Environmental improvements for Peirce-Smith converters with Outotec's converter hood technology for primary and secondary gas capture

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The paper describes the improvements that Outotec has made to the design of Peirce-Smith (PS) converter hoods in order to improve operational performance and environmental conditions in the converter aisle.

Most smelters have changed their primary smelting technology. Reverberatory furnaces have been replaced by more environmentally friendly and energy-efficient furnaces such as Outotec FSF or TSL. When the environmental performance of the primary smelting furnace has been improved, the focus turns toward the acid plant (if single absorption) and later the converter aisle.

Outotec`s converter hood technology ensures that processing of copper matte can be done in a more sustainable and environmentally acceptable manner. Sulphur and dust capture above 95% is easy to attain with Outotec`s water-cooled primary converter hoods, and values as high as 99% have been reported. Outotec's converter hoods for primary gas capture are designed for operation at high temperatures and, accordingly, for low false air inlet and high production.

After changing the primary hoods, the next step in the environmental effort is implementation of a secondary gas system to collect fugitive gas and dust. Fugitive gas escapes during rolling the PS converter in and out, ladle handling etc. With Outotec`s knowhow and technology the converter aisle will become a more environmentally friendly unit with high production.

Introduction

Looking back at the history of copper smelters, it is noted that concern for environmental issues was practically nonexistent about 100 years ago. At that time only the surroundings closest to the smelters were polluted by emissions of sulphur dioxide and dust. The first attempts to decrease the pollution in the area around the smelters entailed building high stacks and increasing the dilution of the process gases. High stacks made the working environment at the smelter sites and in the vicinity of the smelters acceptable, and enabled the smelters to operate without any gas and dust cleaning equipment.

The years went by and people in the surroundings started to see the effect from the emissions. The smelting industries in the western countries were the first out with large-scale copper production. With increased production the emissions increased very quickly. In 1900 copper production was only 0.5 Mt, compared with about 16 Mt today (US Geological Survey, 2012).

Deforestation increased, water was polluted, and people living further away from the smelter sites started to show high blood levels of heavy metals. The copper industry had to find new ways to handle the situation during the middle of the 20th century. New environmental regulations were introduced in Europe, North America, and Japan, which the copper industry had to comply with, and it was also important to win back the confidence of the public.

Gas cleaning for dust capture became necessary, followed shortly by sulphuric acid plants. The first sulphuric acid plant was built at Boliden Rönnskär smelter in Sweden in 1952 (Boliden, undated). The sulphur dioxide (SO_2) capture was initially poor, as can be seen in Figure 1, which shows the SO_2 emission history and. production history for the Rönnskär smelter.

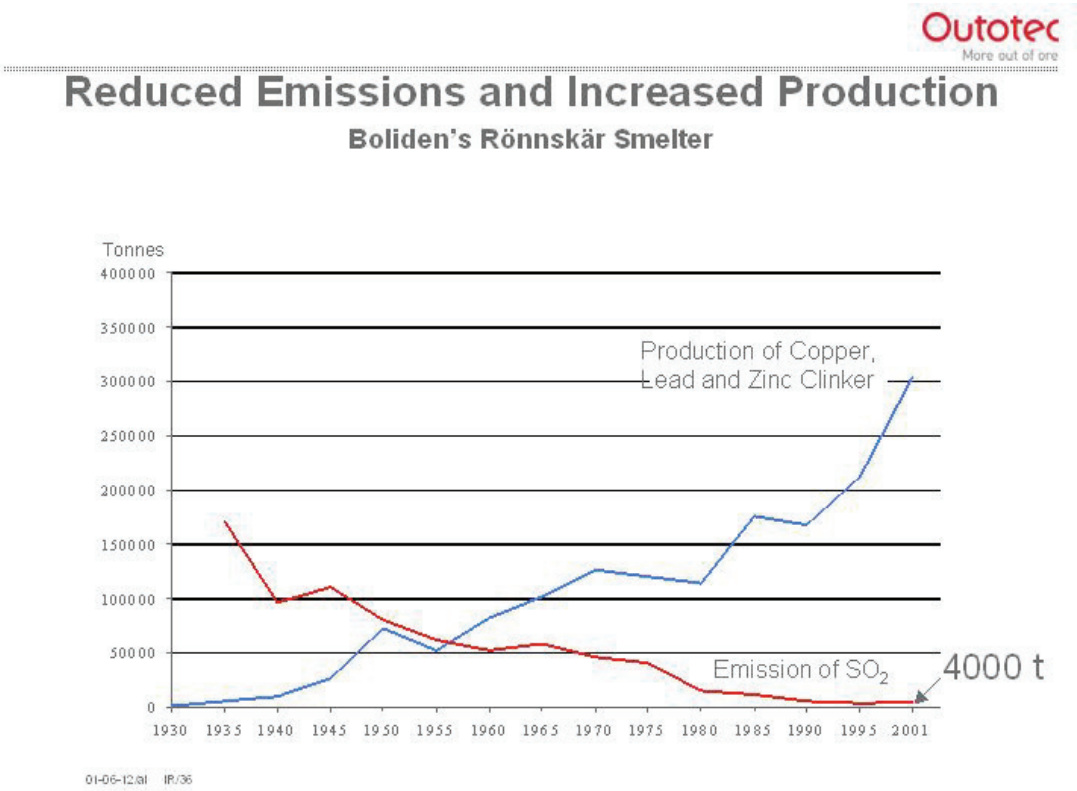

Figure 1. Production and emission history for the Boliden Rönnskär smelter in Sweden

To be able to comply with new legislation in the western industrial countries, the copper industry had to look for new technologies. After the installation of sulphuric acid plants, costs increased due to high gas volumes with low SO_2 concentrations. The gas and dust capture was poor and focus turned towards the primary smelters, which changed their technology from e.g. reverberatory furnaces to more energy- and environmentally-efficient smelting units like Outotec FSF or TSL. When primary smelters achieved a high environmental and economic (power consumption and throughput) performance, the focus turned towards the acid plant tail gas and the converter aisle.

By converting single-absorption sulphuric acid plants to double absorption, SO_2 in acid plant tail gas was reduced. As the next step (or at the same time) the environmental performance for the Peirce-Smith (PS) converters had to be increased. PS converter hoods with better environmental and economic performance are necessary to reach the environmental goals of the 21th century.

Company history

The work by Boliden to develop the Outotec high environmental performance PS converter hoods began in the 1970s. Subsequently, Boliden started a subsidiary called Boliden Contech, which continued the work with development of the PS converter hoods. In 2004 Outokumpu and Boliden merged, and at the same time Boliden Contech was merged with Outokumpu Technology. In 2006 Outokumpu sold their technology subsidiary Outokumpu Technology to focus on steel production. Outokumpu Technology was listed as an independent company on the Helsinki stock exchange in 2006, and changed its name in 2007 to Outotec. The development of today's converter hoods is still done in collaboration between Outotec and the Boliden Rönnskär smelter.

Air-cooled PS converter hoods

During the project to develop PS converter hoods with high environmental performance, it was realized that the hood had to be closer to the converter mouth. The main problem with the air-cooled PS converter hoods is overheating. To avoid this, the PS converter hoods used a high volume of dilution air and had to be installed at a great distance from the PS converter mouth. Before gas cleaning was employed, a high volume of dilution air was not a problem. However,

after gas cleaning was introduced the dilution air decreased and the lifetime of the hoods decreased rapidly due to overheating. Figure 2 shows an air-cooled PS converter hood.

Figure 2. Air-cooled PS converter hood

First attempt – water jacket

With the realization that the PS converter hood had to be closer to the converter mouth, the only way to go was water-cooled hoods or water spraying in the hoods. The solution on the market for water cooling was at that time water jackets, where the hoods are built up by water 'boxes'.

Water jacket hoods were built on PS converters all around the world and made closer fit between the hood and the converter mouth possible. However, this solution did not satisfy the engineers at Boliden Rönnskär. The possibility of having a very close fit without risking local boiling was not yet possible. Too close a fit resulted in problems with local boiling due to uneven water distribution in the water jackets. Uneven heat load from the converter was also a problem. These conditions shortened the lifetime of the PS converter hoods. Two other major drawbacks are the extensive piping required and the non-smooth inner surface.

If a secondary hood is used, the extensive piping takes up a large part of the available space, and also lengthens the installation time, due to the large number of connections. Water jacket 'boxes' and their associated piping can be seen in Figure 3.

The joints between the water jacket 'boxes' constitute ideal locations for build-ups. To remove the build-ups, a heavy device has to be used and the risk of damaging the hood is great. The joints are also prone to corrosion, with increased risk of water leaks. Water jacket 'boxes' and their joints can be seen in Figure 4.

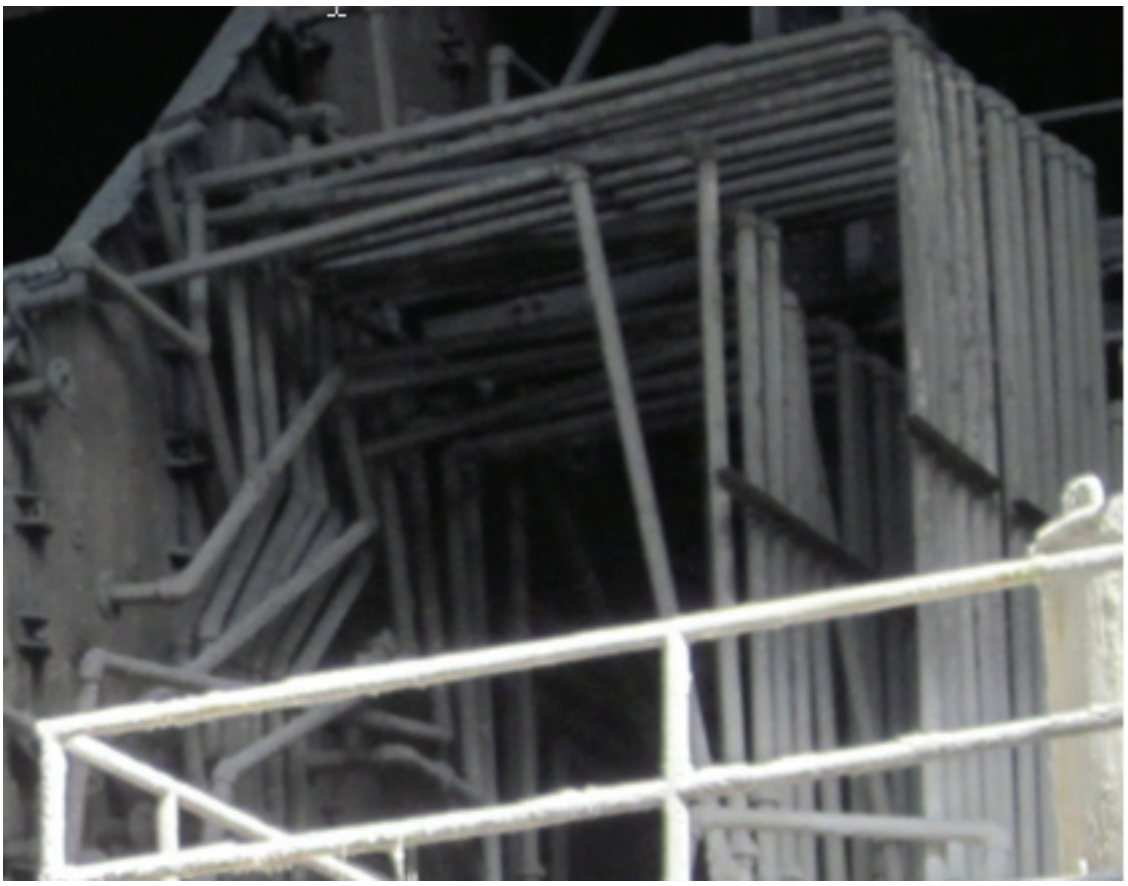

Figure 3. The use of extensive piping to connect the water jackets

Figure 4. Joints between water jackets

Next step – water tubes

The engineers at the Boliden Rönnskär started to look for other solutions for the PS converter hoods. A solution known at the smelters was water tubes used in boilers. The boiler tubes were of course used in other applications. One other solution where water tubes were used was in the zinc fuming plant at the Boliden Rönnskär smelter.

The first hood made from water tubes was introduced during the 1970s. The problem of local boiling due to uneven water distribution was solved by the use of water tubes with a high water flow rate and hoods with closer fit were now possible. The problem with extensive piping was also solved with tube-type panels, as the water could be introduced through headers.

However, the drawback with the use of water tubes appeared soon. Build-ups were created rapidly and cleaning was necessary. Sometimes very large pieces fell down without control and damaged the equipment. The build-ups resulted in corrosion and the cleaning was wearing the tubes. The consequence of the corrosion and cleaning work was, of course, water leaks.

What is needed to create a perfect hood?

The engineers were looking for an even better solution. The new solution had to have the following advantages:

- High production with best-in-class environmental performance
- Smooth panels to make the hood self-cleaning
- Easy installation e.g. water distribution through headers (less piping)
- Closest possible fit for maximum environmental performance and low dilution
- Movable door that can be opened without excessive emissions
- Long lifetime
- Possibility to charge with the boat during blowing without large emissions.

Final solution – smooth panels

Once again the engineers started to look for a new solution for the PS converters. The final solution was panels made from plain steel sheets with welded rectangular water channels on the outside. Around 1980 the first PS converter hoods were installed made from water-cooled smooth panels. The smooth panels performed well from the beginning. Figure 5 shows the panel design and an Outotec converter hood after more than 10 weeks' production.

Figure 5. The water-cooled smooth panel design (top) and an Outotec converter hood after more when 10 weeks' production (below)

Prevention of gas leaks from the front of the converter

By closing the converter at the rear, the flame will be pushed backwards and gas leaks in the front are minimized. Most of the dilution air enters under the front door and less gas will leak out around the door. The dilution air protects the door and reduces the heat load against the door, hence water cooling of the door is not necessary. As most of the dilution air enters from the front, charging with the boat during blowing is possible without excessive gas emissions. Another benefit from closing the converter on the side and the back is that the hood door can be used to control the amount of dilution air.

The door is one other key factor in reducing gas leaks. A well-designed door will prevent gas emissions to the secondary converter hood, or in the worst case, to the converter aisle. The best way to avoid gas leaks is to have a door with a tight fit against the primary hood, especially at the top. The Outotec door has a sealing device in the top of the door, which slides against a rigid water-cooled box that has a smooth surface. The tight fit at the top prevents emissions when the door is opened and makes it possible to charge cooling scrap by the boat during blowing without excessive emissions.

Summary of the primary converter hood development

The development work done on the converter hood since the 1970s consists of:

- Water cooling together with the smooth surface to make the hood self-cleaning
- Use of a controlled high flow rate of water flow, which enables a close fit without local boiling
- A large part of the piping can be installed in advance, resulting in a short downtime

- Many units are delivered pre-erected, e.g. the hydraulic unit is delivered in a container, with the cooling water pumps and heat exchangers on racks
- A movable door with a special top seal to avoid gas leaks
- A low and controllable amount of dilution air due to the close-fitting and tight movable door
- Secondary hoods that are asier to install due to less piping on the primary hood. Water flow distribution done by headers - not piping
- High SO_2 recovery makes scrubbing of secondary gases unnecessary
- The hood is pre-assembled, resulting in a short downtime (Figure 6).

If the hoods are used properly it is possible to achieve dust and SO_2 capture of more than 99% in a primary hood.

Figure 6. Installation of an Outotec pre-assembled PS converter hood

Secondary hoods

If the primary converter hoods work perfectly, it is time to focus on the secondary hoods to improve working conditions in the converter aisle. The first secondary hoods were in use in the 1970s at the Boliden Rönnskär smelter (Edlund and Lundquist, 1979). Since the first hood came into use, most of the development has been on the doors and the layout. The layout should enable charging during blowing.

Secondary hoods are, as the name implies, for secondary gases such as emissions from:

- Rolling in and out the converter
- Charging the converter in both filling and blowing position
- Tapping matte, slag, and blister copper
- Parked ladles.

Secondary hoods are primarily for a cleaner and safer working environment. A cleaner working environment increases worker productivity and extends equipment lifetime thanks to less dust exposure.

With Outotec primary hoods it is possible to capture over 99% of the SO_2 and dust. Only a bag filter is needed to capture dust in the secondary system. If there is too much SO_2 in the secondary system, for example during normal blowing, it indicates that the primary system is insufficient and needs to be modified (Figure 7).

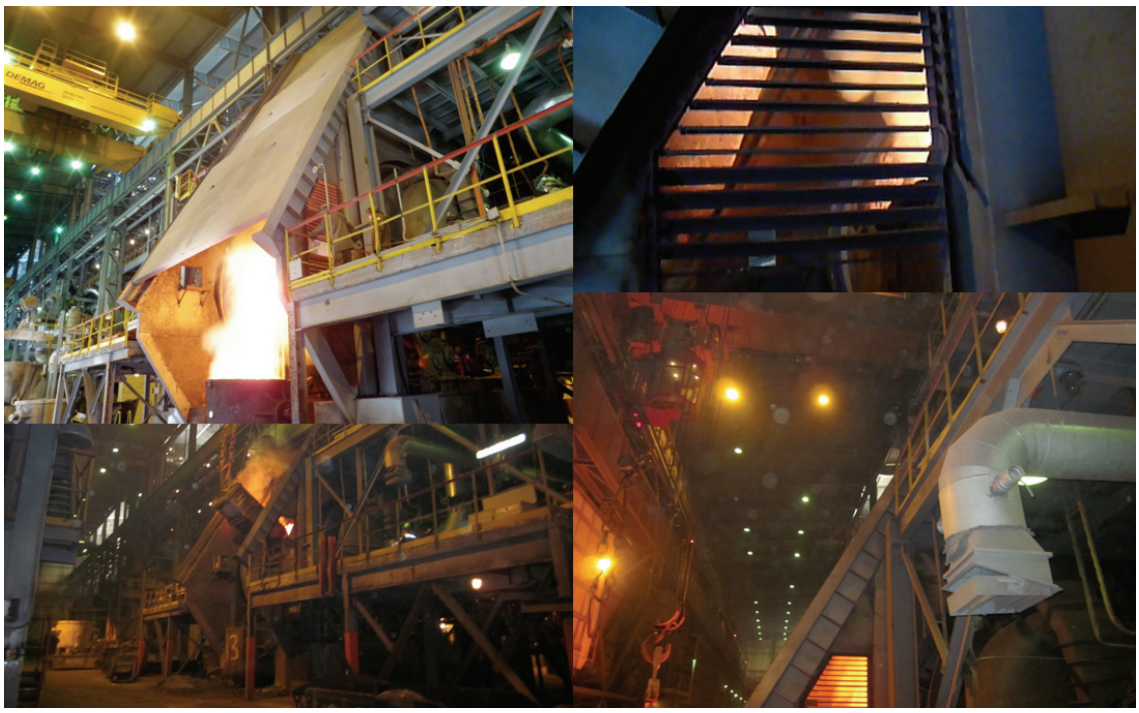

Figure 7. Secondary hood installations

Operational and environmental performance

The information in this section was provided by Boliden Rönnskär smelter (Furberg, personal communiation). The same information has been reported to the Swedish environmental authorities. The total SO_2 emission from Boliden Rönnskär smelter during 2011 was 3 657 t. The main sources of SO_2 emissions are typically distributed as follows:

- Converter aisle – less than 1 000 t/a
- Taphole gases (flash and electric furnace) – about 1 000 t/a
- Zinc fuming plant – about 900 t/a
- Remainder (acid plant tail gas, process gas ventilation etc.) – about 800 t/a.

The emissions from the converter aisle are measured in the secondary gas system. This is possible because the converter building is sealed and the only exit for the gas and dust is through the secondary ventilation system.

The flash furnace tapholes use the same ventilation system as the converter aisle. A large part of the fugitive gas comes from ladle operations and tap gases from the flash furnace (typically 40% of the SO_2 comes from the flash furnace tapholes).

The emission of 1 000 t/a from the converter aisle can be supported with actual data from the ABB PLC system display with online measured production values. During the copper blow the average SO_2 emission is 4.19 t/d (Figure 8) or 175 kg/h from the whole converter aisle and the flash tapholes. Of this amount, 40% originates from the flash furnace tapholes, which means that the SO_2 outlet from the converter aisle is about 105 kg/h or 919 800 kg/a.

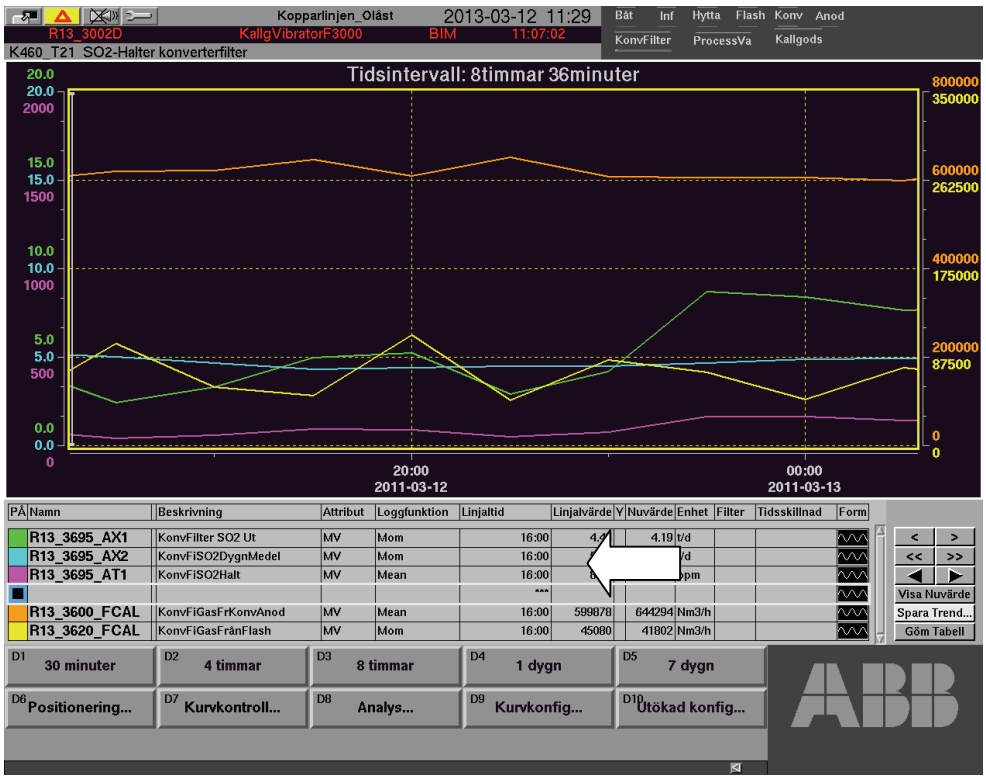

Figure 8. Measurement of gas emissions during a copper blow with 58 000 Nm³/h in blast air

The average SO_2 level in the converter aisle above the converters is 4.9 ppm during the copper blow, as can be seen from Figure 9. Blast air during the copper blow is approximately 58 000 Nm^3/h with 23% oxygen, and the off-gas volume about 115 000 Nm^3/h.

Figure 9. SO_2 measurement in the converter aisle

The total matte production from the smelter (flash plus electric furnace) during 2011 was 338 kt. A typical sulphur content in the matte of 20% gives a total SO_2 content of 135 kt. The SO_2 emission reported above was slightly below 1 kt, which corresponds to an emission of 0.74%.

Conclusion

The results reported support the fact that Outotec's PS converter hood system (primary hood) can capture 99% of the SO_2 gas and dust emissions from the PS concerter, of with high production and long lifetime. Using a secondary hood in conjunction with the primary hood results in an excellent working environment in the converter aisle.

Outotec provides tailor-made converter hoods for all types and sizes of converters.

Acknowledgement

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Boliden. Boliden over the years. http://www.boliden.com/About/History/

Edlund, S. and Lundquist, S. 1979. Copper and nickel converters. *108th AIME Meeting*, Louisiana, USA

Furberg, D. Manager: Converter Operations, Boliden Rönnskär Smelter, Personal communication.

Reference list of Outotec primary PS converter hoods

1. Boliden, Rönnskär smelter in Sweden(installed)
2. Southern Copper, La Caridad smelter, Mexico (installed)
3. Kazzinc, Kazzinc smelter, Kazakstan (installed)
4. NICICO, Sarcheshmeh smelter, Iran (to be installed)
5. Mopani Copper Mines plc, Mufulira smelter, Zambia (two installed and one to be installed in autumn 2013)
6. Custom smelter, Tsumeb smelter, Namibia (to be installed 2014)

The Author

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Process chemistry (Master of Science degree). My degree job was at the Boliden Rönnskär smelter, and during that time I was employed as a metallurgical R&D engineer, with my area of work being the flash furnace, PS converter, and the zinc fuming plant. Subsequently I was responsible for metallurgy and production for the PS converter and anode casting plant. In August 2011 I started working for Outotec in Skellefteå, Sweden. My current position is Technology Manger for Kaldo technology, with responsibility for PS converters, PS converter hoods (primary and secondary), PS converter punching machines, and Kaldo smelting for lead concentrate and copper scrap.