of 5,000 m^3/h slurry each. These are used to transport flotation tailings to the deposition area 6 km away. The

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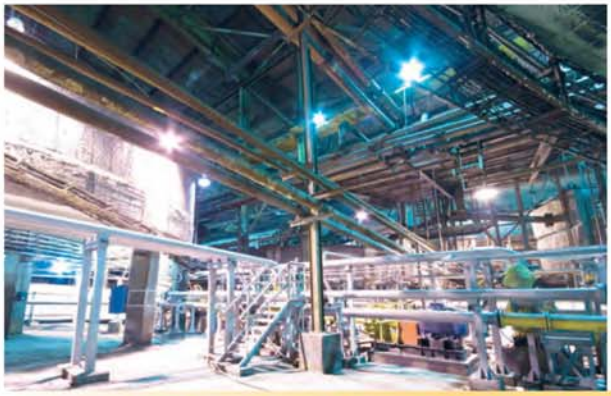

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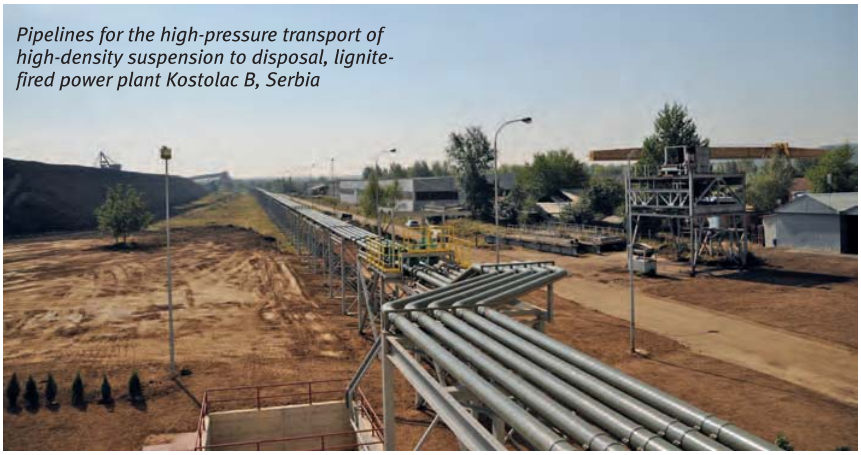


Pipelines for the high-pressure transport of high-density suspension to disposal, lignite-fired power plant Kostolac B, Serbia

double line pipeline has an inner diameter of 1,000 mm and is installed as a ring line on the top of the dam of the disposal site. The steel pipes are lined with a special lining made by the customer. When this lining is worn, the pipes will be turned through 180° in order to use then the upper part of the liner.

A backfill plant in Russia is fed by six high pressure slurry pumps with flotation tailings. The pipes of the 3.5 km long pipeline are lined with a special glass layer, whereas all fittings and bends are rubberised. "This combination is the most effective variation for this task, concerning costs and protection against quick abrasion," reports Jörg Strecker of Engineering Dobersek. "After this the slurry is thickened in a two-stage system consisting of a hydrocyclone cluster ContiClass®System combined with a high performance thickener in order to add the concentrated solids into the concrete mixture for the backfill."

"Ash handling is another challenge," he says. Usually power plants produce bottom and fly ash, both with different characteristics. A company installed a 6.2 km long pipeline consisting of four parallel lines for the hydraulic transport of fly and bottom ash to a disposal area in Serbia. There are a total of 12 slurry pumps to transport 520 m^3/h in suspension – consisting of bottom ash, fly ash and water with a solids content of up to 48%. The installed steel pipes were not lined but had a wall thickness of 6.3 mm. Using another pipeline the re-circulating water is transported from the disposal area to the power plant.

A power plant in Kosovo had problems with ash and slag transport to the disposal area due to a high lime content, which sticks strongly to the steel walls of a pipeline. Dobersek installed a 3 km long pipeline with two HDPE lines for the transport of 280 m^3/h slurry with 50% solid content. This solved the sticking problem.

Water and slurry spills underground are particularly dangerous so it is extremely important to have reliable draining and sludge pumping equipment. Strecker explains that the "standard solution in eastern countries consists of number of transfer pump stations, which are necessary to transport the total quantity of medium upwards resulting in high maintenance costs and high energy consumption.

"For a customer in Kazakhstan, Dobersek developed a two-way solution, one for the water and one for the slurry. A heavy-duty water diaphragm pump is able to discharge large amounts of water from deep underground to the surface. For safety reasons four pumps were installed in the gallery. Depending on the situation, they are individually or combined responsible for pumping water upwards in only one step." In this project, 650 m^3/h of water are pumped from 1,200 m depth to the surface. Each pump has a pumping capacity of 650 m^3/h at 120 bar. "The slurry had to be pumped with a hose diaphragm piston pump with the special feature to be able to pump highly viscous slurry from more than 1,000 m underground. It easily achieves the whole distance, up to slurry treatment on the surface without any problems."

Dobersek installed this pump, frequency controlled, with a capacity of 11.5 m^3/h at 160 bar. In order to ensure the necessary inlet pressure for the hose diaphragm piston pump a reservoir tank was used, filled by heavy duty centrifugal slurry pumps, designed for extremely abrasive substances

Pipes and linings

PEXGOL™ Pex pipes are in use in slurry pipelines across the globe. The company says they "have been systematically proven more efficient and reliable than ordinary pipes, due to their smooth interior, which prevents blockage or build-up on the pipe walls from the substances transported through the pipes."

Steel and polyethylene tube pipes are often blocked by sedimentation in a slurry pipeline. The molecular structure of Pex pipes prevents sedimentation because material substances do not adhere to the slurry pipeline walls. The smooth surface of PEXGOL slurry pipeline reduces head losses, so the pump pressure required is lower, saving energy and maintenance.

Victaulic claims to be "the world's leading manufacturer of mechanical pipe-joining systems." Recently it introduced a line of stainless steel Advanced Groove System (AGS) fittings, allowing customers to create complete large-diameter grooved mechanical piping systems in stainless steel. As a component of the Victaulic AGS, the fittings offer great assembly speed and performance.

The design for a water supply pipeline for Minera Escondida required nearly 8,000 joints of internally and externally coated steel pipe. The interior was coated with fusion bonded epoxy and the exterior was coated with three-layer polyethylene. CRTS completed 7,735 internally coated field joint welds of 406 through 1,067 mm diameter pipe. The majority of the coating production (6,999 joints) was 914 mm and 1,067 mm. The full-length joints were coated in permanent coating plants in the USA and in Brazil near the pipe manufacturing facility. Production using CRTS's remote control robots and real-time video feedback averaged 64 welds per day with rates as high as 183 per day, even while navigating steep slopes and difficult terrain. The result of the coating process was an internally coated pipeline with corrosion protection from end to end

Featuring Victaulic AGS grooved ends, AGS stainless steel fittings are available in 900 and 450 elbows, tees, reducers, adapters and caps. The fittings are joined to AGS-grooved pipe, valves and accessories with the Victaulic Style W89 AGS coupling.

This system offers fast, reliable piping system installation. The wedge-shaped AGS groove facilitates proper coupling positioning and provides increased coupling-to-pipe engagement. The two-piece design of the coupling housing enables quick joint completion. AGS-joined pipe handles higher end loads and a higher pressure rating—up to 2,410 kPa—with a nominal three-to-one safety factor.

AGS stainless steel fittings are available in 350 to 600 mm sizes.

In July, Blasch Precision Ceramics announced CeraLine™ – its new abrasion resistant product line including ceramic lined elbows, pipe and spool linings. Specifically designed for the harsh in mining, Blasch's new CeraLine family of products "exhibits exceptional wear and abrasion resistance which results in unparalleled life," the company says.

Pumping slurry

Outotec is partnering with GIW Industries for slurry pumps in metals mining and processing. Outotec has agreed with GIW, a subsidiary of KSB Partners, to enter into partnership for the sales and marketing of GIW® slurry pumps and related services to metal mining customers globally.

Outotec says "GIW Industries is an international leader in design of high performance slurry pumps. Outotec's complete sales and service network will be available for the two companies' new and existing metals mining and processing customers. The partnership will expand Outotec's service offering and enhance the value to customers. The global market for high performance slurry pumps in metal mining applications is estimated to be around €1.3 billion."

"GIW Minerals products and services fit extremely well into our portfolio. Together with GIW we are able to offer more complete solutions and expanded services to our customers. Our joint technological breadth of experience and applications, extensive research and development capabilities together with life-cycle services will ensure profitable and sustainable operations for our customers", says Kalle Härkki, President of Outotec's Minerals Processing business area.

GIW Minerals LCC heavy slurry pump

GEHO (Weir Minerals) says "piston diaphragm pumps generally are the most economical pump type for long distance slurry pipelines" and it offers state-of-the-art piston diaphragm pumps with high reliability and efficiency and low operating costs.

GEHO cites the following advantages:

- Concept of large piston diameters and large stroke lengths – lower stroke rates => lower wear
- High availability (98%) => suitable for continuous operation

- Low stroke rates allow bigger valve sizes => lower slurry velocity in valves => low wear => easy to maintain and lower spares requirement
- Very high efficiencies (up to 96%) due to roller bearings and specially designed (low friction) piston seals => savings on power requirement
- Variable operation range (10% - 100%)
- No piston flushing: no slurry dilution
- Sophisticated diaphragm control system
- Reduced load on diaphragms, using light weight components, special control systems, etc.
- Different valve concepts, used for different applications.

In 2001, McLanahan Corp acquired the equipment division of Linatex North America. Since then, McLanahan has assembled pumps and supplied spare parts for the original Linapump IIIr centrifugal slurry pump in the North American market. With a growing international presence, McLanahan is now offering the newly developed McLanahan M3H rubber lined slurry pump for the global market.

Re-engineered from the Linapump IIIr design and manufactured by McLanahan for improved quality, the McLanahan M3H pump is dimensionally identical and displays comparable hydraulic performance to its predecessor. Four gland options - hydrostatic, packed, mechanical and dry - combine with an extensive range of high quality, abrasion resistant wear parts, which are available in a variety of materials and hardness, to offer unprecedented levels of flexibility to suit the application.

Warman® says its MCR® range of mill circuit pumps "is an example of where new technology can play a role in reducing costs in slurry handling, offering improved mill discharge performance. These pumps easily manage the large size particles in dense abrasive slurries and are suitable for applications ranging from the most difficult mill discharge to water flushed crushing. Fitted with R55® rubber liners, the wear life of this pump has been significantly enhanced and operating costs have consequently been lowered. The range is popular within the gold and copper sectors, and in mineral sands applications."

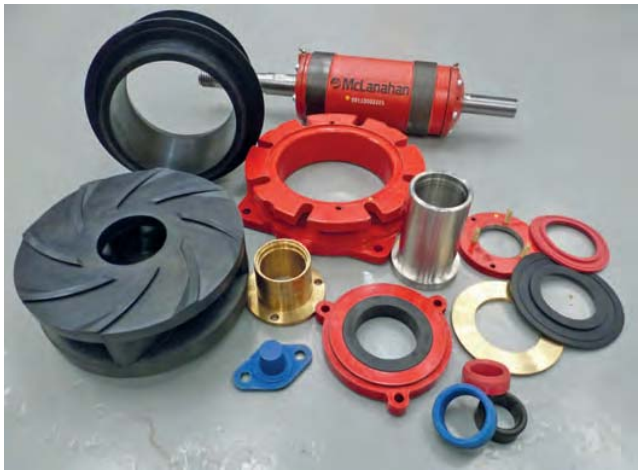
A Warman 350MCR mill circuit pump on primary mill discharge duty at a mine in the DRC

The recent expansion of the Warman WBH® range of pumps gives customers access to an improvement in wear life, with a subsequent reduction in maintenance and operating costs. The WBH heavy duty slurry pump is typically used in mill discharge, slurry transfer and process pumping applications with the added flexibility of either a metal volute or rubber liners, depending on the application.

Developed specifically for slurry handling duties in the mining and chemical industries, the Warman SLR pump range features a moulded high efficiency elastomer impeller. The deep side sealing vanes are designed to reduce wear and improve dynamic sealing. Coupled with the large diameter Hi Seal® expeller design, the SLR pumps are highly efficient at sealing the pump, even with challenging suction conditions.

Grindex says "the growing need to reduce costs without impacting on operational efficiencies or reliability has seen a trend towards the use of submersible pumps instead of vertical spindle pumps. Submersible dewatering pumps offer major advantages over vertical spindle pumps with one of the most important being that the submersible pump will operate directly in the slurry removing the need for costly infrastructure construction.

The McLanahan M3H has been designed so that components are interchangeable with existing Linapump IIIr pumps in all current plants and systems. Parts are readily available for all existing users of the Linapump IIIr design and are backed by McLanahan's renowned customer service and support



Klint Bawden, General Manager: Sales & Marketing at Integrated Pump Technology explains that this ease of installation allows customers to begin pumping operations virtually immediately. "And the cost savings achieved are extended to the actual operation as submersible pumps are known to be more efficient when compared to vertical spindle units," he adds.

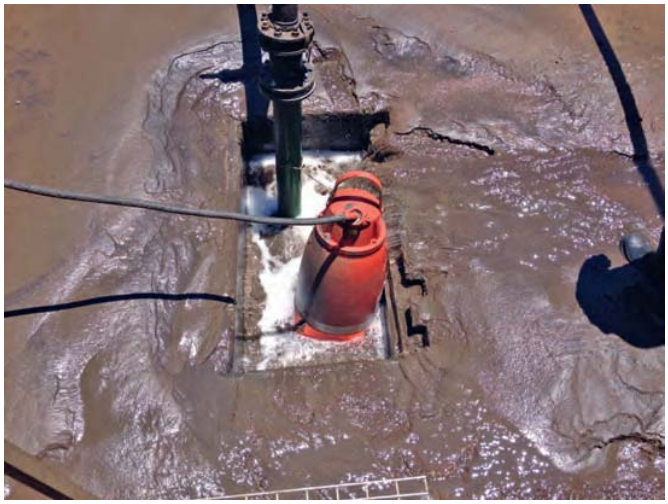
"Slurry handling is considered one of the most demanding pumping applications and where an inappropriate pump selection has been made there is often insufficient agitation in the sump. This leads to a build-up of solids which then settle out and a vertical spindle pump is not capable of dealing with this as it will then only pump out the water component in the sump," Bawden explains.

"Removing excess sediment or silt from a sump can become labour intensive and costly, and this situation is easily avoided by using a submersible pump in the first place."

The range of Grindex Bravo submersible pumps is engineered to pump slurry and fluids with a high content of abrasive solids and with particle sizes up to 50 mm. The range offers reliable pumping performance and the pumps are fitted with a cooling jacket and an agitator for effective slurry handling, eliminating the issue of silt build-up.

The robust construction, with all hydraulic components manufactured from NiHard 4, ensures optimum wear life. Bravo pumps are engineered to operate over the complete pump curve, not just on specific duty and can handle from 30 litres/sec up to 130 litres/sec at a maximum head of 45 m. The slim compact design facilitates quick and easy installation, while low noise level operation is another advantage.

"Our most recent installations where a Grindex submersible pump has replaced a vertical spindle pump are in a gold mine dewatering application and in a sand aggregate operation. Both customers needed to increase the reliability of their dewatering application while reducing the



Grindex submersible pumps replace vertical spindle units

associated costs in terms of unplanned downtime and nuisance issues such as silt build-up," Bawden says.

Integrated Pump Technology is the sole importer and principal distributor for the Grindex range of dewatering, slurry and sludge pumps for southern Africa.

Alternatives to welded piping

Chris Peitchinis, Vice President, Global Business Development of Tube-Mac Piping Technologies says "piping systems need not to be installed in the same way as they were 50 years ago. Strict cleanliness requirements can be achieved and labour costs can be reduced by using non-welded piping.

"Three basic procedures exist for joining high-pressure pipe or tube: flaring the pipe to 37°, grooving the pipe to accept a retain ring and swaging a fitting onto the pipe. The first two methods involve a non-welded style of flanged connection, which is free to rotate about the conductor. The last method is a mechanically attached fitting which is swaged on the pipe to create a permanent connection. Hot work permits and X-rays are no longer required. Welding or threading the flanges or fittings onto the pipe is unnecessary."

Thirdly, Pyplok® mechanically attached fittings are installed cold, in seconds, by swaging the fitting on the pipe with a hydraulic hand held tool. The actual swage cycle time varies by size but typically from 10 to 30 seconds and the swaging procedure is complete. All the labour and associated costs of a conventional welding are eliminated.

The hand held, portable, pre-engineered swage tool assures repeatability, leak-free and reliable connections every time. There is no need to rely on the strength of the installer to tighten bolts or nuts.

The three-step installation process is fast and simple – mark the pipe, pressurise tool, then inspect the joint.

Pyplok connectors have two elastomeric O-ring seals at each end. The inner O-ring seal closes off all the potential leak paths and the outer O-ring seal on the end of the fitting acts as a back-up and an 'environmental' seal to prevent contaminants from entering between the fitting and the pipe.

Pyplok is a solution for outside diameters of metric tubes from 6 to 60 mm. Due to the nature of the design the connector is dependent on outside diameter and the wall can be virtually any thickness. These connectors are suitable for pressures up to 690 bar depending on the size, material and safety factor.

Pyplok conforms to standard end connections, SAE, NPT, DIN and flange patterns in accordance with SAE Code 61/ISO 6162-1, SAE Code 62/ISO 6162-2, ISO 6164 and also with ANSI Class. Apart from standard shapes such as tees, 45° and 90° elbows and reducers, custom connectors are also available.