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White Paper

Logistics in Mining and Minerals – Solutions for the Handling of Bulk Solids in the Supply Chain

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Today raw material transport over great distances is a standard procedure in the minerals and metals industries. Especially under these circumstances, ingenious solutions for the handling of material during storage and transshipping can help save the pivotal dollar.

In past years the location of minerals process plant was generally governed by the availability of ore and fuel and the market for the finished goods. Particularly in the developed economies, driven by the industrial revolution in Europe, iron and steel products were generally produced close to rich mineral deposits particularly of iron ore and coal. The 19th century saw massive changes e.g. in the Ruhr valley in Germany with a transformation from a mainly agricultural tract of land to a vast iron making and coal mining industrial heartland. Cities such as Dortmund, famous today for their huge industrial complexes, in 1800 had populations of only around 4000.

Dust controlled ship discharge by rail mounted Eco Hopper at the port of Jurong.

By 1850 the mining industry had grown to employ about 12 000 miners producing some 1.5 million tons of coal. However, during the second half of the century the Ruhr mining companies, and the steel making plants upon which they depended, developed exponentially and by 1910 there were more than 400 000 miners producing some 110 million tons annually of high quality steam and metallurgical quality coal. For both quality and quantity the Ruhr surpassed all others on the European continent.

The Schade company was born into this fury of industrialisation and with two major steel producers in Dortmund at the time, the Dortmunder Union and Hoesch plants, feeding from the vast coal mining complexes there was no shortage of demand for engineering services. At the same time Aumund in Berlin were developing hoisting and conveying concepts targeted at the mining and metallurgical industries and licensing these products for manufacture and sale. In 2001 Aumund acquired Schade and the following year also acquired B&W Mechanical Handling of the UK, now known as Samson Materials Handling Ltd., a small company with general experience in materials handling including products applicable to the mining industry and for loading ships.

The Samson and Schade products are suitable for surface operations and fit well into a modern strip mining concept and together with the products Aumund had developed for the cement industry raw material handling there is a clear synergy in the product programme. This is reinforced with the know-how and product range developed by Samson for ship loading and discharge extending the range of the Aumund Group from the mine to the port and from the port to the processor. The cost of deep mining and the environmental issues surrounding surface mining in highly populated areas forced the European steel plants to look to overseas suppliers for iron ore and coal, making the logistics of moving huge volumes of material a key issue in the development of the market as a whole.

Samson mobile feeder with integrated rotary sizer.

So were born the huge ore terminals in Rotterdam, Amsterdam, Antwerp and other deep water ports where the cargo of Capesize bulk carriers could be discharged and transhipped to small vessels, barges and rail transportation. In parallel to these changes in the Western world further important developments took place in China with its accelerating demand which is effectively controlling the bulk market today. Of course the general minerals market is not just the huge volume areas of iron ore and steam coal but includes dedicated markets for aggregates and specialised minerals such as Gypsum, Bauxite, Olivine, Basalt, Clays, Kaolin, Industrial Sands and much more. Many of these materials are traded in smaller packages suitable for Panamax (65 000 DWT), Handymax (40 000 DWT) down to small bulk carriers and barges of 5000 DWT all of which require loading and discharge facilities.

Industrial minerals are now shipped across the globe in vast volumes demanding efficient logistics to minimise both the cost of transportation and the carbon footprint. The Aumund Group has developed a range of bulk handling solutions at each link in the mineral logistics chain allowing the operator to take maximum advantage of any combination of truck, rail, barge and deep sea shipment.

Apron plate feeder for raw material intake to crushing plant.

At the mine site the fundamentals of extracting the raw mineral has not changed in centuries, the rock is blasted from the face and loaded to trucks to be taken to a central primary crusher and then conveyed to a secondary crushing and screening station to be stockpiled before export. The apron plate feeder is first in the chain, handling the as-mined lumpy rock, providing a controlled feed rate to the primary crusher with typically an electrical interface to match the feeder to the crusher performance and avoid over-feeding.

The feeder design is based on tracked vehicle type chains and supported on close pitch matching rollers plus central skids to absorb impact loads. Each plate is made in two overlapping parts with milled edges ensuring the plates articulate at

the head and tail sprocket and an effective seal maintained to reduce risk of spillage between the plates. Available with a total plate thickness of 80 mm and maximum plate width of 3 metres these machines may be matched to the largest haul trucks for handling rates to 3,000 tons per hour.

Self propelled mobile link conveyors for a track mounted face crusher.

Of course the blast-haul-crush concept with a remote central fixed primary crusher is expensive to operate when the hauling distance increases. One solution is to bring the crusher to the face thus eliminating the intermediate handling by haul truck. Samson pioneered the concept of mobile link conveyors used with a track mounted mobile crusher and hydraulic excavator such that all the equipment operating at the face remained mobile and could be moved back for blasting.

From the link conveyors the sized material may be conveyed on conventional fixed or semi-permanent field conveyor equipment to the secondary crusher and final screening station and stockpile. Whilst the link conveyor solution eliminates all truck haulage there is no doubt that for short distances the flexibility of haul trucks is attractive for the operator.

Mobile material feeder feeds overland conveyor in a diamond mine.

Since the 1970s Samson have evolved their Samson Surface Feeder also into the mining industry finding application as a mobile feed point to receive as-mined

rock from articulated dump trucks and deliver to an ongoing belt conveyor incorporating an integral sizer to bring the material down to a manageable size for economic long haul conveying. In this manner of operation the sizer and feeder combination may be moved easily along the length of the conveyor to bring the feed point as close as possible to the work face, blasting permitted. The work face therefore runs parallel to the field conveyor and when the workable length of the field conveyor is exhausted the complete package may be moved sideways on the lateral sledges towards the face again and the process repeated. This is a typical example of blending the best attributes of truck and conveyor haulage to achieve the least operating cost and minimum carbon footprint.

Expanding this concept Samson have recently commissioned three of their new wheeled Material Feeders in a large mining operation in Southern Africa handling as mined rutile sands delivered by ADT achieving an average loading rate of around 1300 tons per hour per feeder. Based on the Berco “SALT” (Sealed And Lubricated Track) chains type D6 these feeders are able to operate reliably under extreme conditions handling highly abrasive ore.

Loading Melafyr (Basalt) via Storemajor to railcars in Poland.

Where the mine is close to the processor then this is the end of the external logistics story but in many operations there is a huge disconnect between miner and processor requiring complex logistic operations in between involving any combination of road, rail, barge and coastal or deep sea freight. Of course where the mine and processor are both either rail connected or close to suitable sidings haulage by rail is by for the better solution being both more economical and much less polluting with a very low carbon footprint. At the mine site railcars may be simply loaded using a silo and loading chute system mounted to a suitable supporting structure above the rails.

However many mine sites are not rail connected although there may be existing rail sidings close by. In this situation the mobile Samson Stormajor developed by Samson Materials Handling offers a unique solution allowing railcars to be loaded

direct from road trucks at an existing rail siding without the need for fixed plant or infrastructure. Typically, a recent installation at Poznan, Poland, where Melafyr rock (similar to Basalt) is delivered to the Stormajor® by articulated dump trucks and loaded at a rail siding close to the mine.

Stormajor loading Gabros rock for aggregate onto a barge in Russia.

The Stormajor® may equally be utilised for loading to barges for distribution on inland waterways, such an operation is on Lake Onega (Russia) where Gabbro rock is delivered to the lake side from the adjacent mine and loaded to barges of around 5000 DWT for distribution to Moscow and St. Petersburg.

The equipment operates on a simple berth using the long cantilevered outloading boom of the Stormajor to load the barges moored just off shore in deeper water thus avoiding costly dredging and an expensive permanent concrete dock. Samson has pioneered the concept of direct loading from truck to railcar, ship or barge.

Of course for deep sea shipment the concept is similar but larger equipment is required to load larger vessels: two examples are covered herein showing a project in Peru handling copper and gold concentrate and another project in Liberia handling iron ore.

Exporting copper concentrate from Peru direct from truck to ship.

In Peru the Goldfields Company operate from an existing port jetty and receives material direct from tipping trucks coming from the Cerro Corona Mine situated in the highest part of the Andes in northern Peru. The project involves the production of gold and copper by conventional open pit mining methods, and the copper-gold flotation concentrate is trucked to the Port of Salaverry for shipment to smelters in Japan, Korea and Europe. In this operation the concentrate is transferred direct from truck to ship using an integrated Samson style feeder mounted to the Shiploader chassis as a single and fully integrated one piece machine.

Exporting iron ore from Arcelor Mittal Liberia for steel production.

In Liberia, Arcelor Mittal mine iron ore in country close to Yekepa town which is transferred by rail some 280 km down to the port at Buchanan. In the port the ore, mainly fines, is extracted from the railcars by excavator and stockpiled in a covered storage for export on Panamax vessels. Samson supplied a mobile shiploader including twin mobile tracked Material feeders offering a loading rate in excess of 2000 tons per hour, limited only by the wheeled loaders. Using a combination of mobile equipment such as in Buchanan offers a relatively fast track and economical solution to start exporting ore with the minimum of fixed port equipment or infrastructure. Such equipment offers a long term solution for exporters or, thanks to the equipment inherent residual value, an effective answer for short term situations or pending installation of a permanent rail mounted alternative.

Similarly at the port of entry mobile discharge equipment, based often today on grab fitted mobile harbour cranes, is the preferred solution allowing the berth to be used for multiple cargoes including bulk, container and break-bulk. However, for bulk discharge of dusty cargoes due consideration must be given to environmental pollution from wind-blown fugitive dust created by material falling free from the grab. Free falling material separates into particles and dust is free in the air within the material stream, dust released in this way is readily disturbed by air movement including side winds. The only solution to control the dust is to control the material free fall into a suitable hopper. However, as the material falls

from grab into the receiving hopper air is displaced which collects the free dust particles and the dust laden air is ejected from the hopper at high speed. The same problem applies to the loading of the tipping trucks where again air is displaced and any uncontrolled dust is ejected from the truck body. If uncontrolled combining both the dust generation from the grab discharge and from the truck loading is a double whammy and the result will be billowing clouds of dust from the discharge operation causing considerable pollution and being a hazard to the health of all working in the vicinity.

Dust controlled tyre mounted Eco-Hopper ship discharge to tipping truck.

The solution is the Eco Hopper concept comprising both dust controlled grab discharge and dust controlled truck loading using a concentric chute with dust extracted through the annulus ring. Controlling dust from the grab requires a two pronged attack using the Flex-Flap system to minimise the flow of displaced air from the hopper and also a high capacity dust extraction and filtration system to both clean the displaced air and create a net air flow into the hopper from the grab discharge. To mitigate the effects of side winds it is essential the grab discharges within a shroud extending around 2 metres above the Flex-Flap and then the dust laden air from the shroud can be drawn into the hopper bowl to be cleaned by the dust extraction equipment.

In most applications a quayside stockpile is not acceptable and therefore the bulk cargo must be moved off the berth to a remote storage area using either a fixed conveyor system or, as illustrated herein, by tipping trucks operating on a merry-go-round basis. Using mobile Eco Hoppers and truck transfer the berth maybe cleared of equipment completely after the bulk vessel is discharged freeing the berth for other port operations.

In many situations the mobile option for both ship loading and discharge offers clients a viable alternative to permanent fixed installations and in today’s market is an attractive flexible investment.

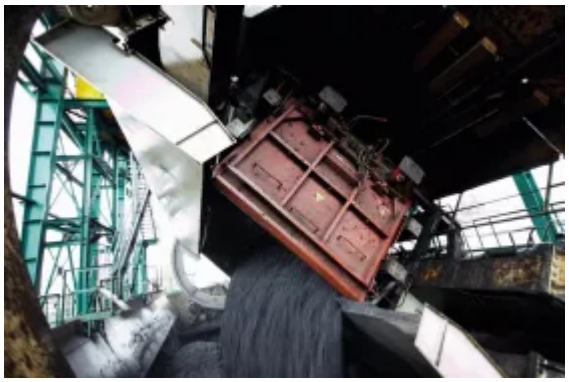
Whether shipped by rail, barge or deep sea vessel the final link in the logistics chain is the intake and storage of these materials at the process plant. From the rail or road intake facility typically the bulk mineral will be conveyed to local storage facility such as a dome or silo system. For larger volumes a horizontal storage system including perhaps blending where material may be supplied from a range of sources may be appropriate and blended into a homogeneous output.

The Samson Surface Feeder concept offers the most economical and environmentally friendly solution for raw material or fuel import from tipping trucks. Being surface mounted of course saves on civil works but also reduced the uncontrolled free fall with associated displaced air and as a result dust generation is mitigated at source saving on expensive dust plant and reducing operating costs.

Hopper bottom railcar discharge to circular storage.

Of course the same equipment may be used for under rail discharge of hopper bottom rail wagons and in this case similar arguments apply in that the excavation depth is reduced saving civil works costs and reducing material free fall with a corresponding reduction in dust generation.

The same general arguments for dust control is applied at the Eco Hopper and the Samson® feeder based on mitigation at source to save on capital and operating costs.



Automated discharge of flat bottom railcar by wagon tippler.

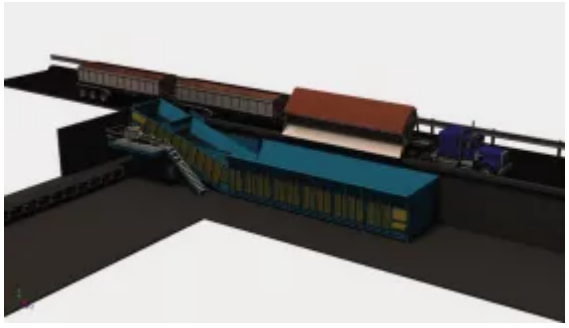
Where hopper bottom wagons are not available then flat bottom wagons may be employed but a Wagon Tippler will be required if the discharge is to be automated. Typical designs from Schade include the O-frame, C-frame and pivot-frame designs all supplied with various designs of indexer to automate the movement of the wagon and wagon rake eliminating the need to hold a shunter or switcher for the duration of the rake discharge.

Of course the wagon tippler may be supplied with the associated plate feeder or, where excavation depth may be limited, the Samson feeder offers significant advantages.From the road truck or railcar discharge the raw material or fuel may be conveyed into the storage hall and stacked by travelling stacker or from overhead tripper system all of which are offered by Schade along with the automation package for unattended operation.

Circular storage and blending bed by Schade for BHP Blackwater mine Australia.

Typical longitudinal storage solutions with travelling and luffing boom stacker plus a cantilevered boom style reclaimer recovering dissimilar materials from discrete storage bays or when handling the same material the circular storage offers a compact alternative with also the option of layered loading and blending using the Bridge Reclaimer system.

The boom type chain scraper reclaimer concept draws material from the inclined stockpile face and discharges to a collecting conveyor running parallel to the stockpile. The recovered material may be conveyed to silo storage or bunkers where it may be blended and delivered in controlled proportions to perhaps a milling system before processing.



Side-tip material feeder for road train trucks.

For larger installations typically in such as Australia and South Africa central preparation plants draw raw materials from often a number of satellite mining operations for blending, washing and loading to trains for transfer to the port. Clearly the central prep-plant has an enormous advantage in that only one railroad is required clearly saving significant cost and enabling most efficient use of the rail network. However, material must be hauled from the mine sites to the prep-plant using a fleet of large dump trucks or more often road trains with multiple side tipping trailers. The intake of material from these road trains is a challenge since the trucks must be rapidly discharged and returned to the mine requiring high performance intake capacity and high holding capacity. Again the Samson Surface Feeder with D6 conveyor chains and rollers extends the required receiving area and offers a high holding capacity without the need for deep excavations and underground hoppers. Surface mounting is less polluting and offers easy access for maintenance and housekeeping.

In the complex market that exists today many minerals of vastly different handling characteristics must be transported from the mine site to processors, often on different continents, with often many logistics steps along the way.

And in addition to extracted minerals we also have to consider the movement of industrial by-products from such as power plant (Synthetic Gypsum) and steel works (Slag) which have become important assets in the global fight to reduce greenhouse gas emissions.