



# Iron ore to market

In the last in the series on LKAB, John Chadwick looks at its processing plants where the crude ore is upgraded to pellets and fines, and the logistics chain that takes the product to market

Ore is ground to a fine powder in several stages; then, undesirable components are removed by magnetic separators.

The concentrate is mixed with water to form a slurry and pumped to the pelletising plant. The slurry is dewatered with large filters, and then mixed with binders and additives, depending on the type of pellet to be produced. Olivine, quartzite, limestone and dolomite are examples of additives.

The mixture is fed into gigantic drums and rolled into small 'green balls'. These are then, in the grate-kiln process in Kiruna and Svappavaara, heated in a large rotary kiln at 1,250°C to become pellets. This gives them the hard surface they need to withstand long transport by rail and ship.

The red-hot pellets are cooled to about 50°C before they are tipped into an underground storage facility beneath the pelletising plant. From there, they are automatically loaded to railway cars for further transport.

Unlike pellets, fines must be sintered to larger pieces before the product can be used in blast furnaces. Fines from Malmberget is a screened product from the mine. It is processed in sorting and concentrating plants by dry and wet separation. The Kiruna processing plants produces different types of iron ore pellets to the steel industry. Only Malmberget has the capacity to produce fines, but the main product

from Malmberget will also be pellets in the future.

A new pelletizing plant in Malmberget (MK3) came on line in December 2006. The new concentrating and pelletising plants (KA3/KK4) in Kiruna were inaugurated in June 2008 (*IM*, November 2008, pp18-22).

## AggloLab

LKAB is the world's leading supplier of pellets and now has the world's best value-adding services, whereby it can assist customers with ongoing product development. To maintain its lead in the market, LKAB is now complementing the Experimental Blast Furnace in Luleå with an agglomeration laboratory in Malmberget. Agglomeration is the actual production/balling of the iron ore pellet.

"Our goal is to sell the world's best 'pellet package', said Acting President Lars-Eric Aaro at the time the project was launched. The aim is to offer customers products that enable optimal function in their increasingly larger and fewer blast furnaces. Or to put it even more succinctly: the lowest cost per tonne crude iron. The AggloLab is therefore crucial for LKAB's research and future development.

The new agglomeration laboratory is being built directly adjacent to the R&D facility in Malmberget. It is expected to be operational at the turn of the year 2010/2011.

"At the AggloLab, we will be able to

*IORE-loco on the Ore Railway*

conduct cutting-edge research in a modern facility that has everything we need, including full-scale equipment for balling," says Seija Forsmo, Research Manager and expert in particle technology at LKAB R&D. "The lab is very important for our process and product development, and it will raise the level of our research and pellet expertise. It is essential that newly-won knowledge from research is transferred to those who produce the pellets, and here, AggloLab is a new step towards closer contact between researchers and production personnel."

The performance of pellets in customers' blast furnaces is a function of chemistry (the content of the pellet), mechanics (how the pellet product is made), and metallurgy (how the pellet behaves in the blast furnace). Research in agglomeration refers to all necessary research in all process stages from mine to finished product. Ultimately, the goal is to produce the best, optimal pellet product. The most important component is the actual agglomeration i.e., the production/balling of the iron ore pellet.

LKAB's long-term vision is the realisation of an 'AggloCenter'. The vision entails the assembly of interdisciplinary research groups with expertise in areas such as mineralogy, chemistry, mineral science, metallurgy, and



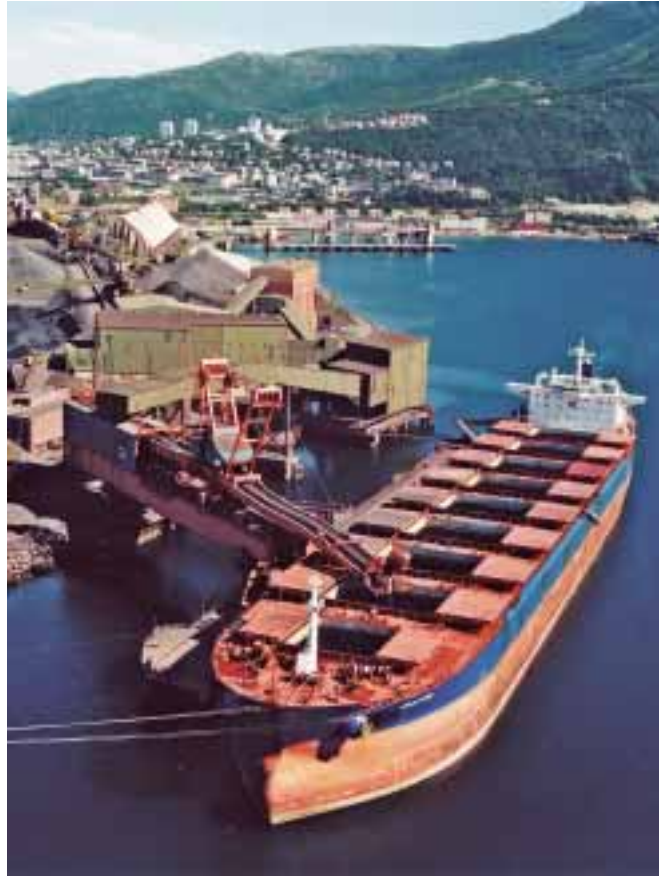
process control and automation. Research at the AggloCenter will be heavily focused on securing LKAB's position, as perceived by the customer, as the global leader in pelletizing.

"The AggloLab that will now be built is the second step towards that goal," said Aaro. "The first was when we built the experimental blast furnace in Luleå more than 10 years ago. So far, the EBF has been the only facility of its kind in the world, and thanks to it, we and our customers have learned a lot about pellets and the blast furnace process.

"This invaluable knowledge for the future can now be developed even further. The third step towards an AggloCenter, an experimental pelletizing plant, is also part of the plan for the future. As yet, it is too soon to say just when it will be built."

Areas of operation in the AggloLab can be summarised as:

- Preparation - crushing, comminution, screening, separation, concentration, flotation, dewatering, characterisation, structural analysis, ore base inventory
- Agglomeration - micro balling, balling circuit



Narvik ore harbour

development, oxidation, sintering, development of binder additives, thermo analysis, pot furnace, coating, product development, characterisation, structural analysis, ore base inventory

- Training - of process engineers, process operators, junior researchers, shift personnel, etc.

## Rail to harbour

The value of the iron ore deposits in Kiruna increased when the railway linking Kiruna and Narvik was opened. The line, known as *Malmabanen* in Sweden and *Ofotenbanen* on the Norwegian side, was inaugurated by King Oscar II in July 1903. However, the first ore trains had already begun to traffic the new railway six months previously. Since then, Narvik has been LKAB's most important shipping port, and the investments in logistics have been extensive.

In 1906 the first permanent ore quay is completed in Narvik, and in 1923 the railway was electrified. During WWII, the quay was bombed and many ore



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carriers were sunk. After the war, construction of a new ore harbour began immediately, and the harbor has been successively developed.

In 1956 the ore harbour was rebuilt and capacity increased to 12 Mt/y. The harbour was refurbished again in 1977, and could now receive vessels of up to 350,000 dwt.

During the 1990s, LKAB gained traffic rights on *Malmbanan* and *Ofotenbanen*. At the close of that decade, agreements were reached for an upgrade of the line to accommodate a 30-t axle load.

The Ore Railway runs from Narvik (Atlantic coast) in Norway, through Norrbotten via Kiruna and Malmberget, to Luleå on the coast of the Gulf of Bothnia. The railway is 536 km long (including the Kiruna-Svappavaara branch). Products from Malmberget are transported mainly to Luleå for direct delivery to SSAB's blast furnace in Luleå or further delivery to SSAB in Oxelösund, and to customers in Finland and other countries around the Baltic. Each day, five or six trains make the 220-km, five to six hour journey from Malmberget to Luleå. Most products from Kiruna and Svappavaara are transported to Narvik for further delivery to customers in continental Europe and the rest of the world. Daily, 11-13 trains make the 170-km run between Kiruna and Narvik. The trip takes a little more than four hours.

The Ore Railway between Luleå and Narvik is managed by LKAB's Swedish subsidiary Malmtrafik i Kiruna AB (MTAB) and its Norwegian subsidiary Malmtrafik AS (MTAS), both included in Mining Division. Operations are controlled from an ore transport centre in Kiruna. With its current fleet of locomotives and cars, MTAB has a mine-to-harbor freight capacity of more than 25 Mt/y.

terminal structure for Kiruna is also ready, with loading of ore trains at surface level from two high storage silos and a new receiving facility for additives. The rail yards in Kiruna, Svappavaara and Narvik are being rebuilt to accommodate the new longer and heavier trains.

Two investment decisions are improving logistics operations. Four new regular traffic locomotives (IORE type), equipped for a 30-t axle load, were purchased. Two single cab locomotives are always used in each train set. LKAB already had nine IORE locomotives (18 single cab locomotives); three on the southern circuit and six on the northern circuit of the Ore Railway. The four new engines will operate on the northern circuit and replace the old, remaining Dm3-type locomotives, which are being decommissioned during the period 2009-2011. All the new locomotives are expected to be in operation during the third quarter of 2010.

LKAB has higher costs for rail transports than its competitors in, for example, Brazil or Australia. Thus it aims to reduce operating costs to a similar level to those competitors. That objective is being achieved by investing in the new 30-t axle load. The amount of product per car will be increased and each train set will consist of 68 cars instead of 52.



**Our goal is to sell the world's best 'pellet package'**

Acting President Lars-Eric Aaro



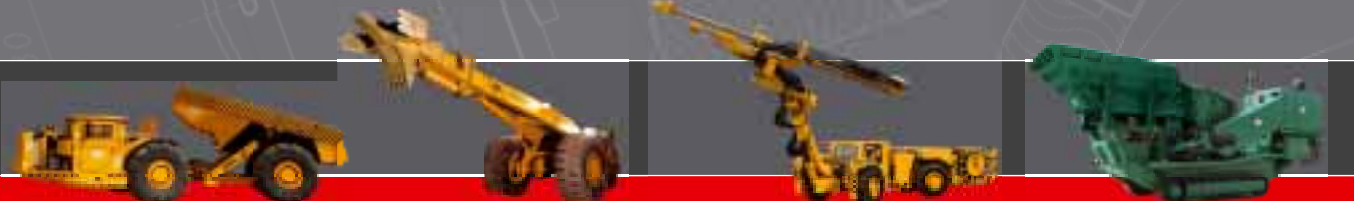
Increased payloads and shorter turn-around times for trains will enable greater rail haulage capacity. This will be accomplished mainly through the introduction of a uniform fleet of locomotives and ore cars for a minimum 30-t axle load, and better efficiency in infrastructure, such as terminals. In all, ten full train sets of cars are now operational and the 30-t structure has been fully implemented. The terminals in Malmberget and Luleå are ready to meet the future production requirements. A new

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Three new train sets, built for a 30-t axle load, are being acquired for the northern circuit. With each train set consisting of 68 cars, plus six reserves, the total is 222 cars in all. The payload of each car is more than 100 t. With this investment, decisions have thereby been taken on five of the seven train sets required for the northern circuit. Investments for an upgrade of the southern circuit to the new 30-tonne structure have been completed.

LKAB, together with K-Industrier, developed the new, larger ore car for the 30-t axle load and with a 100-t payload. The first car was delivered in autumn 2005, and about four cars per week roll out from the Kiruna Wagons assembly shop at LKAB in Kiruna. The final total will be 750 new cars.

## Ore ports

There is continuous, rolling discharge from the rail cars at both harbours, Narvik and Luleå. Thanks to the Gulf Stream, Narvik is ice-free year round. This is a good location, close to the mines and to LKAB's customers in Europe. The facility consists of a terminal for discharging the ore trains, stocks of the various iron ore products, and quays where the vessels dock for loading.

Narvik is also a receiving harbour for additives used in LKAB's pellet manufacture. For

### Narvik ore harbour in figures:

Shipping capacity: 25 Mt/y  
 Stockpiling capacity: 1.5 Mt  
 Maximum dead weight: 350,000 dwt  
 Loading capacity: 12,000 t/h  
 Number of shiploaders: one  
 Height under shiploader: Not limited  
 Length of quay: 208 m  
 Depth: 27 m  
 Loading time: 25-30 hours per vessel  
 Number of ships per year: 220-250  
 Average tidal range: 1.75 m

example, olivine is shipped here for further delivery to the processing plants in Kiruna and Svappavaara.

In January 2006, construction of a whole new storage and discharging structure with underground silos began in Narvik – SILA, an investment of SEK2 billion. Commissioning of the new harbour facility started during the third quarter of 2009. Inauguration took place in October, 2009. There are 12 underground storage silos, each 60 m deep, blasted out of the bedrock. LKAB says this is "a world-unique design for an ore harbour of the future, with better efficiency and minimal environmental impact, in the center of Narvik."

Each silo holds about 105,000 t of pellets (about 15 train sets, fully loaded) or 130,000 t of fines. The total storage capacity is 1.3-1.5 Mt. The decision for the SILA project was taken by LKAB's board in December 2005. The aim of the investment was to improve the efficiency of material handling in the harbor and to increase the flexibility and capacity of the facility. Another very important objective was to improve the environment for personnel and local residents.

Together, the new SILA material handling system, an upgraded railway infrastructure and new locomotives and

ore cars enable an increase in shipped tonnage from 15-16 Mt to over 19 Mt/y of iron ore products. The harbour facility is built to handle 9,000 t/h of iron ore products.

One of the main objectives in creating SILA has been to improve the local environment. For example, dust generation in the harbour is significantly reduced, thanks to the tightly enclosed material-handling system between train and screening station. The ore trains bottom-dump into the silos. Noise levels will also be reduced. Visible at surface level is the 650-m-long discharge station, one of Norway's longest buildings. The 12 rock silos are below the new railway track, and their tops are each 40 m in diameter.

Most operations are automated; the rest being controlled remotely from a control room. The equipment that empties the ore trains has been custom-designed for SILA. It is portable

### Luleå ore harbour in figures:

Shipping capacity: 10 Mt/y  
 Stockpiling capacity: 350,000 t  
 Maximum dead weight: 55-60,000 dwt  
 Loading capacity: 3,500 t/h  
 Number of shiploaders: one  
 Height under shiploader: maximum 17 m  
 Length of quay: 250 m  
 Depth: 12.1 m  
 Loading time: eight hours  
 Number of ships per year: 320-350

and is also operated via remote control. The ore trains are backed into the facility and maintain a constant speed of 0.35 m/s. The cars are opened exactly as they pass over the silo into which the particular ore product is to be discharged. It takes a mere five seconds to empty a car, and a train stops for only two hours before returning from Narvik to Kiruna or Svappavaara.

Luleå harbour is on Outer Sandskär, about 7 km from Luleå's city centre. It was opened in autumn 1996. The entire chain of transport - from discharging of ore trains to loading of vessels - is accomplished with new technology and efficient equipment. Ships are assisted by icebreakers in the winter. Most ore handling takes place under cover. Belt conveyors and stockpiles are roofed-in. Ore products are mainly stockpiled in three silos, with a total capacity of 135,000 t. It is also possible to hold ore in open stockpiles that can serve as buffers in the event of disruptions in production.

Luleå (Victoria Harbour) is also a receiving port for coal, oil, and additives for LKAB's operations, e.g., bentonite. These products are transported by rail to MalMBERGET, Svappavaara and Kiruna. **IM**

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