Alba to host Arabal 2019 Conference

The primary aluminium industry in the Gulf region

System optimization for emissions reductions in feeding systems for aluminium electrolysis cells

Gautschi Engineering: Technologically up to the mark with the best market participants

More efficiency in furnace tending operations

New protections against potline freeze

19 to 21 November 2019
in the Kingdom of Bahrain
Reduce emission with Direct Pot Feeding System

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Aluminium Bahrain (Alba) will host the prestigious Arabal 2019 event under the patronage of HRH Prince Khalifa bin Salman Al Khalifa, the Prime Minister of the Kingdom of Bahrain, from 19 to 21 November 2019 at the Gulf Hotel in Bahrain. Held under the theme *Shaping the Future of Aluminium in the Arab Region*, Arabal 2019 is being hosted for the fifth time by the Kingdom of Bahrain.

Arabal, the Arab International Aluminium Conference & Exhibition, which started in 1983, has become an event of international repute, bringing together industry leaders from around the world to discuss current issues in the aluminium industry whilst also exploring investment opportunities. It comprises a conference focusing on the current industry prospects and challenges, as well as an international exhibition coupled with workshops, a site visit and networking platforms.

On this occasion, Alba’s chairman of the board of directors, Shaikh Daij bin Salman bin Daij Al Khalifa, said: “Arabal is reputed as one of the premium platforms for the aluminium industry in the Arab world that brings together the who’s who of the aluminium industry across the globe. Being the first aluminium smelter in the GCC, Alba is privileged to host the 36th edition of the prestigious Arabal under the patronage of the Prime Minster HRH Prince Khalifa bin Salman Al Khalifa. We look forward to welcoming our peers and industry experts to showcase Bahrain’s thriving aluminium sector. We look forward to hosting Arabal 2019 at a time that Alba’s evolution to become the largest aluminium smelter is moving ahead as planned.”

**Alba – largest aluminium smelter in the world**

Starting as a 120,000-tpy smelter in 1971, Alba produced more than a million tonnes of aluminium in 2018. The company’s product portfolio comprises high-grade aluminium and value-added products including standard and T-ingots, extrusion billets, rolling slabs, properzi ingots and molten aluminium. The Potline 6 expansion will boost Alba’s annual production capacity to 1.5 million tonnes and make the company world’s largest aluminium smelter. The Line 6 expansion is one of the biggest brownfield developments in the Middle East Region. With a capex of around USD3 billion, Potline 6 will use EGA’s proprietary DX+ Ultra Technology.

**Exclusive visit to Alba’s Line 6**

Alba offers to Arabal conference delegates a smelter site visit, which will take place in the morning of Tuesday, 19 November. The site visit is free of charge for all conference delegates but the number of participants is limited to 75 only. Pre-registration is mandatory and Alba will need to receive a copy of your valid ID / passport for submission to Alba security. Kindly note that all pre-registrations for Alba smelter visit will close on 5 November 2019.
Arabal 2019 – the conference programme

Shaping the future of aluminium in the Arab region

**PRE-CONFERENCE DAY**
**TUESDAY, 19 NOV.**

10:00 – 13:00 Alba plant visit (Plant visit by special registration only. Limited space.)

16:00 – 18:00 Workshops
Workshop 1: Aluminium premiums – utilizing independent reference prices (assessed by PRAs) and exchange-listed premiums contracts
Workshop 2: Safety in the aluminium industry
19:00 – 21:00 Welcome reception

**DAY 1 – WEDNESDAY, 20 NOV.**

09:00 – 10:00 Registration
10:00 – 11:00 Opening Ceremony
• Opening Speech, Mohamed Al Naki, chairman, Arabal
• Alba Speech, Video to highlight the Prime Minister’s support to Alba
• Award ceremony
• Official exhibition opening and ribbon cutting ceremony

11:00 – 12:00 **SESSION 1: Arab Smelter Panel – impact of current economic challenges on the aluminium industry**
• Arab aluminium smelters’ current position versus the world
• Influencers on the value chain
• View on current LME prices and premiums and other market forces
• Impacts of USA and Europe aluminium taxation

12:00 – 13:00 **SESSION 2: Panel Discussion: Outlook for the global aluminium industry**
• Industry trends, opportunities, challenges and future predictions
• The forces that will impact supply / demand from a global perspective
• Raw materials – bauxite and alumina price outlook
• Taxation challenges – Brexit, USA and global developments

13:00 – 14:00 Networking lunch

14:00 – 15:00 **SESSION 3: Debate: warehousing and price trends – today and tomorrow**
• Warehousing rules and updates
• How indicative are LME prices for current and future performance?
• Is regulation the key to increase LME prices?

15:00 – 16:00 **SESSION 4: Bahrain after Line 6 – growth of downstream and anticipated challenges**
• Impact of Line 6 on the downstream in the economy in terms of employment and customer development
• Trends and developments and the anticipated challenges
• The role of technology and innovation in securing success

16:00 – 17:00 **SESSION 5: Energy efficiency and its impact on energy costs**
• Arab power managers to share the issues (existing and potential) and how to deal with it
• Energy considerations and rising costs of power generation
• The current use and potential of renewable energy

17:00 – 17:15 Closure of Day 1
19:00 Arabal gala dinner hosted by Alba

**DAY 2 – THURSDAY, 21 NOV.**

08:30 – 09:00 Morning coffee

09:00 – 09:45 **SESSION 6: Investing in upstream: opportunities and risks**
• Bauxite availability and cost and its effect on the bottom line
• Insights on the changing landscape for raw materials in light of the recent developments in the alumina supply chain
• Required steps to secure reliable upstream channels in the Arab region as a hub for aluminium production

09:45 – 10:30 **SESSION 7: The use of aluminium for innovative products and advanced applications**
• Aluminium as a substitute for other materials and vice versa
• Automotive – EU reduced emissions – laws and regulations and the need for lighter vehicles
• Aluminium alloys in aerospace and its role in producing next generation aircraft

10:30 – 11:00 Coffee break
11:00 – 11:45 **SESSION 8: Panel discussion: environment, sustainability and recycling**
• Linking the current capabilities of the aluminium industry to sustainability targets
• Maintaining compliance to environmental requirements and legislation
• The role of R&D and advanced technologies in maintaining the bottom line and reducing waste, cost and overheads
• The future of the circular economy – innovations in recycling

11:45 – 12:30 **SESSION 9: Safety as a driver for growth and success**
• The best practices / approaches to incorporate industrial health and safety as an instrument for success
• Protecting individuals and tapping into the discretionary energy from teams towards securing more growth and success

12:30 – 13:00 Closure of conference, summary and thanks
13:00 – 14:00 Lunch

15:30 Alba plant visit (Plant visit by special registration only. Limited space.)
The primary aluminium industry in the Gulf region

Rudolf P. Pawlek, Sierre

The primary aluminium producers in the Gulf Cooperation Council (GCC) states collectively produced more than 5.4m tonnes of primary aluminium in 2018 for the local and international markets. This was an increase of around 230,000 tonnes over the previous year as a result of improved efficiency and completion of modernization projects, with Alba surpassing 1m tonnes production for the first time. The primary and downstream aluminium producers in the GCC continued their drive to maintain a leadership position on all aspects related to the environmental protection. GCC is also considered to be one of the leading and most dynamic regions for aluminium production in the world, contributing around 10% of the world aluminium demand, and exporting 60% of its production to more than 65 countries around the world.

The US Section 232 tariffs on aluminium imports reportedly are having little effect on GCC Arab member state producers’ ability to sell to the United States. Representatives for the major producers in the GCC area said that their businesses are not feeling any ill effects from shipping prime aluminium to the US, even though none of the countries are among those exempt from the 10% Section 232 import tariff.

The GCC aluminium executives are sceptical of the US industry’s ability to take advantage of the tariffs. High electricity costs have long been an issue for US smelters trying to stay afloat, and US industrial power rates have been rising for the past few years. Aluminium smelters’ intense 24/7 power usage means high power costs are crippling their bid to be competitive, especially when smelters in the GCC enjoy far cheaper rates.

UNITED ARAB EMIRATES Operations

Emirates Global Aluminium (EGA) reported record primary aluminium production of 2.66m tonnes in 2018, by operating its smelters above the rated capacity. This could drag on growth prospects in the region during the coming years. EGA’s technology development has focused both on the reduction cells themselves and on the software to manage their performance, and so has reduced its total GHG emissions produced per tonne of aluminium by 10% since 2001.

Among over 350 customers in total in more than 60 countries in Asia, the Middle East and North Africa region, Europe and the Americas, about 10% EGA’s production is supplied to customers in the UAE, serving the growing needs of the UAE’s downstream fabrication sector. This included sales of hot liquid metal to customers located near EGA’s Al Taweelah smelter in Abu Dhabi.

In October 2018, EGA completed a major project to retrofit its older production lines at Jebel Ali with EGA technology. The new reduction cells can each produce 20% more aluminium than those they replaced, with 10% less specific energy consumption to make each tonne of metal.

EGA continues to invest in developing its smelter technology and is at the forefront of innovation in the industry. It has demonstrated how growing use of technologies such as robotics, machine learning and advanced analytics can support continuous improvements in operating performance.

The Jebel Ali smelter complex produces extrusion billets in two casthouses. Casthouse I currently has two continuous homogenizing furnaces and five batch furnaces. A total of five ultrasonic testing stations are installed for inspection, two of them for helical testing. The equipment is supplemented by four sawing plants as well as the necessary equipment for handling (stacking, charging, transporting...), and two further batch furnaces will be installed as part of the order placed now, one as a replacement.

In Casthouse II, two continuous homogenizing furnaces and a Hertwich batch furnace are available for homogenizing. Four ultrasonic testing stations (one of them for helical testing) are used for inspection; in addition, there are five sawing plants as well as a charging machine and handling system for the batch furnaces. As part of the current order, an additional batch furnace will be installed in this casthouse. Furthermore, two existing cooling stations from other suppliers will be replaced by Hertwich stations for metallurgical reasons.

The Jebel Ali paste plant manufactures the material for the anodes which are used in the aluminium smelting process. The paste plant team has worked more than 2m hours over the past 22 years, producing over 7.8 million anodes. During the same period they have completed 84 different major refurbishments, projects and improvements on-site, boosting efficiency and bolstering production from 168,000 tonnes of paste in 1996 to more than 505,000 tonnes in 2017.

EGA, Mubadala and Dubai Holding signed an agreement to develop a state-of-the-art power block and a water desalination plant at EGA’s smelter at Jebel Ali in Dubai. The new facilities will improve the efficiency of power for EGA’s aluminium smelting, reducing environmental emissions and natural gas consumption. Mubadala and Dubai Holding are to establish a joint venture to develop the new facilities. EGA intends to buy the facility’s output for 25 years following commis...
sioning. The joint venture will install a combined cycle power facility at EGA’s Jebel Ali site to generate over 600 MW of electricity.

The shareholders of the joint venture have signed an agreement with Siemens to install the UAE’s first combined cycle H-class gas turbine, an advanced technology in efficient power generation. Once the project is complete, five older, smaller and less efficient turbines at EGA Jebel Ali will be put on standby for use only in emergencies. The new, more efficient power facility will reduce GHG emissions from EGA’s power generation at Jebel Ali by some 10%. Emission reductions per tonne of aluminium produced at Jebel Ali, which includes both power generation and aluminium smelting, are expected to be up to 7%. EGA’s total CO₂ equivalent emissions, from all its operations in the UAE, were 8.1 tonnes per tonne of aluminium produced in 2017, and they are currently below 8 t/tAl produced. The estimated average GHG emissions per tonne of aluminium produced globally is 12.7 tonnes CO₂ equivalent.

In addition, EGA’s NOx emissions at Jebel Ali are expected to reduce by 58%. NOx is amongst a group of emissions targeted for reductions under ‘UAE Vision 2021’ to improve local air quality. EGA requires much electricity for aluminium smelting and other industrial operations, and its captive power plants at its sites in Jebel Ali and Al Taweelah have a current combined generating capacity of 5,450 MW. This makes EGA the largest power producer in the UAE, after Dewa and Adwea. EGA’s power fleet is already amongst the most efficient fleets in the Middle East.

Bauxite

In August EGA announced the first exports of bauxite ore from Guinea Alumina Corp. (GAC), its mining project in the Republic of Guinea in West Africa. This marks the completion of EGA’s strategic expansion upstream in the aluminium value chain to create an integrated global aluminium giant. The GAC project together with Al Taweelah alumina refinery, where EGA began production in April, create new revenue streams for the group and secure at competitive prices the raw materials that the UAE’s aluminium industry needs.

The GAC project has been one of the largest greenfield investments in Guinea in 40 years, and cost some USD1.4bn to develop. The GAC project is expected to make a direct, indirect and induced economic impact of some USD700m per year in Guinea once production is fully ramped-up, a 5.5% boost to the national GDP.

GAC’s operations include a mine, railway infrastructure (some shared with other operations), and port facilities. Bauxite ore is transported from GAC’s jetty at the port of Kamsar by self-propelled barge to a transhipment point operated by EGA in deeper water. This enables EGA to export bauxite ore from GAC using bulk cargo vessels that are amongst the world’s largest, including Capesize and Newcastlemax ships.

GAC is expected to produce 12m tpy of bauxite ore at full design capacity. The raw material from GAC is sold by EGA to customers around the world. EGA is importing bauxite ore for processing at the Al Taweelah refinery from Compagnie des Bauxites de Guinée under a long-term agreement, also using transshipment and Capesize vessels.

In March EGA announced it will intensify research partnership with the European research and technology organization, Vito NV. The partnership aims to find uses for bauxite residue by the UAE construction industry by further developing two of the potential applications identified in the first phase of the project. Since 2017 EGA and Vito have been working together on research into the large-scale use of bauxite residue in construction materials.

Once fully ramped up, the Al Taweelah alumina refinery will produce some 2m tpy

EGA commissioned its Al Taweelah alumina refinery in the Khalifa Industrial Zone Abu Dhabi on 10 April. The refinery is expected to produce more than a million tonnes of alumina by the end of 2019. Once fully ramped up, the refinery will produce some 2m tpy, enough to meet 40% of EGA’s alumina needs.

The UAE previously imported all the alumina it needs. Bauxite for the refinery will be imported from Compagnie des Bauxites de Guinée. Construction of the USD 3.3bn project took 72m hours of work – the equivalent of one person working for more than 25,000 years. More than 20 major contracting companies worked on the project and 80% of the contracts by value were awarded to UAE-registered companies.

Inventions and Innovations

EGA has focused on technology innovation for over 25 years to improve the energy efficiency of the aluminium smelting process, saving costs and emissions. The company’s technology development, and earlier work since 1980, has reduced the amount of electricity required to produce a tonne of aluminium by 37.5%.

EGA also saves around USD1.1m each year in energy costs by implementing energy conservation ideas from shop floor staff ideas to reduce energy use.

The company has operated an employee suggestion scheme since 1981. In 2017, EGA staff submitted a record 34,419 ideas, generating USD9.8m in cost savings. EGA employees share in the financial benefits of their ideas that are implemented. This is the most savings ever generated through the suggestion scheme in a single year.
Environment and waste management

Emissions of perfluorocarbons (PFCs) from EGA were a record low in 2017, and the company signed an agreement with the University of New South Wales to research further reductions. PFCs are greenhouse gases which cause thousands of times more global warming than the same quantity of carbon dioxide. Reducing PFC emissions is an important environmental goal of the global aluminium industry.

EGA’s emissions of PFCs were 22 g/t Al produced in 2017 compared to a global average of 380 g/t Al in 2016, the most recent year for which figures are available from the IAI. At EGA’s newer Al Taweelah smelter, PFC emissions in 2017 were 7 g/t Al.

Through technology development and operational improvements, EGA has reduced the frequency of anode effects in its operations from an average of one every three days in each reduction cell in 2009 to less than one every 12 days in each reduction cell in 2017. The average duration of each anode effect has similarly decreased, from 44 seconds in 2009 to below 21 seconds in 2017.

The new research aims to reduce what the industry terms ‘background’ PFC emissions – those that are from variations in reduction cell conditions that are too small to be detected and remedied by the control technology available today.

Since 2010, the company has invested almost USD1bn in environmental technologies and facilities to reduce and manage emissions and waste.

EGA signed an agreement with Gulf Cement Company to supply spent pot lining (SPL), which is a by-product from aluminium smelting, over the next three years for use in cement manufacturing. Although EGA has been supplying SPL to the cement industry since 2010, the agreement is the first directly between EGA and a cement company, rather than via specialist third party pre-processors.

EGA is building facilities at its Al Taweelah site to process SPL into a form ready to be used by cement companies as an alternative fuel and raw material. SPL is the used inner lining of aluminium smelting pots, which is worn out and replaced every four to five years. It contains both carbon, which is an alternative fuel, and refractory materials that survive the firing process and become part of the finished cement. In 2017, EGA supplied more SPL to the UAE’s cement industry than it produced. EGA has been supplying Gulf Cement Co. with SPL via third parties for testing since 2010. Under the new agreement, EGA delivered 2,000 tonnes of SPL to Gulf Cement Company in 2018. In 2019, the volumes will increase to 10,000 tonnes, followed by 15,000 tonnes in 2020. EGA also signed an agreement with Arkan, a building materials company, to supply Arkan with SPL.

In February EGA announced that it is to supply almost all of its production of carbon dust, a by-product of aluminium smelting, for use as an alternative fuel by the UAE cement industry. Carbon dust is generated during the process of producing anodes, large carbon blocks that are consumed during aluminium smelting. High carbon content makes carbon dust suitable for use as an alternative fuel. Over the next two years, EGA will increase its supply of carbon dust to the UAE cement industry to some 78,000 tonnes. The use of EGA’s carbon dust will reduce UAE cement companies’ requirements for other fuels, including in some cases coal imported from as far as South Africa. Reducing mining and long-distance transport of coal is expected to save some 36,000 tonnes of CO₂ emissions over the next two years, the equivalent of removing 7,800 cars from the roads. EGA will supply the cement industry with freshly produced carbon dust together with dust stockpiled in earlier years while the company was working to find a viable, large-scale industrial use. Freshly produced carbon dust will be supplied directly to the cement industry. For stockpiled carbon dust, EGA has signed a contract with Heavy Machinery Viqa for processing and re-use. Heavy Machinery Viqa specializes in recovering and recycling by-products from heavy industries in the UAE. In 2018 EGA recycled over 102,000 tonnes of waste, up from 96,000 tonnes in 2017.

BAHRAIN

Operations

Aluminium Bahrain (Alba) achieved a record production of 1,011,101 tonnes in 2018, up 3% on the previous year. This is the seventh year in a row that the company has increased its annual production.

Alba launched the Titan Phase IV cost saving project with the objective to reduce cash costs of USD100m by the end of 2020. Through the Phase I to III, five-year Titan programme, Alba achieved cost savings of USD281m.

Technology partner Fives was awarded a contract to supply the Continuous Emission Monitoring System (CEMS) of Potlines 4 and 5. The CEMS will monitor the emissions (hydrogen fluoride and dusts) inside the pot room and at GTC inlet / outlet. The scope of supply includes general engineering, equipment delivery as well as installation and commissioning of the system.

Alba commissioned the batch homogeniza-
pects in its products as well as improved productivity of billets.

Alba secured a long-term agreement with Fluorsid SpA for the supply of smelter grade aluminium fluoride (AlF₃). The agreement comes as part of the Line 6 expansion. A large producer of aluminium fluoride and synthetic cryolite, Fluorsid meets the bulk of Alba’s yearly AlF₃ requirements for its annual metal production.

In line with the relationship between Alba and Fluorsid, Simplis Logistics’ dedicated warehouse and logistics operations have been set up in the Bahrain Logistic Zone to ensure a proximate, reliable and uninterrupted supply of raw materials to Alba, as well as to other aluminium smelters in the Gulf region.

**Potline 6 expansion project**

Alba officially commissioned its Line 6 with the first pot energization on 13 December 2018. This achievement not only marks the beginning of a new era for the company but also a new record as the First Hot Metal from Line 6 was produced ahead of its scheduled date on 1 January 2019 – making it the fastest construction ever delivered in the aluminium industry. First Hot Metal from Line 6 took place six months earlier than the industry standard, says EPCM contractor Bechtel. This milestone precedes the gradual ramp-up of 424 pots in Line 6 which on completion will make Alba the largest smelter in the world. Full ramp-up is scheduled for the third quarter of 2019. At year-end Alba’s total production will top 1.350m tonnes.

Alba started the biggest furnace in its history with the First Cold Charge of Furnace 3 in its new Casthouse 4 on 26 December 2018. Part of the Line 6 expansion, Casthouse 4 has a total design capacity of 530,000 tpy.

For the Potline 6 Anode Baking Furnace (ABF), Riedhammer GmbH finished the refractory lining of the ABF 5 on time. From the project start to the end of the lining works, about 28,000 tonnes of refractory material were installed and over 640,000 man-hours, with a peak of 485 people on site, have been spent without a single LTI. Another milestone was the start of the first fire for the dry out of the furnace; that was scheduled for November 2018. Anode production start was announced by Riedhammer for January 2019.

REEL Alesa announced the successful start-up of the first pots of its latest HDPS (High Dense Phase System) pot feeding system at Alba Line 6 smelters.

In December 2018 Fives announced that the team produced the first anode at the Alba Potline 6 green anode plant. Teams are already engaged to reach the contractual milestone of 5,000 good green anodes.

**OMAN**

Sohar Aluminium was formed in September 2004 to undertake a landmark greenfield aluminium smelter project in the Sultanate of Oman. It is jointly owned by Oman Oil Company, Abu Dhabi National Energy Company PJSC – TAQA, and Rio Tinto. In 2018 Sohar Aluminium produced around 390,000 tonnes of primary aluminium.

In August 2018 Sohar Aluminium partnered with Synergies Castings, a leading manufacturer of aluminium alloy wheels in India. Synergies Castings is building a USD100m alloy wheel manufacturing plant situated in the Sohar Industrial Estate adjacent to Sohar Aluminium premises. Production is expected to start in 2020. At full capacity, Sohar Aluminium will supply more than 24,000 tpy of aluminium to Synergies’ wheel plant. The wheels will be supplied directly to car manufacturers around the world. Once fully operational, the plant will produce around 2.5m wheels annually with an estimated 500 direct jobs created.

In December 2018 the company appointed Agnello Borim as chief operating officer. In his new role, he heads the Reduction Operations, Services and Maintenance, Technical Department, Anode Plant, Casthouse, Port and Lab Areas.

**QATAR**

Qatar Aluminium (Qatalum) produced some 645,000 tonnes of primary aluminium in 2018. The smelter uses the HAL275 system, an environmentally friendly, energy-efficient technology.

**SAUDI ARABIA**

Ma’aden, the Saudi Arabian Mining Company, established a joint venture with Alcoa in 2009 to build the world’s most efficiently integrated aluminium project in Saudi Arabia. This USD10.8bn industrial complex includes a bauxite mine, an alumina refinery, a smelter and a rolling mill.

Ma’aden produced 760,000 tonnes of primary aluminium in 2018, which corresponds to the production in 2017. The company’s 2017 annual report says that the rolling mill is to go into commercial production in 2018.

The rolling mill produced 153,000 tonnes of flat rolled products in 2017, well below its production capacity of 430,000 tpy.

In June Alcoa Corp. announced that the company is to divest its minority interest in Ma’aden’s rolling mill. Alcoa will transfer its 25.1% stake to Ma’aden and make a contribution to MRC in the amount of USD100m. The parties will maintain their commercial relationship, which includes Alcoa providing sales, logistics and customer technical services support for MRC products for the North American market sheet market. The company will retain its 25.1% minority interest in MBAC and MAC, and Ma’aden will continue to own a 74.9% interest.

**Final remarks**

Alba’s huge Potline 6 expansion will increase the smelter’s capacity from 1m tpy in 2018 to 1.350m tonnes at the end of this year. With cheap fossil energy, all the Middle East smelters are confident in their continued growth. They are investing greatly in efficiency, process development, working practice and maintenance. They also stress safety, reducing emissions and environmental pollution, promoting ideas from all employees and building strong maintenance services which are independent of OEM suppliers. All of these investment areas are logically related to regulations and to financial results. Besides this, several companies report action beyond their own industry interests to promote recycling and environmental awareness.

Some of these companies also emphasize their activities and large investment in social areas, which do not directly help the bottom line. They are supporting a wide spectrum of education and training, at least for their regional citizens – also for women. They encourage voluntary social work done by employees in their own time. In these Middle East countries generally seen as very conservative, these are remarkably progressive policies, fully comparable with those of global Western companies.

**Author**

Dipl.-Ing. R. P. Pawlik has been a contributing editor of the International ALUMINIUM Journal for many years. He is founder of TS-C, Technical Info Services and Consulting, Sierre (Switzerland), a service for the primary aluminium industry. He is also the publisher of the standard work Primary Aluminium Smelters and Producers of the World. This reference work is continually updated and contains useful technical and economic information about all primary aluminium smelters of the world. It is available as loose-leaf files and/or CD-ROM from Beuth-Verlag GmbH in Berlin.
Successful system optimization for emissions reductions in feeding systems for aluminium electrolysis cells

Dirk Hauschildt, FLSmidth Hamburg

To optimize the gas treatment centre (GTC) of Potline 8 at the Jebel Ali smelter in Dubai, UAE, in mid-2017, FLSmidth Hamburg (FLS) was commissioned by Emirates Global Aluminium (EGA) to substantially lower the dust concentration at the entrance to the GTC. The 24 vent domes of the two pneumatic conveyor systems for the transport of secondary alumina to the 44 aluminium electrolysis cells (pots) were identified as the principal source of emissions. The following report describes the requisite studies of the system as well as in the test centre and delineates the measures undertaken to reduce emissions.

System description and function of direct pot feeding for Potline 8

The structure and function of the pot feeding system will be discussed in brief here. Further information is found under [1].

Potline 8 at the Jebel Ali smelter consists of two pot rooms. In each pot room, 22 electrolysis cells of type DX are arranged in a row (Fig. 1). The total length of a pot room is about 140 metres. In 2008, two identical pot feeding systems were installed to supply 22 cells each with a maximum alumina consumption of 9 t/h. Each of the two systems is structured as follows (Fig. 2). The secondary alumina from the gas treatment centre is stored in a shared 275-tonne day silo (Fig. 3).

The bulk material discharge from the silo goes through an fluidization bottom and proceeds via a Fluidflow discharge air slide to a main bin along the pot room wall, which serves as a lock bin.

On the floor of the main bin, two Fluidflow distribution air slides are connected; these run parallel to the pot room outer wall, in an opposite direction, and supply all cells with alumina. The longest distribution air slide supplies 14 cells over a distance of 85 metres and is installed completely horizontally due to the limited construction height. The air supply for fluidization of the alumina in the discharge and distribution air slides is provided by a rotary piston blower.

To avoid flow disturbances in the distribution air slides, fluidization air is vented into the gas duct via vent domes at regular intervals. The vent domes are wear- and maintenance-free gravity separators with the task of separating swept up alumina in the vent air in order to minimize dust emissions to the gas duct and ensure uniform bulk material quality along the conveying line.

The distribution air slides along the pot room have regularly spaced outlets with downpipes to supply two electrolysis cells each. The distribution of the alumina on the individual electrolysis cells proceeds via horizontally arranged Fluidflow pot air slides (Fig. 4).

Every pot air slide is approx. 16 metres long and distributes the alumina through filling spouts into five pot bunkers with a volume of approx. 1 m³ each.

The amount of air required for fluidization of the alumina is also provided by a rotary piston blower. As the amount of air for fluidization is extremely small, the venting air can escape via the filling spouts into the pot bunker; from there it goes through a connection to the gas duct.

Through the self-regulating filling spouts in the pot bunkers, the bunkers are always filled to the maximum. If alumina is taken...
out of the pot bunkers for electrolysis, the fill level in the bunkers sinks and the opening of the filling spouts is opened to enable automatic re-filling of the alumina until the filling spouts are automatically closed by the alumina.

**Function of the gas treatment centre**

In the electrolysis cells, secondary alumina is generally converted into primary aluminium. The exhaust gases generated by this are conveyed to large gas treatment centres via gas ducts. The gas treatment centres are principally bag filter systems in which primary alumina serves as an adsorbent and is thereby converted into secondary alumina.

Usually, venting air from other emissions sources is also sent to the gas treatment centres. In addition to large quantities of pot exhaust gases, smaller venting air quantities for dedusting of conveyor and silo systems also get into the gas ducts.

**Elevated dust concentrations in the exhaust gas to the gas treatment centre**

Over recent years, high dust concentration values of up to 2,800 mg dust per m³ exhaust gas have been observed at the entrance to the gas treatment centre. Average values reached 1,280 mg dust per m³ exhaust gas. Due to the very small dust particle size, this led to an increase in the fine particle share of the secondary alumina from the GTC and thus to a compromising of the smelting process in the electrolysis cells. Furthermore, the deposits of dust in the gas ducts are also problematic.

Through dust concentration measurements in various operating modes, it was determined that the pot feeding systems were responsible for a large amount of the emissions in the gas duct. It was demonstrated that an average of approx. 850 mg dust per m³ exhaust gas (66%) was emitted by the two pot feeding systems.

Examinations of the fill level in the vent domes of the Fluidflow distribution air slides and the main bins showed excessive levels, which meant that the separation rate in the vent domes was too low and that a substantial amount of alumina dust was escaping into the gas duct with the venting air.

The reasons for the excessive fill level in the vent domes were:

- The design of the vent domes
- Non-uniform distribution of the fluidization air for and distribution air slides
- Elevated fluidization air quantity for and distribution air slides
- Segregation phenomena of fine and coarse particles due to uniform constant operation of the conveyor systems.

**Solution approaches and system reconfiguration**

1. Optimization of vent domes

It was notable that the design of the existing vent domes (Fig. 5) had to be modified to markedly improve the separation rate.

In addition to the high dust concentration conveyed to the GTC, the alumina quality along the conveyance path was changed such that at the beginning of the Fluidflow distribution air slide, the quality of the alumina was equivalent to that from the day silo, while the fine particulate amount at the end of the conveying distance was significantly reduced [2].

Through investigations on full-scale test systems at FLSmidth’s technical centre in Hamburg, the separation rate for various vent dome geometries and operating modes could be determined (Fig. 7).

2. Optimization of air distribution

To transport the alumina in the Fluidflow air slide from the silo to the main bin as well as in the Fluidflow distribution air slides along the pot room, it is necessary to reduce the viscosity of the alumina. To achieve this, the alumina is fluidized with compressed air. To prevent flow disturbances in the Fluidflow air slide, the fluidization air must be distributed evenly along the entire conveying distance of 170 metres. To achieve this, throttle devices were installed at regular intervals in the fluidization air line. Due to the low pressure level at the end of the Fluidflow distribution air slide, the throttle devices in this area have to be more strongly throttled than at the beginning in the vicinity of the main bin.

Measurements on the system showed that too much air was getting into the discharge air slide and the area at the end of the distribution air slides. Due to the non-uniform air distribution, the flowability of the alumina was reduced in some parts of the air slides. To compensate for this, more fluidization air than necessary had to be used. The uneven air distribution and increased fluidization air quantity led to a higher fill level in the vent domes.

With the aid of FLSmidth-developed design software for this system type, the requisite opening diameters of the throttle devices along the conveying distance could be recalculated and modified. In addition to the more uniform air distribution, this also enabled a reduction of the required total air quantity. This led to lower fill levels in the vent domes.
matic conveying systems.

**Conclusion and outlook**

FLSmidth Hamburg successfully managed to reduce significantly the dust emissions of the existing pot feeding systems while exceeding the expectations of the system operator EGA.

In the future, the quality of the secondary alumina will no longer be impacted by the pot feeding systems and will thereby support the aim of uniform quality in the smelting process.

Through the installation of various direct pot feeding systems, FLSmith Hamburg has a strong body of references. With the aid of the design software, direct pot feeding systems can be planned for a variety of different conveying capacities and conveying routes and calculate all relevant system parameters. Emissions threshold values and degrees of segregation can be calculated based on technical centre tests and can be guaranteed.

**Results**

After implementation of the aforementioned measures, performance tests were issued by the system operator. Dust concentration measurements from the entrance of the gas treatment centre showed values of 640 to 880 mg dust per m³ exhaust gas. The share emitted via the pot feeding systems then only amounted to 64 mg dust per m³ exhaust gas, which corresponds to an average share of 7 to 10%.

A comparison of the proportional emission values from the pot feeding systems before (850 mg dust per m³ exhaust gas) and after (64 mg dust per m³ exhaust gas) the modification shows an emissions reduction of over 90%.

Overall, only roughly 11 g dust per m³ vent air is still emitted by the pot feeding systems. This is a comparatively low value for the vent air dust concentration of pneumatic conveying systems.

**Literature**

DESIGNING SMART PLANTS
BY ASSOCIATING
NEW TECHNOLOGIES
WITH FIVES’ EXPERTISE

DIGITAL TECHNOLOGIES ARE THE DRIVING FORCE BEHIND PERFORMANCE AND FLEXIBILITY. By combining analysis and advanced control based on consistent data with knowledge and expertise on equipment and processes, Fives improves both global overall operational efficiency and working conditions in the smelters.

Fives offers comprehensive digital solutions such as AMELIOS Suite for a full Carbon Digital Chain, SMARTCranes for optimal crane maintenance, Skill2Perf for customized crane driving and Solios SMART GTC for enhancing the smelter environmental performance.

For more than two centuries, Fives has been adapting to changes which mark the industrial revolutions, including the Digitalization era.
As a technology and innovation-driven company, Sohar Aluminium is harnessing the transformational potential of the 4th Industrial Revolution (a.k.a. Industry 4.0) in its quest to position itself as the ‘Smelter of the Future’.

In its 10-year history as one of the youngest greenfield aluminium smelter in the Middle East, Sohar Aluminium excels in technological operational excellence. From the use of leading-edge smelting technology with progressive increase in amperage to the use of efficiency and safety optimization tools, technological innovation has been the cornerstone of Sohar Aluminium’s ambition to become a benchmark smelter in the region.

Today, Sohar Aluminium is on the cusp of yet another exciting leap into the future, this time supported by technologies that form part of the 4th Industrial Revolution. From mobile connectivity, artificial intelligence and big data to robotics, Internet of Things (IoT) and machine learning, Industry 4.0 has the potential to accelerate the digital transformation underway at Sohar Aluminium.

“Sohar Aluminium has embraced some elements of Industry 4.0 ever since we came on stream, and we continue to evaluate new technologies and innovations as they materialize. This is a continuous journey of improvement which we don’t foresee an end to,” says IT manager Abdullah Al Maamari.

Automation, a key facet of Industry 4.0, has long been the hallmark of Sohar Aluminium’s investment in a modern smelter. Advanced automation technologies are a defining characteristic of the company’s operations. Similarly, robotics is an integral part of the company’s casthouse operations, eliminating human interaction with unsafe material handling as far as possible, thereby reducing the risk of injury to operators. Robotic cranes assist in the stacking of the refined metal bundles and applying labels to them.

A potential game-changer for Sohar Aluminium is the Internet of Things (IoT) – an system of connected machines, equipment, devices and physical objects that can communicate with each other.

“In our case, we use the industrial IoT, which connects all of our systems with the enterprise,” says Ibrahim Al Maawali, Automation superintendent. “Thus, all of the data from the shop floor, production units, and so on, is captured on our dashboards in real time. Right now, we are evaluating various IoT solutions that add value to our business.”

Equally promising is the deployment of machine learning (ML) and artificial intelligence (AI) solutions to improve process control at Sohar Aluminium. With a combination of ML and AI, the IT and Automation team sees the potential to automatically record, network and use numerous machine and system parameters that can be harnessed to plan downtimes, increase productivity and drive quality.

Some ML elements are already part of Sohar Aluminium’s processes. “Machine Learning has been around for quite a time, under the guise of intelligent systems. It’s only now been rebranded as machine learning. Still, we are looking into the use of ML in some of our processes to better formulate our set-points,” explains Automation specialist Paul Ridgway.

Data analytics proves useful in maintenance and operational processes at Sohar Aluminium. “We use our historical data to forecast equipment failures and process deviations. This improves our uptime and allows us to do more proactive maintenance rather than reactive and it also enables us to achieve a high level of operational production,” says Ibrahim Al Maawali.

Industry 4.0 promises to unleash a wide range of benefits for Sohar Aluminium, says Paul Ridgway. “Sohar Aluminium believes that Industry 4.0 helps in improving productivity, efficiency, safety, resource utilization, increasing machines uptime and reducing breakdowns by using smart sensors and such technologies. Also, it enables self-diagnosis, reducing turnover time, preventing breakdowns, reducing the human intervention which will reduce human errors.”

Abdullah, Ibrahim and Paul are part of a core team of IT and Automation experts at Sohar Aluminium – ‘Smelter of the Future’.
Sohar Aluminium with the mission to implement Industry 4.0 within the company. “We are a young, dynamic group of professionals with the requisite skill set to unlock the potential of the 4th Industrial Revolution for the benefit of our operations. Our management, recognizing the immense potential of Industry 4.0, is eager for the comprehensive roll-out of these solutions across all facets of our operations and indeed the wider value chain.”

The adoption of Industry 4.0 tools picked up speed last year with members of the Core IT Team evaluating the applicability of these technologies and their use in key departments within the organization. At the same time, the IT team began to engage with vendors of 4.0 technologies and solutions with a view to ascertain their efficacy within Sohar Aluminium. Furthermore, as talented professionals in their own right, members of the IT and Automation team have come up with their own in-house solutions as cost-effective alternatives to vendor-promoted offerings.

As for a timeline to have Industry 4.0 technologies up and running within the company, there is none! Abdullah explained: “Technologies, by their very nature, keep evolving. Before Industry 4.0, there were three different waves that also evolved over decades. Our responsibility is to look at technologies and trends, as and when they come on the market. That will help us enhance our productivity, cost-efficiency and competitiveness. Industry 4.0 is just another leg on this continuous journey in our quest for business and operational excellence. Besides, as some of these technologies represent expensive investments, we need to suitably evaluate them to ensure there are returns for the company.”

Since the roll-out of Industry 4.0 is no small feat, Sohar Aluminium has embarked on a plant-wide awareness programme in order to ensure that the company’s sizable technical staff are fully on board in the delivery of this ambitious project. At the same time, the company is also engaging with key stakeholders and local communities on the importance of this initiative in ensuring the safe, successful and sustainable operation of Sohar Aluminium well into the future.
EGA: innovative equipment for safe operation of potrooms

M. Reverdy, A.B. Rahal, M. Abdulmalik and J. Pradhan; EGA

Over the last years, Emirates Global Aluminium has developed new items of equipment to improve safety in the operation of potrooms. They include the smart mobile earthing trolley (SET), the hydraulic wedge puller, emergency bypass busbars for all EGA cell technologies, and a crane for the maintenance of potroom tending machine (PTM) rails.

Smart Mobile Earthing Trolley (SET) [1]

Modern aluminium smelters are operated at high DC currents and potline voltages up to 2,000 V. These potlines are usually earthed at mid-point so as to limit the potential of all the pots, with respect to earth, to a maximum of half of the total potline voltage. Even though the potroom aisles and the basement are designed to be at floating or earth-free potential, some activities, such as pot shell replacement and basement cleaning, require moving the earthed point to the worksite to ensure an additional safeguard for the personnel. This is usually done with a Mobile Earthing Trolley (MET) which connects a specific pot busbar to a nearby earthing post on the potline earthing circuit.

EGA has developed an advanced Smart Mobile Earthing Trolley, using a Programmable Logic Controller (PLC), a standard high-speed DC circuit breaker, and a high speed fuse, as well as other standard electrical and electronic components. All these features increase its reliability and safety for potline workers [1]. SET with some features is shown in Fig. 1.

SET has various protections to alert the potroom basement working crew in case of excess current leakages or of sudden high voltage at the earthing point, so that they can quickly stop their activity and leave the area. Through a wireless connexion, SET activates a visual and audio alarm unit which can be up to 60 m away. SET continuously monitors current flow through the ground connection using a high accuracy and fast response bi-directional current transducer which is connected to the PLC analogue input. SET also monitors pot voltage to ground through a high voltage transducer which is connected to the PLC analogue input. Thus the current and voltage signals are both processed in the PLC for continuous monitoring and protection, and these values are displayed on the HMI, as well as on potline Scada, through a wireless communication network installed across the potroom basement. These values are recorded in the form of historical trend for further analysis. Continuous operation of the SET during power shutdown and loss of main power is assured by a built-in UPS,

![SET front view with low and high voltage panels (left); and a view inside the high voltage panel (right) [1]](image1)

![Wedge positions for cutting out a DX+ cell (one half of the cell is shown). A total of ten wedges are used per cell [2]](image2)

Fig. 1: SET front view with low and high voltage panels (left); and a view inside the high voltage panel (right) [1]

Fig. 2: Wedge positions for cutting out a DX+ cell (one half of the cell is shown). A total of ten wedges are used per cell [2]
which gives more than three hours autonomy to SET.

Another significant feature includes SMS notification. Any alarm / fault will be sent as SMS notification to the programmed mobile phones of SET end users. This safety feature plays a very important role to help end users to take immediate and appropriate action as and when any alarm / fault appears on SET while they are working in the basement. SET has been tested in the potline, and it is now available for technology transfer.

Hydraulic wedge puller device ‘Quick Start’ [2]

When aluminium electrolysis cells suffer serious deterioration from old age, they need to be stopped for relining of the cathodes. The

Fig. 3: Wedge extraction system. Left: wedge extractor (A-frame). Right: wedge puller hydraulic unit (front view) and wedge extractor installed for action. On the reels are the hoses that connect the two units and supply hydraulic oil to the extraction jacks [2]

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shutdown and restart of these cells is a very important and extremely critical part of the process. In EGA cell technologies, wedges are installed between the busbars of a pot to be shut down and the busbars of an adjacent upstream pot, so as to by-pass the electrical current and to disconnect the affected pot (Fig. 2). The wedges are later extracted to restart the re-lined cell. The extraction of these wedges should be quick and simultaneous in order to prevent arcing on the conductor contact faces, oil to activate the jacks.

The features, functions and improvements of the Quick Start wedge puller system are:

- Using spring retractable reels without removing hydraulic jacks. The operator can pull the hose with jacks, lock at that position and pull again to automatically retract
- All hydraulic pumps were installed into a common tank with common outlet header to have interchangeability of the pump operation without disconnecting any hose

and to avoid possible overheating / fusing of the last wedge left in the process.

Carrying out wedge extraction is a laborious task involving a lot of manpower and movement. The operators must cope with heat fumes in a hazardous area congested with other equipment. The hydraulic wedge puller is part of a wedge extraction device (Fig. 3). It is a jacking system designed to remove up to ten inserted wedges together. It uses a single hydraulic tank unit coupled with three pneumatically operated, high-pressure hydraulic pumps. Two of these pumps are operated at a time, and a standby is always pump ready for action in case of any failure. A new hydraulic unit has been invented, designed and tested by EGA Reduction Main Technology transfer. Different designs were developed and tested for different technologies, and they use different options: one-cell, two-cell or three cell pot bypass, and upstream and downstream bypass. Design concepts are based on pot busbar design and site conditions so as to allow the operators freedom to act flexibly in an emergency.

The EGA preferred method of installation is by clamping on the potroom floor or from the basement, because this requires less time than welding. The design is based on ensuring the minimum sustainable current for potline operation, and on keeping the maximum busbar temperature below 250 °C, in order to reduce bypass weight and to make the bypass installation easier. Modelling is used to evaluate these parameters.

Fig. 4 shows examples of design and installation of emergency bypass busbars in D18+ and DX Technology. EGA’s Technology development is capable of designing any bypass system for any cell technology, provided that all design information is available to the design team.
(PTMs) are used for many tasks, such as cathode replacement, superstructure removal, anode beam raising, anode setting and metal tapping. These PTMs run on potroom building rails which are fixed to the potroom building structure by clamps and bolts. Due to continuous operation and movement of PTMs on these rails, the clamps and bolts eventually become loose or wear out, and then the rail track requires maintenance or replacement.

in maintenance jobs

- Vacuum machine on the rail inspection crane to remove the alumina / dust from the rails
- Air-conditioning unit installed, with cooling ducts to the man-carrying basket
- Rail cleaning brushes installed on the crane
- Emergency stop push button installed in each man-carrying basket
- Audio alarm installed for communication

Traditionally, two forklifts, one on each side of the potroom, were used to inspect and maintain the building rails. This work required eight people working simultaneously, and the work was dangerous due to working at heights and the risk of bridging cell potential to earth. Recently, a new method was invented: A potline construction crane was modified and dedicated to this potroom crane rail maintenance work. Fig. 5 shows the modified crane.

The features of the new rail inspection crane are:

- Four-sided man-carrying baskets with safety harness hook points
- Tool box and storing boxes for clamps and bolts
- Anti-collision sensors
- Air compressor for pneumatic tools used between an operator on the floor and people on the crane
- Separate audio alarm to indicate crane movement
- Variable frequency drive installed for smooth acceleration and deceleration of the crane.

The new crane and work methods were developed specifically to carry out building rail inspection and repair. They not only reduce the maintenance time but also improve safety at work, and they reduce the associated electrical hazards.

**References**


**Authors**

Michel Reverdy is senior manager Technology Transfer. Ali Bin Rahal is senior manager Reduction Maintenance. Mahmood Abdulmalik is senior manager Technology Engineering. Jasbant Pradhan is supervisor Crane Maintenance. All four are at Emirates Global Aluminium.
Hertwich Engineering supplies multi-chamber melting furnace to Exlabesa

Exlabesa, Europe’s largest independent extruder and a world leader in the supply of aluminium extrusions is expanding its aluminium remelt capabilities at the Padron plant.

In close partnership with Hertwich Engineering, Exlabesa put into operation a Hertwich continuous homogenizing plant at its Padron facility in Spain in the second half of 2018. Following this investment Exlabesa has now ordered a Hertwich Ecomelt PR130 multi-chamber melting furnace (complete with charging unit) which will increase the annual capacity of the Padron casthouse to 60,000 tonnes.

Exlabesa is a global company that covers the complete aluminium extrusion cycle including coating, anodizing, machining, bending and recycling for a wide range of industrial sectors and fields of application. With a total of 22 extrusion lines (press capacities from 13 to 65 Meganewton) across seven global locations with factories located in the United States, UK, Spain, Germany, Poland and Morocco, Exlabesa now has the capacity to produce up to 176,000 tonnes of profile per year.

Investment and expansion programme

With its ongoing investment and expansion programme Exlabesa has overseen a high volume of key upgrades and installations across a number of its facilities. The ongoing programme, which commenced two years ago, has seen a number of multi-million euro investments across the group resulting in Exlabesa being at the forefront when it comes to meeting today’s market demands.

Last year the casthouse in La Coruña was modernized by replacing several old batch homogenizing furnaces with a modern continuous homogenizing plant including billet saw and stacking unit from Hertwich. The gas-heated continuous homogenizing plant is designed for a throughput capacity of 32,000 tpy.

Billets in a diameter range between 178 and 406 mm and at a length of 6,500 mm are uniformly heated over the entire length in the heating zone of the furnace. The cooling rate in the air cooling station can be adjusted to the metallurgical requirements. The billet saw, which is installed downstream of the cooling station, cuts off the head and butt ends and divides the billets into processing lengths. The billets are automatically stacked, semi-automatically strapped and weighed. All these processes are integrated into the automated process, along with the necessary transports.

Two years ago, Exlabesa placed an order with SMS group for the supply of two modern 35-MN extrusion presses to expand the processing capacity. Each of the presses has been designed for an annual production capacity of 10,000 tonnes of aluminium profiles. The presses are equipped with the ecoDraulic system and a self-regulating, movable press rest shear. The eco-Draulic system includes a smart start-stop function turning off all hydraulic pumps which are not required during extrusion. Thereby energy savings of 10 percent on average are achieved. One of the extrusion presses has been commissioned at the beginning of 2019 in Doncaster (UK).

Next year Exlabesa will expand its remelt capacity in La Coruña by installing a Ecomelt PR130 multi-chamber melting furnace including charging unit. This investment will increase the extrusion billet capacity of the group to 60,000 tpy.

Recycling material in trend

Exlabesa has selected the Ecomelt PR130 furnace type as the recycling rate of extrusion material is increasingly growing. Today’s scrap return rises in the same degree as the use of aluminium has increased in the past. This development improves the environmental footprint of aluminium, since the energy for remelting amounts to just five percent of the energy which is required for reclamation of primary aluminium.

This trend has inspired Hertwich Engineering to be one of the first equipment suppliers which have intensively focussed on the remelt technology. Due to its extensive experiences Hertwich has developed a furnace range under the name of Ecomelt, which is able to provide the best suited furnace type for all different kinds of contaminated scrap. Today, Ecomelt melting furnaces have become well established within the industry. In practice, Hertwich Ecomelt furnaces using suitable scrap achieve energy consumption values which are even lower than the reference value of five percent.

Multi-chamber melting furnace with preheat ramp

The new furnace with a melting capacity of 130 tonnes per day is designed for a relatively wide range of scrap: production scrap, clean profiles with a length of up to seven metres, sawing chips, clean and lacquered scrap (shredded or in pieces), ingots and market scrap are processed. To remelt this loose and moderately contaminated scrap, the Ecomelt-PR furnace with preheat ramp, melting chamber and main chamber is suitable. This furnace concept has been developed about 20
years ago. Since then it has already proved itself in many casthouses.

The scrap to be melted is transferred onto a ramp in the preheat chamber by an automatic charging unit. The environment is protected from the furnace atmosphere during the charging process.

In the preheat/melting chamber material is heated to approx. 500 °C, whereby adhering organic compounds are combusted. Based on an extensive operational experience this chamber has been designed to optimize heat transfer and reduce preheat time. For a furnace with a daily capacity of 130 tonnes, Hertwich specifies two charging cycles per hour (each with three tonnes of scrap).

The preheated and decoated material is pushed from the ramp into the melt bath. An electromagnetic liquid metal pump provides the melt transfer between both furnace chambers. Furthermore, it ensures the availability of the required energy for melting in the melting chamber. The melt level in the melting chamber and the melting rate can be adjusted by the metal pump. During melting scrap remains submerged at all time in order to avoid oxidation losses.

The temperature level in the main chamber from which the melt is tapped for casting is about 1000 °C. Hot enough to burn all pyrolysis gases generated during preheating of the scrap. The heating system uses the energy content of the flue gases for heating the combustion air. In this way, energy consumption values of 450 to 500 kWh/tonne are achieved when melting moderately contaminated scrap.

Outlook

The installation of the new melting furnace will not interfere the ongoing casting operation. Commissioning is scheduled for mid-2020. Once this investment is completed, Exlabesa will have state-of-the-art melting, homogenizing and extrusion equipment.
Innovations in charging and skimming

Efficient furnace practices with low cost production standards start with automated charging and skimming. Using the right technology allows for significant reduction of energy consumption, minimum cycle times, lower furnace maintenance cost and a safer environment for the operators. RIA Cast House Engineering has been focusing on the development and manufacturing of charging and skimming equipment since 1997. The company is now focused on the development of innovative automation and process optimization solutions. Its newest charging and skimming systems utilize full artificial intelligence (AI) to make charging and skimming cutting-edge technology. The RIA systems achieve the lowest possible operational cost and the safest operating environment for this important part of the process.

**Skimming machines**

Leaving dross on top of the furnace causes more dross to generate in the next cycle, thus increasing operational melt losses. Quickly removing all the dross is the object of the RIA automated skimming process. The standard automated machines are laser-guided and the charging machine is programmed with the exact furnace geometry for quick movement across the bath to remove the dross. Typical cycle times are 8 to 12 minutes. The next generation of RIA AI skimming machines achieve the goal to fully automate the skimming machine and improve the process at the same time. This unit, equipped with a Fioscope air-cooled camera system that uses digital image processing, helps to automate the skimming process. The cameras are installed to overview the bath area at all stages of the skimming process. The video images will be processed in real-time and distributed to the machines PLC. This data is compiled in movement commands to allow a full autono-

high quality standards and continuously improving those has helped to design the most reliable, robust, maintenance friendly and custom-made furnace tending equipment on the market. RIA’s goal moving forward in 2019 is to expand to sheet ingot and primary aluminium casting facilities.
The robust base frame is equipped with wheel blocks for travelling. Furthermore, the base frame accommodates the operator cabin when manual furnace floor or wall cleaning is required. The electric cabinet and the hydraulic unit are mounted on electrically driven carriage. This carriage runs in guide profiles the skim boom into the furnace. The boom is pivoted on the carriage. The pivot is done by a hydraulic cylinder. This simple, but solid design assures continuously good results and builds the base for the In-Furnace Dross Pressing (IFDP). Multiple tools are available with quick change capabilities.

RIA’s next innovation in the skimming area is a ‘game changer’ regarding dross processing. The IFDP process is a joint development with David Roth, GPS Global Solutions. The concept behind the IFDP is to press the dross before it leaves the furnace and gets too cold or too hot to effectively removal all the contained aluminium. The mechanical unit to press dross is a horizontal and vertical moving press plate. The In-Furnace Dross Pressing is achieved in harmony with the skimming cycle. The dross will be dragged on the furnace sill and pressed against the lifted press plate. The liquid aluminium flows back into the furnace through openings in the skim plate. After pressing is finished the remaining dross will be moved into specially designed cooling dross pan in front of the furnace. The press plate is used for a precise positioning of the dross cake. The procedure will be repeated until the furnace is completely de-drossed.

The IFDP gives a lot of advantages compared to traditional technologies. Most important is the reduction of metal loss at its occurrence. Up to 80% of the liquid metal contained in the dross flows back into the furnace and does not need to be processed or remelted. Further, the dross will be cooled immediately during pressing. This reduces additional metal losses. The skimming cycle is minimally extended by pressing dross in the furnace.

The precise machine movements and the programmed refractory contour as well as the adjusted plate pressure to the refractory eliminated collisions with and damage to the refractory lining. This reduces maintenance on the refractory significantly. Using a RIA skimming machine increases the occupational safety in all modes of operation, because even in manual mode the operator is protected by an insulated operator cabin.

The AI and IFDP features in combination with the known advantages of the RIA skimming machine make this the best technology for furnace skimming.

Charging machines

The melting process efficiency begins with good charging practices. Automated charging gives consistent reliable practices that minimize cycle times and fuel usage, and maximizes aluminium recoveries.

The RIA automated charging machine is composed of three solid steel frame sections. The base of the rail guided car is the travelling frame with wheel blocks. It can be designed to travel in multiple directions. This frame is equipped with two laser systems: one, for precise placement of the unit in relationship to the furnace door and the second looking for obstacles or personnel in the way of the moving frame. The intermediate frame is connected to the travelling frame by load cells. The integrated load cells record charge weights and cumulate the charging cycle to a furnace weight. This allows for immediate recovery information for process monitoring.

Furthermore, the intermediate frame is equipped with support, guiding and drive elements for the upper carriage. The upper carriage performs the actual charging cycle. The forward section is built as a container to accommodate up to 50 m³ of scrap or sows, weighting up to 20 tonnes. The actual dimensions will vary with the furnace size. The upper carriage can be designed to swivel to allow scrap charging from various directions to the machine. The drive for the pusher is located in the back of the unit. During charging the container enters the open furnace. As soon as the container is fully extended, the pusher starts to drop the material into the furnace. At the same time the retraction of the container starts to distribute the aluminium even over the bath area. This procedure assures highest melt rates and lowest metal losses.

The next generation of cutting-edge technology now being provided by RIA relies on artificial intelligence (AI) jointly developed with the German company, Fioscope. The charging machine in combination with the use of the Fioscope in-furnace camera system...
The task of the In-Furnace Dross Pressing is to press out the aluminium dross in the furnace before it cools down reliably determines the ideal point to charge the furnace and starts the automatic cycle. The autonomous charging is independent of any operator and ensures maximum output and highest safety standards.

Furthermore, this feature ensures that the furnace temperature loss is reduced to a minimum due to a maximum charge cycle time of 120 s. This minimized temperature drop affects not only the furnace atmosphere, but also the refractory material. During the loading with a RIA charging machine there is nearly no furnace refractory temperature loss. This results in improved energy consumption and increased furnace productivity. Some customers have noted as much as 20% improvement in furnace throughput over standard charging units. This continuous and automated furnace process reduces stress to the refractory lining significantly.

An important additional advantage of using this full AI system on the RIA charging machine is occupational safety. Operators are no longer required in this very dangerous area of the melting process. The dangers of charging wet scrap are eliminated from the operators concerns. RIA’s next step is to use AI to monitor scrap safety and determine proper shutdown and remediation practices when the monitoring system sees wet scrap being charged into the furnace.

**Summary**

RIA Cast House Engineering provides tailor-made rail-bound cast-house-proven charging and skimming equipment for aluminium cast houses. The design and development of all machines is taking account of reliability, durability, maintenance and occupational safety. Adding the innovative features of full AI camera-based charging and skimming as well as the In-Furnace Dross Pressing assures the best equipment for today and tomorrow.

**Rio Tinto to review future of New Zealand’s Aluminium Smelter**

Rio Tinto will conduct a strategic review of its interest in New Zealand’s Aluminium Smelter (NZAS) at Tiwai Point, to determine the operation’s ongoing viability and competitive position.

Under current market conditions and in view of high energy costs, the company expects the short to medium outlook for the aluminium industry to be challenging and this asset to continue to be unprofitable. Rio Tinto Aluminium CEO Alf Barrios said: “The aluminium industry is currently facing significant headwinds with historically low prices due to an over-supplied market. This means that many aluminium providers are reviewing their positions.”

Rio Tinto will work with all stakeholders including the government, suppliers, communities and employees in order to find a solution that will ensure a profitable future for this plant. The strategic review will consider all options, including curtailment and closure and will be complete in the first quarter in 2020.

NZAS is a joint venture between Rio Tinto (79.36%) and Sumitomo Chemical Company Limited (20.64%) and employs around 1000 people.

Only a few days ago, Alcoa announced a multi-year portfolio review aimed at driving lower costs and sustainable profitability with refined strategic priorities. Alcoa has placed under review 1.5m tonnes of smelting capacity and 4m tonnes of alumina refining capacity. The review will consider opportunities for significant improvement, potential curtailments, closures or divestitures.
The participants of the Hamburg Conference in 2017

Contribution of ICSOBA in setting development trends in global bauxite, alumina and aluminium industry

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The modern aluminium industry was born with the invention of the Hall-Héroult process in 1886, and for more than 130 years the technology development has never stopped. Equipment development has been the most spectacular. However, during the second part of the 20th century, automation, PLC and computers as well as lean organizations further transformed the aluminium industry, in line with the 3rd industrial revolution. For the last few years, a new revolution, Industrie 4.0, born in manufacturing industries, has gained momentum. The aluminium industry, like most process industries, is somewhat lagging behind in this journey. However, numerous signals show the ball is now rolling. Icsoba, which was founded in 1963, has since supported technology developments by increasing the shared knowledge in the field of bauxite and encouraging exchange of ideas and cooperation between the alumina and aluminium professionals. Those considerations are as important today as ever, and Icsoba is transforming itself to support the aluminium industry in its journey towards Industrie 4.0.

1. Introduction

In 2018 we celebrated Icsoba’s 55 years of activity. More than half a century of vocation for an organization such as Icsoba is quite an achievement by all means. Many entities created around the same time no longer exist today, but Icsoba is alive and doing better than ever.

In order to understand the success of Icsoba over the years, one has to look at the reasons and motivation behind bringing it to life1. The first Icsoba symposium was organized by the Yugoslav Academy of Sciences and Arts in Zagreb in October 1963. The Academy took the leadership role by realigning its scientific activity for solving economic and technical problems. By giving scientists and scientific institutions of various countries an opportunity to remain in direct contact, the Academy contributed to establishing solid links for international collaboration in the interest of progress in science. After the Congress, a very successful visit was arranged to the bauxite deposits of Dalmatia. During the concluding session, the Hungarian and French participants made the proposal that the Yugoslav Academy contemplate the possibility of establishing a permanent international working community. The Yugoslav Academy accepted this proposal and elaborated the Statute of the International Committee for the Study of Bauxite, Alumina and Aluminium. Icsoba was established.

2. Icsoba contribution to industry development trend

Since Icsoba was founded, the industry size has increased over ten times. All the time, Icsoba has unwaveringly supported technology developments by increasing the shared knowledge in the fields of bauxite, alumina and aluminium and encouraging the exchange of ideas and cooperation between the professionals in these fields, and in this way more often than not set the development trend of our industry.

a. Bauxite resources and mining

Icsoba’s role is significant in knowledge sharing in the field of geological research, analyses, data interpretation and exploration of alumina bearing raw materials in the last 55 years – mainly bauxites but also non-bauxitic ores2:

- Exploration techniques developed: double/triple walled bits, air-core drillings, bucket auger, etc.
- Development in material testing and new methods introduced: DTG, X-ray diffraction, scanning electron microscopy, mass spectrometry, infrared spectroscopy, atomic absorption, Mössbauer method, RD/Rietveld method, Al, Si concentrations determined in situ, etc.
- Geomathematical methods: geo-statistics, kriging, semi-variogram, fuzzy function, etc. resulted in reducing the errors in the resource estimate and risks in mining
- New huge resources have been identified and new mines established in Australia, China, India (Eastern Ghats), Vietnam, Indonesia, Guinea and Brazil
- Bauxite beneficiation at Weipa (Australia), Bao Lok (Vietnam), Zhengzhou (China), Trombetas and Paragominas (Brazil) became a common, routine procedure
- Conveyor belt system (Australia, India) and slurry pipeline (Brazil) are applied for the first time in bauxite supply to refineries.

b. Alumina refining

In the last 40 to 45 years, a very intensive development of the Bayer process took place with the support of Icsoba, whose publications captured the following most important tendencies3:

- The conversion from batch to continuous tank reactors in the early days. The development of the tube digestion technology increased the production capacity of a single line and reduced operation cost4
- Red mud thickening and washing technol-
ogy and equipment have been significantly improved, resulting in low soda loss with residue and high throughput of the units.

- The transition from pond-type bauxite residue storage areas to dry stacking after paste thickeners and then after press filters allowed to significantly reduce the required surface area and capital cost. The development and proposal of best practices of bauxite residue disposal and utilization was explored as well.

- The change from floury to sandy alumina quality is a significant tendency taken by the industry. On equipment side, using of larger units, better mechanical performances, higher liquor productivities at precipitation allowed to save electrical energy and steam, and to reduce capital cost for building new lines/plants.

- The shift from rotary to stationary alumina calcination units was overwhelming. Continuous evolvement of Fluid Bed and Cas Suspension calciners equipment allowed not only to improve product quality in terms of alpha phase content and particle size distribution but also to achieve energy consumption close to theoretically possible level.

Along with the Bayer process, the details of alternative technologies to process low grade bauxite, nepheline, alumite and clays including sintering, Bayer-Sintering, acidic processes have been presented and discussed giving insights on development and industrial implementation of those technologies.

c. Aluminium smelting

Icsoba accompanied the rapid development of the aluminium reduction technology in the last 30 years, most notably:

1. The fast cell amperage increase in many existing potlines by as much as 20 to 40%. At the same time new potlines increased the current from 300 kA to more than 600 kA. The fastest development of new cell technology took place in China.

2. The development of the pneumatic transport of alumina to the cells, the development of cell pot feeding technology and control to operate the cells without sludge and anode effects, which enabled very low FPC emissions.

3. The increasing anode quality in spite of deteriorating raw materials and the introduction of slotted anodes, which resulted in better cell performance by decreasing bubble voltage drop.

4. The development of potroom service equipment such as pot tending machines (PTMs), allowing easy anode changing and cavity cleaning as well as laser marking for accurate anode positioning. The safety of crane operations increased by the automatic monitoring of crane insulation resistance.

These examples of the development of process technology and equipment illustrate the huge progress our industry made in the second half of the 20th century. However, during the same period, automation, PLC and computers as well as lean organizations further transformed the aluminium industry in line with the 3rd industrial revolution.

3. New industry development trends

Most refineries and smelters have reached a competitiveness plateau today and future gains cannot come from a new wave of headcount and cost reduction but from a significant improvement in process performance. In recent years, new solutions that have emerged in the manufacturing industry have gained momentum: automation and digitalization in the overall framework of Industrie 4.0. The aluminium industry, like most processing industries, is somewhat lagging behind in this journey to 4.0. However, numerous signals show that the ball is now rolling.

a. Automation

Driverless trucks in bauxite mining, developed by the major mining companies (20% of Rio Tinto’s existing fleet of almost 400 trucks in the Pilbara, Australia, drive autonomously to save electrical energy and steam, and to reduce capital cost for building new lines/plants.

b. Digitalization

Considerations regarding ‘Refinery of the Future’ and ‘Smelter of the Future’ have been around for some years now. Industrial implementations of the digitalization approach, as illustrated by such ‘predictive anode quality’, based on processing (advanced analytics) large numbers of real time and historical process data, are rapidly spreading. Machine learning has been recently presented in the field of anode quality interaction with reduction cell performance. Digitalization is moving a step further with experimentation of cell process control via ‘digital twin’ as pioneered by Aluminium of Greece.

Many digitalization examples are also found in the upstream part of our industry. An illustration is the approach taken by Emirates Global Aluminium (EGA) when preparing the start-up of the first Middle East alumina refinery at Al Taweelah in Abu Dhabi. Taking the
opportunity of being a greenfield project, the authors claimed to have developed “one of the most modern Process Information Management Systems (PIMS), applying the latest of the Industrie 4.0 elements as a first step towards the Smart Refinery”[32]. The concept of the whole refinery digital transformation has been also discussed by Honeywell: it includes elements of big data analysis, the connected worker and the connected plant. It is rightly said that it takes a big step to implement the emerging and most challenging technologies in the field including smart sensors and autonomous machines[33].

Other illustrations are given, for example, with the development of a digital twin to achieve predictive analysis of wear mechanisms in the refinery digestion plant facility, supplementing the non-destructive monitoring[34]. On the white side, the construction of process simulation models and detailed equipment model allowed further significant optimization of the alumina calcination plant[35]. It is worth mentioning a concluding remark from the authors: “A comprehensive digital system will not be able to achieve the desired level of performance without the inclusion of process understanding.”

Finally, we should also mention the application of 4.0 quality concepts of digitalization, data acquisition, scalability, analytics and connectivity to elevate traditional management system tools to the Industrie 4.0 standard in the context of bauxite mining[36].

4. Icsoba evolution to support industry transformation

As shown above, multiple examples demonstrate that the aluminium industry has entered the era of digitalization. This transformation is unlocking new opportunities along the whole value chain and all the players have either started or are about to start the journey. Transforming our industry is requiring and will require for several years to look at our processes with different lenses from different angles. It will require different skills, knowledge and probably people whilst, at the same time, the fundamentals principles will remain. How can a technology conference support such a transformation? This is the challenge Icsoba is presently facing and aiming to meet successfully!

a. Build on Icsoba DNA which proved so successful during the last 55 years

i. Multiculturalism of its board of directors

Icsoba is an international association of members, which elect the board of directors. The board is responsible for managing and supervising the activities and affairs of the corporation and is accountable to the members. The directors have legal responsibility for Icsoba and are registered with Canadian authorities. The present composition of the board confirms not only its international status but also reflects its multicultural character. Among the board directors are two Canadians (with Polish and Iranian backgrounds), two French, a Swiss, a Russian and an Indian. Such board composition promotes universal understanding and vastly facilitates global communication.

ii. High quality of publication and scientific content

A key element of Icsoba’s reputation is the high quality of publications and scientific content. The Technical Committee oversees maintaining and enhancing the reputation of Icsoba publications through the rigorous selection of high-quality papers and of the practical organization/running of the sessions during the annual conference. The Technical Committee (TC) is composed of the programme director (a member of the board of directors) as its chairperson and of 3-5 subject organizers. The TC members jointly represent the technical areas: bauxite, alumina, bauxite residue, carbon and aluminium.

The author guidelines and template for Icsoba abstracts, papers and presentations provide a uniform standard and appearance of each contribution. Approximately 100 papers and corresponding presentations are selected each year for the conference and the papers are included in the Travaux volume of the conference proceedings, which have reached more than 1,000 pages in recent years.

iii. Travelling around the world

Icsoba’s international success is based on the practice of rotating the venue of international conferences to countries that play an important role in the global aluminium industry. Unlike many other organizations that are stationary, Icsoba moves from place to place around the globe and the delegates attending the annual conference travel with it. Visitors often bring expertise and solutions that locals may not have, and the opposite is also true. Icsoba provides a unique forum for discussions and plant visits, allowing its members to see the aluminium world, to learn and share know-how from research and current practices.

Over the years Icsoba has been travelling the world visiting major bauxite and aluminium production centres: Goa (India, 2011), Belem (Brazil, 2012), Krasnoyarsk (Russia, 2013), Zhengzhou (China, 2014), Dubai (UAE, 2015), Quebec (Canada, 2016), Hamburg (Germany, 2017) and Belem again in 2018. In the last two decades China, Middle East and India had an extraordinary growth of activity in alumina and aluminium production thanks to available energy. To put emphasis on these countries, Icsoba has plans to stage conferences there again in the near future.

iv. Proposing field trips associated with each conference

Field trips (plant visits) organized at the end of each Icsoba conference are highly instructive and appreciated by the delegates. For example, at the end of the 2018 conference in Belem, the delegates enjoyed visiting three different Hydro plants: the Albras aluminium smelter, the Alunorte alumina refinery and the Paragominas bauxite mine. A year before (in Hamburg) visits were organized to the DadCo alumina refinery and the Trimet aluminium smelter. The field trips offer the delegates a unique opportunity to see the production facilities, meet local personnel and discuss selected technical issues.

v. Offering grants to students

The student grants originate from the Icsoba funds and mark our presence in a specific country. The grants are offered to two to three students who present papers at the conference.
and who are nominated as grant recipients by a local academy representative. Two student grants were offered in 2018 to the students from the Universidade Federal do Este do Pará, Brazil. In addition, the elected students obtain free access to the conference.

b. Enhancing collaboration within the aluminium industry
i. Integrating industry input: the Icsoba Corporate Members Council

The vision of Icsoba to become ‘The Technology Conference of the Aluminium Industry, for the Aluminium Industry’ translates our view that the future of our organization lies in the high engagement of the aluminium industry.

The industry engagement requires participation from companies to orient Icsoba conferences to industry issues and challenges, pragmatically. To this aim, Icsoba revisited its corporate membership status and set up a Corporate Members Council in order to get direct feedback on industry needs and to ensure that all industry players from major producers, engineering firms, equipment suppliers to service providers get the opportunity to influence the Icsoba strategy and its deployment.

The Corporate Member Council meets once a year, during the annual conference. Icsoba’s activity report is presented as well as the progress report on developments associated with the current strategic plan. The Corporate Members input is collected and further discussed during the board meeting for integration in its development plan.

ii. Partnering with aluminium associations

Icsoba undertakes to play the role of the industry’s leading voice, providing global standards, business intelligence, sustainability research and industry technical expertise to member companies, policymakers and the general public. In the spirit of equality, mutual benefit and friendly co-operation, Icsoba has identified a framework within the aluminium sector. The objectives of this framework are to contribute to the industrial knowledge base and to stimulate economic activities along the aluminium value chain.

Several organizations have signed Memorandum of Understandings (MoUs) for cooperation with Icsoba, which is beneficial for both sides. For example, over the years the MoUs were signed with the Aluminium Association of Canada, China Nonferrous Metals Industry Association, The Aluminium Association of India and Associação Brasileira do Alumínio (Abal). Icsoba highly values these partnerships and intends to further extend their number in the coming years.

iii. Partnering with other conference organizers

As already discussed, digitalization implies different knowledge. As a consequence, different players, namely automation and IT companies, are taking up more space in the process industry landscape. However, as the fundamental principles remain, it is of prime importance to ensure a close connection between the data and cooperation among systems experts and process experts. The mission of ‘The Technology Conference of Aluminium Industry, for the Aluminium Industry’ is to provide a platform for such connection.

This is why Icsoba signed an MoU with Quartz Business Media to organize an Icsoba session within the framework of the next ‘Future Aluminium Forum’35, which was held on 22 and 23 May 2019 in Warsaw, Poland. The Icsoba session dealt with ‘Aluminium 4.0: when process approach meets data-driven approach in mining, refining and smelting’ and saw representatives from aluminium companies willing to share their developments and success in their journey toward Industrie 4.0.

With this initiative, Icsoba aims to encourage and facilitate cross fertilization between process and data approach of our industry.

c. Enhancing knowledge dissemination

Dissemination of knowledge is the key factor to promote the collective effort of people acting in the whole aluminium value chain, from mine to metal. Therefore, beyond the organization of its annual conference and exhibition, which enhances the generation and exchange of ideas during the four-day event, Icsoba has a proactive strategy for knowledge dissemination and deploys all efforts to maximize the impact of the knowledge and know-how developed and shared by its members:

- A particular attention is made to invite influential keynote speakers with different backgrounds; i.e. technology, science, market, environment, etc. Dissemination of such a broad spectrum of keynote talks enhances the development of all facets of the industry.
- Icsoba has an agreement with MDPI to publish some selected papers in the open-source journal ‘Metals’ to further disseminate the knowledge to a broader audience.
- The Icsoba Platform for Industry-University Collaboration for Innovation is another example where our members share their valuable knowledge about the R&D infrastructure and available resources worldwide.
- Several thousand technical papers have been published in the Travaux volumes over more than half a century. All submitted papers are subject to a rigorous peer-review and edition process, performed by experienced Icsoba members from industry and academia. The value of this documentation for building a collective knowledge is better understood if one assumes that each paper addresses a hurdle of the industry, which is usually determined by the industry. All published documents have been electronically scanned and Icsoba will soon launch a user-friendly interface for access to this documentation.

5. Conclusion

Icsoba, who celebrates 55 years of activity, has unwaveringly supported the aluminium industry and, in many respects, contributed to set its development trends. This resulted in the impressive developments experienced during the decades of Icsoba history in the bauxite, alumina and aluminium industries that have grown 10-fold and reached what it is today.

Now, the aluminium industry is starting its journey towards digitalization. Icsoba considers that sharing knowledge and encouraging exchange of ideas and cooperation between the alumina and aluminium professionals is as important as ever. Icsoba is therefore act-

Travaux books with conference proceedings
ing to transform itself to support this new development trend. This transformation is based on three pillars, namely:

- Building on Icsoba DNA which proved successful for the last 55 years (multi-culturalism of its board members, high quality of publications, travelling around the globe, proposing field trips and grants to students)
- Enhancing collaboration within the aluminium industry (widen its corporate members base and integrating their input through the Corporate Members Council, partner with aluminium associations and other conference organizers)
- Enhancing knowledge dissemination (inviting influential keynote speakers, proposing a platform for industry-university cooperation and a user-friendly interface to access to the 2,000 technical papers of the Icsoba library).

With those actions in place, and with an open mind regarding input and suggestions from all of its members and partners, Icsoba aims at its vision of being ‘The Technology Conference of the Aluminium Industry, for the Aluminium Industry’.

6. References


6. references


More efficiency in furnace tending operations

G. Magarotto, T.T. Tomorrow Technology

T.T. Tomorrow Technology SpA is approaching 20 years of producing machines for casthouses and anode plants. The board of directors responsible for this joint stock company and all its staff are well prepared for the new challenges in the aluminium industry. The high ability to understand the customers’ needs for innovative solution, the flexibility in adapting the products, the perfect design and high-quality components characterize the company. This article describes the advantages of the current range of equipment for dross removal and furnace cleaning.

T.T. Tomorrow Technology, which is located in Due Carrare near Padua, Italy, has always been focused on providing the best solution to the installed melting capacity of the melting furnaces in order to prevent the negative effects of dross on aluminium production. High efficiency and thus in a reduction in chamber temperature (reduction of metal oxidation) and a shorter melting cycle. These are all factors that lead to cost savings and higher productivity.

Dross adhering to the furnace walls and corners and the presence of solid deposits of dross and heavy metals on the furnace bottom reduce bath capacity. There is also a reduction in metal quality due to the presence of uncontrolled alloy constituents and composition-plugging elements (especially iron) that can easily dissolve in aluminium.

Again, the ability to easily and effectively remove deposits from the furnace bottom leads to higher productivity and quality improvement.

The automation (both in terms of the frequency and the operation itself) of these routine furnace tending procedures significantly improves all aspects of the melting process. It also ensures that these often unpleasant and strenuous operations are routinely carried out on night shifts during unattended periods.

Advantages of skimming and furnace cleaning equipment

Skimming and furnace cleaning equipment from T.T. Tomorrow Technology provide the following advantages:

- Increased furnace utilization and lower gas consumption by reducing the time it takes to de-dross and clean the furnace effectively and accurately;
- Clearly better heat transfer by easily and accurately removing the dross that acts as thermal insulation on the molten metal;
- The amount of aluminium removed with the dross during skimming operations is reduced to an absolute minimum;
- Prevention of dross sludge and metal build-up that will gradually reduce furnace capacity and adversely affect metal composition; deposits also require unplanned downtime to clean the cold furnace with hammers, excavators, etc.;
- An increase in the speed of the cold charge melting cycle through the ability to mix scrap and submerge it into the melt;
- Service life extension of refractory material by avoiding thermal stress due to lengthy scraping processes with associated temperature drops in the furnace and mechanical stress due to the use of percussion tools during cleaning operations;

Effective skimming and furnace cleaning are therefore important factors in achieving efficient production in addition to quality and cost-effectiveness. These are also the main advantages that customers have achieved by using the latest generation of T.T.’s special furnace tending vehicles and automatic or semi-automatic de-drossing and furnace cleaning equipment.

Over the past 19 years, the company’s development and production of equipment and vehicles designed to skim and clean furnaces has been driven not only by productivity and quality issues, but also by health and safety regulations that require operators to be protected from injury, heat and other hazards near furnace doors.

Different customer requirements led to the design and manufacture of various machine concepts, such as rubber-tyred, driver-controlled diesel vehicles and rail-bound or stationary machines that can be operated manually or fully or semi-automatically under wifi control.

It is well known that the dross acts as a thermal insulator on the surface of the molten bath and reduces the efficiency of heat transfer from the flame to the metal. The ability to easily and quickly remove dross from the furnace results in a higher heat exchange efficiency and thus in a reduction in chamber oxidation rate, poor thermal efficiency and reduction of furnace melting efficiency are generally recognized negative factors caused by the presence of dross. The contaminated scrap available on the market today often leads to excessive dross formation, despite the low oxidation target of the latest generation of melting furnaces installed and operated in many casthouses today.
• Reduced need for personnel to carry out furnace tending operations;
• Greater safety in the casthouse by keeping the operator away from the furnace door during de-drossing operations;
• No forklift trucks required to work in front of the furnace.

The tool is moved back and forth parallel to the liquid bath with precise and controlled movements during the de-drossing operation. This optimum control standard eliminates the oscillations that often occur with conventional de-drossing systems.

The tool movements can be precisely controlled by the operator via the joystick on the remote control or fully automatically (without operator intervention). The precision of this furnace tending operation offers a number of economic and production advantages as it minimizes the unintentional removal of aluminium while maximizing the cleanliness of the melt. While controlling the skimming procedure, the operator sits in a safe cabin. Alternatively, he can operate the remote control console at the safest location to avoid the potential risk of metal splashes from the furnace.

**Entire range of furnace tending vehicles updated**

During the last three years, TT Tomorrow Technology has updated its entire range of furnace tending vehicles and tending robots, offering the aluminium industry a new model with all-wheel steering and telescopic boom up to a length of 12 metres. The high flexibility of the rubber-tyred, diesel-powered vehicles is not subject to any restrictions so that they can also be used for scrap feeding and thus become multi-purpose furnace tending vehicles. The new generation of skimming robots has been delivered with full wifi control to many customers in Europe, North America and several countries.

A great advantage of the skimming robot on rails is that no special foundations or complex construction work are required for its installation. Mostly, these robots are already assembled and delivered ready to be placed on the rail prepared in front of the furnaces, which allows quick operation after operator training.

As a result, a single operator in a multi-furnace casthouse can perform all tending work including charging, skimming, alloying and furnace cleaning.

T.T.’s production policy and market strategy are aimed at providing high-efficient vehicles and equipment to protect the aluminium industry from inferior and low-cost products that flood the market at the expense of good quality.

Customers around the world who use T.T.’s furnace tending machines point to a number of advantages:
• High economic return;
• Ease of use;
• High reliability and minimal maintenance;
• Flexibility;
• Easily implemented in existing casthouses.

In addition to skimming and furnace cleaning systems, T.T. Tomorrow Technology’s casthouse products includes various types of furnace-charging systems (rubber-tyred diesel vehicles and electric rail-bound or stationary machines, fully or semi-automatic), material handling systems (scrap, liquid, metal, coils, billets, slab and rolling mill roll transporters), dross treatment and other downstream equipment.

**Author**

Giovanni Magarotto is managing partner of T.T. Tomorrow Technology SpA in Due Carrare, Italy.
First successful cast from the Alba Potline 6 expansion casthouse furnaces

In March 2017 Mechatherm was awarded the contract from Bechtel on behalf of Aluminium Bahrain (Alba) for the turnkey supply of the melting / holding furnaces and launder systems for their Potline 6 expansion. This prestigious contract award for Mechatherm affirms the company’s position as a leading supplier of casthouse furnaces, in particular to the Middle East and Gulf countries. To date Mechatherm has installed over 70 melting and holding furnace references across the Middle East region, commencing from the late 1980s.

The Alba contract to Mechatherm was for the supply of casthouse equipment, including the integration of the hot metal treatment systems which feed various casting processes. The Mechatherm equipment includes three 165-tonne capacity tilting melting/holding furnaces, three 85-tonne melting/holding furnaces, and two under hearth electromagnetic stirring systems (EMS). One other supplied feature of the casthouse scope and overall layout is a fully integrated and interconnecting hot metal delivery system. This system allows aluminium to be delivered from each furnace to any one of the newly installed casting machines supplied by other OEMs as part of the same project.

The furnace design scope was such that the furnaces should supply liquid aluminium to three different casting machines via a common launder system. The casting machines include a 165-tonne slab casting machine, an 85-tonne VDC billet casting machine and a continuous 10-kg ingot caster.

Under normal circumstances the supplied 165-tonne capacity tilting melting/holding furnaces will be predominantly used to serve the 165-tonne VDC rolling ingot casting machine. However, there is enough design capacity and cycle time built in for one of these furnaces to feed the continuous 10-kg ingot caster. Likewise, the 85-tonne furnaces are dedicated to feed the 85-tonne VDC capacity billet casting machine in the same way, but also having cycle capacity to feed the 10-kg ingot caster.

This overall casthouse layout gives Alba optimum casting flexibility, dependent upon their production and cast product needs. In addition, Mechatherm also supplied and installed ‘third party’ in-line degassing, refining and filtration systems.

The Line 6 Expansion Casthouse Furnaces contract was awarded to Mechatherm on a full turnkey basis by the project nominated EPCM, Bechtel Co. Ltd – USA (Bahrain Branch). Mechatherm has worked closely with Bechtel throughout the design engineering phase, right through to the on-site installation execution, which is scheduled to be fully complete by September 2019.

Mechatherm reported that in January 2019, the first liquid aluminium was delivered from one of the 165-tonne tilting melting / holding furnaces to allow the first continuous cast of 10-kg ingots. Thanks to this prestigious contract award from Alba/Bechtel, Mechatherm has seen recent business growth not only in turnover, but also in the number of employees working now at their UK headquarters. Working on a large and engineering-intensive project such as the Potline 6 casthouse, Mechatherm has recruited and built up its professional workforce, after previously experiencing a slow period of business activity, mostly blamed on the drop-in price of world aluminium during 2015–2017.

Mechatherm is well positioned to tender for other large-scale casthouse contracts on a global scale. This perception has already been vindicated, as over the last two years Mechatherm has been successfully adding to its references, particularly in the USA, and recently won its biggest ever single-value order at JW Aluminum in Goose Creek, South Carolina.

This order is for the supply of four 140-tonne multi-chamber contaminated scrap de-coating/melting furnaces to feed two 155-tonne tilting holding furnaces, as part of JW Aluminium’s new continuous sheet production expansion. The supplied melting furnace technology will receive the contaminated scrap and utilize energy from pyrolyzed volatile organic compounds (VOCs) by destroying them by incineration. This technology increases the overall furnace efficiency by reducing gas consumption and minimizing toxic emissions sent to the fume treatment plans for final clean-up.

As part of Mechatherm’s continued growth and brand-building efforts, the company’s first satellite office for sales and services has recently been established in Dubai, UAE. The intention is for this dedicated branch office to offer maximum support to Mechatherm’s customers in the Middle East and GCC countries, as this region has provided a large proportion of Mechatherm’s business over the years.
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Primary aluminium activities in 2019

Rudolf P. Pawlek, Sierre

During the first half of 2019 some 31.5m tonnes of primary aluminium have been produced. Of this volume some 18.9m tonnes were produced in China. Even though some Chinese primary aluminium smelters are shut down, there still seems to be enough capacity to increase total production, and more new, state-of-the-art technology smelters are waiting to be taken into operation.

However, as in the first of 2019 the LME cash price for primary aluminium has stayed under USD1,900/t – the average is at USD1,827/t and the average of June is USD1,754/t – the question remains: for how long can companies produce aluminium when most of them cannot cover their production costs? And this low price level looks set to continue into the near future.

Therefore, only companies with their own energy sources of hydropower or natural gas can persist and produce profitably. These companies are located in the Middle East, Iceland, Canada and Russia.

THE AMERICAS

BRAZIL: Albras’ board of directors decided in May to restart aluminium production at its plant in Brazil. The smelter is expected to be 51% of Albras, the remaining 49% is owned by Nippon Amazon Aluminium.

Fives has started the refurbishment of 39 casting trolleys on the old ECL pot tending machines at Albras. The installation is under execution through a 21-month supervision contract managed by Fives’ local team.

CANADA: Alcoa on 2 July released that the Aluminerie de Bécancour (ABI) smelter plans to restart curtailed capacity after members of the United Steelworkers union in Quebec approved a 6-year labour agreement. In December 2018, Alcoa cut half of the sole operating potline at the ABI smelter, bringing its capacity to a sixth of the nameplate capacity, or less than 70,000 tpy.

ABI, owned by Alcoa (74.95%) and Rio Tinto Alcan (25.05%), has a total production capacity of 433,000 tpy. The restart was announced to begin on 26 July 2019 and is expected to be complete in the second quarter of 2020. Salaried employees had operated one of three potlines during the lockdown, until Alcoa released an additional curtailment of one half of that potline in December 2018.

In April Elysis announced the site for its new R&D facility in the Saguenay–Lac-Saint-Jean region, which will directly employ over 25 experts when it is fully operational. The new Elysium R&D Centre will be located at Rio Tinto’s Complexe Jonquière, the site of the Arvida smelter and Vaudreuil refinery. It will be fully operational in the second half of 2020. The new research centre is located in the Saguenay–Lac-Saint-Jean because of the region’s notable expertise in the aluminium sector and financial backing from both the Quebec and Canadian governments. The construction work on the R&D Centre has officially started in August.

The Elysium JV of Rio Tinto and Alcoa is working to commercialize by 2024 a breakthrough technology that eliminates all direct greenhouse gases (GHGs) from the traditional aluminium smelting process, instead producing pure oxygen. The Elysium process has the potential to reduce the environmental footprint of the aluminium industry on a global scale.

In May equipment supplier Stas Inc. acquired Sermas Industrie. A global leader in the sawing of large materials for the aluminium industry, Sermas Industrie develops a complete range of equipment for the manufacture of cast aluminium products. More than 500 Sermas units are in operation around the world. Through this acquisition and the implementation of broad synergies, Stas realizes its vision of becoming a key player for the aluminium industry by offering turnkey, reliable and robust solutions to its customers: aluminium smelters, rolling mills, extrusion and forging plants, recyclers, distribution centres and the carbon industry. With over 1,500 equipment units in operation and thousands of tailor solutions, Stas is recognized for its innovative qualities and engineering expertise adapted to the aluminium sector.

Also in May Mecfor confirmed that its first electrical automatic guided vehicle (AGV) is in operation in a Quebec smelter. The Govern-
Primary aluminium smelters in Africa and America: Nameplate capacities and shutdown capacities on a temporary basis

Compiled by R.P. Pawlek, July 2019

<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
<th>Nameplate capacity (tpy)</th>
<th>Shutdown capacity (tpy)</th>
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nies like Mecfor in designing products like an electrical AGV for heavy industrial sectors.

The showcase will demonstrate Mecfor’s AGV Team technology to potential customers from around the world over the next six months. Currently, the AGV Team prototype transports molten metal crucibles in a smelter. The technological showcase aims the AGV Team to be operating in real 24/7 conditions, executing metal flow orders coming from the aluminium smelter. The AGV conditions fit into the spirit of Industry 4.0. These vehicles also handle the issue of shortage of skilled labour in industrial operations.

**USA:** In March the US Department of Energy (DOE) in partnership with Lawrence Livermore National Laboratory (LLNL) was providing nearly USD1.2m for four projects to support American aluminium manufacturers in improving energy efficiency, increasing productivity and accelerating manufacturing innovation. Among the projects to be funded is Alcoa’s ‘Large eddy simulation to improve cell design’. This is one of the projects selected from the sixth solicitation for the High Performance Computing for Manufacturing (HPC4Mfg) program. The program, supported by DOE, facilitates technical support from national laboratories, including access to supercomputing capabilities, high-end modelling and simulation software, and subject matter experts. Alcoa in Kensington, Pennsylvania, will receive USD300,000 for its project to develop a novel hybrid advanced smelting process. This aims to increase productivity and cell performance while minimizing GHG emission.

In May Century Aluminum reported that all three curtailed potlines at Hawesville were again in full operation. The teams are now turning their attention to rebuilding and installing new technology on the two lines that have been continuously producing; the first of these lines was taken out of service in March 2019 and is currently being rebuilt. The new technology continues to perform above expectations in efficiency and process stability. All operations are stable, and safety performance has been excellent.

On 17 May the United States reached an agreement to remove Section 232 tariffs from Canada and Mexico. The deal is expected to pave the way for the passage of the US-Mexico-Canada agreement, the replacement for the North American Free Trade Agreement. US President Trump implemented the tariffs – 25% on steel imports and 10% on aluminium imports – in March 2018. Those tariffs were applied to Canada and Mexico, along with the European Union, on 1 June 2018, causing a major disruption in the US steel and aluminium markets, as well as markets around the world.

**Venezuela:** A power outage in Venezuela has forced local aluminium producers Venezuela and Alcasa to temporarily stop operations at their smelters, the state-owned parent group of both companies, CVC, said on 9 March. Venezuela’s hydro power plant, Guri, was out of commission for most of the day on March 7, and many parts of the country were left with no electricity for over 24 hours. Venalum is a primary aluminium smelter with capacity for 430,000 tpy of ingots and extrusion billets. Alcasa can produce 185,000 tpy of ingots and 16,700 tpy of finished aluminium products. Most Venezuelan aluminium producers export material to the US, Japan and Europe, the companies said.

Output has been under pressure for years now. BMO Capital Markets, for example, previously estimated Venalum’s production in 2019 at 100,000 tonnes, down from full capacity usage a decade before. “After a country-wide blackout following a failure at the Guri Dam hydroelectric plant, the remaining pots at the facility were turned off and are unlikely to restart in the near future,” BMO analysts wrote in a note on 12 March.

Venezuela is in the midst of a deep political and economic crisis. The Venalum smelter was operating with 59 cells while Alcasa was operating with only 14. Both companies were already at their minimum operational capacities, and they stopped entirely on 8 March. Venalum has an installed capacity of 905 cells; Alcasa, whose technology is more outdated, has 596. Venalum’s fifth potline alone consumed 4.5m kWh, equivalent to the monthly consumption of 90,000 homes, with a ratio of 1,500 kWh per month. The collapse of the aluminium sector inflicted another blow to Venezuela’s already battered economy and industrial productivity.

The closure will also impact the operations in CVG Bauxilum and CVG Carbonorca: the first is focused on mining bauxite to turn it into alumina; the second, on producing carbon anodes for cells. This will also lead to a job loss of about 5,000 employees. The blackout brought down the curtain to these historical smelters causing a final shutdown to the Venezuelan aluminium sector.
Primary aluminium smelters in Asia and Oceania:
Nameplate capacities and shutdown capacities on a temporary basis

<table>
<thead>
<tr>
<th>Country</th>
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**GULF REGION & ASIA**

**ABU DHABI:** In May Emirates Global Aluminium (EGA) said that its Al Taweelah site has received certification from the Aluminium Stewardship Initiative (ASI) for its sustainability practices and performance. EGA is the first company in the Middle East to achieve a certification to ASI standards.

In May EGA announced the start-up of a new AED15m (USD4.1m) pre-treatment and crusher facility for spent pot lining (SPL) in a step forward for the recycling of industrial waste. The new facility can pre-treat 60,000 tpy of SPL to be used by cement companies in the UAE as an alternative feedstock. EGA has worked with UAE cement firms since 2010 to develop the potential of SPL to replace some fuel and refractory materials required in cement manufacturing.

In 2018, EGA supplied over 41,000 tonnes of SPL to UAE cement companies, reducing stockpiles from previous years and making EGA a global leader in the re-use of this industrial waste. Worldwide, the aluminium industry produces over 1m tonnes of spent pot lining every year. The new pre-treatment and crusher facility is located at EGA’s Al Taweelah site, and is the largest in the Gulf region.

EGA is also supplying most of its carbon dust, another by-product, to the UAE cement industry for use as a fuel. In addition, EGA sends some dross for processing to recover aluminium. A new dross processing facility to enable all this waste to be re-used is currently under construction by a third party near EGA’s Al Taweelah site. EGA’s waste generation, excluding SPL, reduced by 15% in 2018 compared with 2017.

At the end of May, China’s manufacturing firm East Hope Group reportedly entered into an agreement with Khalifa Industrial Zone Abu Dhabi (Kizad) to explore the feasibility of setting up a project in that region by investing USD10bn. The potential project may take place in three phases over 15 years. In Phase 1, there could be the development of an aluminium facility, while in Phase 2 and 3, there could be a red mud research centre, a recycling project, and large-scale upstream and downstream non-ferrous metal processing facilities. Kizad will support East Hope Group in acquiring land for the project, creating a masterplan, and handling the import of raw materials through Khalifa Port. In addition, Kizad is also in charge for exploring options for the sustainable generation of energy and a sustainability programme to preserve the environment, including the research centre.

**BAHRAIN:** In January Alba launched Phase IV of Project Titan, with the objective to reduce cash-cost of USD100m by the end of 2020, and announced that it has achieved USD102m savings in Phase III of Project Titan. Alba’s Project Titan – Phase IV is a 24-month programme and aims to achieve USD 40m in 2019 and USD60m in 2020. Through Project Titan, Alba achieved benefits of USD 281m over the five years during which Phase I to III had been executed.

In May Alba successfully started another 106 pots in Line 6, bringing 212 pots into life by 18 April, which is equivalent to 50% of Line 6 capacity. Potline 6 was commissioned on 13 December 2018 with the delivery of the First Hot Metal. Since then, there has been a gradual ramp-up of Line 6. Full ramp-up of Line 6 is scheduled for the end of July.

In May Fives announced that it had completed four improvement projects on ECL equipment at the Alba smelter, namely:

- Replacing the compressor control system of the ten ECL Pot Tending Machines (PTMs) of Potline 5. The aim was to facilitate the machine maintenance by reducing breakdowns and making the system more accessible.
- Modernizing the hydraulic drive of the same PTMs.
- Improving the tapping hoist by replacing the current motors and mounting frames of 3 PTMs of Line 4 in order to facilitate maintenance and improve safety.
- Performing a structural, mechanical and electrical Life Expectancy Audit of a 25-year ECL cathode transport crane, which Alba uses on the Lines 4 and 5. Engineering was executed by Fives in France, while project management and supervision were executed by its Service entity located in the Gulf area. Site inspection was jointly performed by both companies.

Already in January Fives signed a 5-year maintenance contract for the Line 6 PTMs.

**CHINA:** In May it was reported that new Chinese aluminium projects are planned in 2019. The Chinese spot alumina price could rise in the course of 2019, despite new capacity planned in 2019, due to new downstream aluminium projects which outpace the raw material’s capacity expansion. China is projected to add 5.4m tonnes of new alumina capacity this year, a y/y rise of 69% from 3.2m tonnes of new capacity the year before.

New aluminium projects, including capacity swap and capacity replacement, have been under construction since the beginning of the year. Chinese aluminium capacity is forecast to rise by 8.6% or 3.45m tonnes to 43.05m tonnes this year from total capacity of 39.6m tonnes at the end of 2018. This means aluminium smelters may need an extra 8.63m tonnes of alumina to secure their production expansion schedule, based on the typical aluminium production formula of 2.5 tonnes of alumina required for a tonne of aluminium produced.

The recent better performance of the aluminium price on the Shanghai Futures Exchange is also expected to encourage more production to return, which may further draw on alumina supplies.

Zhongwang Group, a leading aluminium
products producers in China, received approval in 2018 for an aluminium smelter with over 300,000 tpy of new capacity. The project is now under construction. A second 200,000 tpy smelter is in the final stage of approval, although there is no set date for construction.

The difficulty in finding a stable domestic bauxite supply for producing alumina has heightened alumina availability. Xinfa Group’s alumina plant in southwest China has reportedly stopped two of five lines due to shortage of bauxite supply in that region, totalling 1.2m tonnes of alumina capacity. China started its supply reform policy in the mining industry in 2017, requiring a stricter approval process for new mine projects. One result of the reform policy is that it is almost impossible to open new bauxite mines in certain regions where accessible farm land is reserved for farmers.

In August China’s Ministry of Finance published a list of retaliatory tariffs including an extra 5% tariff on imports of copper and aluminium scrap from the US as from mid-December. Beijing had already levied a 25% tariff on aluminium scrap from the US as from mid-December.

EGA’s new bauxite mines in certain regions where accessible farm land is reserved for farmers. new bauxite mines in certain regions where accessible farm land is reserved for farmers. In August China’s Ministry of Finance published a list of retaliatory tariffs including an extra 5% tariff on imports of copper and aluminium scrap from the US as from mid-December. Beijing had already levied a 25% tariff on aluminium scrap from the US as from mid-December.

The tariffs saw China’s aluminium scrap imports fall by 16% to 229,837 tonnes.

EGA produces 2.64m tonnes of aluminium, with generation capacity of 5.45m MW. In 2018, EGA produced 2.64m tonnes of aluminium. The new power generation and aluminium smelting, are expected to be up to 7% lower.

The project is expected to reduce EGA’s NOx emissions at Jebel Ali by 58%. NOx is amongst a group of emissions targeted for reductions under UAE Vision 2021 to improve local air quality. EGA needs electricity for aluminium smelting and other industrial operations, and has captive power plants at both Jebel Ali and Al Taweelah. EGA’s electricity generation capacity is 5.45 MW. In 2018, EGA produced 2.64m tonnes of aluminium.

**DUBAI:** In April EGA, Mubadala and Dubal Holding officially broke ground on a new AED1bn (US$272m) power block at EGA’s Jebel Ali smelter in Dubai. The new power plant should reduce GHG emissions from EGA’s power generation at Jebel Ali by some 10%. Emission per tonne of aluminium produced at Jebel Ali, which includes both power generation and aluminium smelting, are expected to be up to 7% lower.

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**INDIA:** In April Vedanta Ltd reported an aluminium production of 1.959m in FY2019, an increase of 17% year-on-year, mostly driven by stabilized production increase after the
Primary aluminium smelters in Europe, Russia and the Gulf region:
Nameplate capacities and shutdown capacities on a temporary basis

<table>
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<th>Country</th>
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<th>Shutdown capacity (tpy)</th>
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complete ramp up of Jharsuguda smelters. This has made Vedanta the largest aluminium producer in India, as the company contributed 53% of the total aluminium production of about 3.68m tonnes in FY19. While Nalco produced 440,000 tonnes of aluminium, Hindalco is expected to produce about 1.29m tonnes of aluminium in FY19.

Production from Jharsuguda-I stood at 545,000 tonnes and Jharsuguda-II recorded a production of 843,000 tonnes in FY19. Vedanta’s Lanjigarh alumina refinery produced 440,000 tonnes of aluminium, about 3.68m tonnes in FY19. While Nalco contributed 53% of the total aluminium production in India, as the company contributed 53% of the total aluminium production of 3.68m tonnes in FY19. While Nalco produced 440,000 tonnes of aluminium, Hindalco is expected to produce about 1.29m tonnes of aluminium in FY19.

OMAN: In April Sohar Aluminium (SA) celebrated ten years of excellence. As Sohar Aluminium has strived successfully to help diversify the Sultanate’s growing economy, it has also streamlined the import of raw products and made huge strides in the past ten years. The smelter has produced more than 3.7m tonnes of finished product since it started operations.

EUROPE

BOSNIA: Aluminij Mostar had to stop production on 10 July after Elektroprivreda HZHB stopped the supply of electricity and disconnected the smelter from the power grid. EP HZHB terminated the power supply contract with Aluminij in mid-June due to accumulated debts and unpaid electricity bills over a long period. The debt to the electricity supplier amounted to €28m. KAP went bankrupt in 2013 after years of financial difficulties, with a debt of €383m, and made huge strides in the past ten years.

With the use of this virtual battery, Trimet is trying to shift away from the conventional smelter process to make the energy-intensive electrolysis process more flexible. Trimet worked with Bergische Universität Wuppertal to develop a controllable heat exchanger for the virtual battery. This keeps the temperature in the pot constant despite the change in energy supply, and provides flexible control of the process.

MONTENEGRO: Uniprom released plans to invest €26m (USD29.3m) for upgrading the KAP aluminium smelter. Uniprom KAP or Aluminium Plant Podgorica is located on the southern outskirts of Montenegro. Uniprom plans to open a 30,000-tpy production unit for its Silumin alloys, investing €11m (USD 12.4m). €15m will be invested in the construction of an aluminium billet production unit with a capacity of 70,000 tpy, which will start operation by the end of 2019. Uniprom had installed an LNG facility in the plant to replace petroleum fuel.

Uniprom bought the KAP smelter from the Government of Montenegro in 2014 for €28m. KAP went bankrupt in 2013 after years of financial difficulties, with a debt of €383m,
which was more than double of its €180m worth. KAP was owned by Salomon Enterprises, later renamed CEAC – Central European Aluminum Company. The Government of Montenegro bought a large stake in the formerly privatized company from CEAC to save it from bankruptcy. Later it was bought by Uniprom.

**THE NETHERLANDS:** In January Aldel, located in Delfzijl, reopened its Potline 1 following the purchase of the business by York Capital in 2017. This is part of the ongoing capital investment in both equipment and people as the plant moves towards full production by the end of 2019. Aldel’s return to the European aluminium industry has been very well received, and this is reflected by the strong support the business has received from customers and suppliers alike.

**NORWAY:** In March Hydro became victim of a cyber-attack, impacting operations in several of the company’s business areas. IT-systems in most business areas were impacted and Hydro switched to manual operations as far as possible. It took Hydro several weeks to neutralize the attack.

In April one of Hydro Karmøy’s two production lines, with a capacity of 195,000 tpy of primary aluminium, suffered a power failure. Power at the affected facility was restored at a lower amperage. The affected line has 288 production cells, of which 45 were taken out of production to enable stable operations. This represents 10% of the total production capacity at the Karmøy plant.

In April Hydro also said that casting operations at the Husnes plant will be upgraded with new technology to produce more advanced products for the growing automotive aluminium forging market. Hydro will invest NOK150m (USD17.6m) with the aim of starting operations in 2020.

The in-house developed casting technology ‘Low Pressure Casting’ (LPC) enables Hydro to provide materials with enhanced properties for various extruded and forged products, where Hydro is already a major material supplier. After the upgrade, the Husnes plant will also be able to offer materials for forging. The Hydro-developed technology enables a shift from traditional extruded forge stock to cast forge stock, eliminating costly steps in the production process, while also improving quality. The as-cast surface is ready for forging and does not need homogenizing.

**ROMANIA:** In June Alro reported in its new sustainability report, that it invested in R&D and state-of-the-art equipment and technology, with the purpose of improving the products’ quality and quantity, while reducing the total resource consumption rates and its impact on the environment.

One of the group’s main objectives regarding its production facilities is to achieve near-zero waste and emissions. The first steps in this direction have already been taken: in 2018 Alro signed an agreement with Aluminium Pechiney (Rio Tinto Aluminium) to implement a technology at its plant in Slatina that will allow further reduction in electricity consumption.

**RUSSIA:** At the end of March Rusal and PJSJ RusHydro announced that they have launched the construction of Potline 2 at the Boguchansky smelter (BoAZ), part of the Boguchany Energy and Metals Complex (Bemo). The Bemo project was completed at a record pace: in 2012 the first hydro-electric units went into operation; three years later the station reached the design capacity of 2,997 MW. The capacity of the first potline of BoAZ is 298,000 tpy of aluminium.

The US treasury lifted the sanctions on Rusal in January. Novelis is one of the key customers that Rusal lost in 2018. The company is partially resuming deliveries to them, but hopes to get back more old customers by September. The 2019 volumes for most of its US and Japanese customers are already contracted. Rusal is negotiating with Glencore for renewal of a contract which expired in late September. The 2019 volumes for most of its US and Japanese customers are already contracted. Rusal is negotiating with Glencore for renewal of a contract which expired in late 2018. Rusal plans to keep its 2019 production and investments unchanged at 3.8m tonnes and USD900m, respectively.

In June Rusal announced the launch of a potroom control system to improve production efficiency. The control system will use advanced scientific and methodological approaches based on forecast analytics known as Big Data. The system is expected to detect the causes of any reduced reduction cell performance, to recognize the optimum conditions depending on the status of equipment, and most importantly, to predict malfunctions. Several Rusal smelters in Siberia are implementing the pilot project. If successful the system, which is currently being designed, is due to be rolled out to other Rusal plants.

The implementation of the new system will increase the company’s aluminium production efficiency two-fold; by decreasing the abnormalities throughout the process and by improving the reduction cell control quality. At the end of 2019, the project investment will amount to around RUB20m (USD311,000).

**SPAIN:** At the end of July Alcoa completed the deal with Parter Capital Group in Switzerland, for that firm to acquire Alcoa’s Avilés and La Coruña aluminium plants. The acquisition includes the casthouses at both plants and the paste plant at La Coruña, which are currently in operation, and the curtailed smelters at both plants. Parter Capital has proposed reindustrialization projects for both sites and a potential restart of the plants’ smelting capacity.

**TAJIKISTAN:** In April Tajik Aluminium Co. (Talgo) announced it will get a facelift by China’s state-owned engineering company CMEC. The refurbishment cost will be some USD545m. The contract between CMEC (China Machinery Engineering Corp.) and Talco was signed in April. Details on how Talco would finance the deal were not revealed. Over the past years, the smelter’s annual production dwindled significantly.© Hydro

Hydro’s technology pilot in Karmøy
Ma’aden Aluminium implements 8Sigma MES solution for automotive sheet plant

Ma’aden Aluminium, one of the largest aluminium groups in the Middle East, decided to digitalize its automotive sheet plant by implementing a Manufacturing Execution System (MES) from 8Sigma. Ma’aden decided in favour of the 8Sigma MES because the company has already proved its expertise in the metals industries.

The cooperation is an integral part of Ma’aden Aluminium’s plan to digitalize the complete production processes in its rolling mill, which produces aluminium coils for the automotive industry. The cooperation agreement, which was signed in July 2019, refers to the first phase of the implementation of the 8Sigma MES solution in the factory in Ras Al Khair Industrial City and will be put into operation during 2020.

According to this agreement, the implemented MES will enable the factory’s staff and management to have a quick and real-time overview on all production steps. It will provide them with the capability to track the product from the very moment when it enters the plant as a raw material to the moment when it is ready for delivery to the end customer. Some of the most important benefits of implementing the MES solution will be the increase in product quality and process optimization, as well as the possibility to compare employees’ performance and control machine efficiency.

“We expect a quick and efficient implementation of the MES solution by 8Sigma that will bring Industry 4.0 to the automotive part of our complex and support us in further digitalization activities that we have been implementing from the very beginning of our plant. It will help us to increase quality control and also to strengthen our leading position on the market,” said Ma’aden Rolling’s operation director, Abdulaziz Al-Ruwaily.

Signing the cooperation agreement with one of the largest integrated aluminium complexes in the world is an additional proof of the quality of 8Sigma. On the occasion of signing the agreement, Marko Šatrak, director and co-founder of 8Sigma, said: “It is a great honour to be a partner of a leading company in aluminium production and to support them in their further development. The implementation of 8Sigma MES is a confirmation of Ma’aden’s tendency to be a state-of-the-art company focused on reaching the highest product quality and achieving the most challenging business goals.”

As a supplier of primary aluminium and rolled products, the Saudi Arabian company includes the development, design, construction and operation of two sites integrated in a mine-to-metal network. Since 2009, it has been a joint venture company with Alcoa. Only recently, in June, Alcoa announced that it will divest its 25.1% minority interest in Ma’aden Rolling Company (MRC).

8Sigma is a premium MES supplier based in the EU and established by software experts with valuable experience gained in developing MES solutions in the factories on five continents. Their 8Sigma MES is adjustable to all types of manufacturing industries and various plant sizes, as it is very configurable and at the same time user-friendly solution. It also provides clients with a wide range of benefits and features, such as immediate factory visibility, automatic comparison or results and targets, proactive maintenance, downtime analysis, standardization of production and better planning.
Gautschi Engineering: Technologically up to the mark with the best market participants

With its product range, which covers melting and holding furnaces, casting machines and heat treatment units, Gautschi Engineering GmbH in Berg, Switzerland, has established itself as a comprehensive equipment supplier for aluminium cast-houses. ALUMINIUM spoke with Robert Schmidt, managing director Operations & Sales at Gautschi Engineering, about the company’s product range, technological further development and new products – and about collaboration with its sister-companies within the Ebner group.

Gautschi offers melting furnaces of various designs – round and rectangular, stationary or tilting, up to a furnace capacity of 140 tonnes. The focus is on large round top furnaces, for which the company holds a strong market position and has numerous references.

A majority of the melting aggregates sold in the recent past are large-capacity round top furnaces charged from above by charging buckets. The charging buckets can hold up to 35 tonnes of charge material consisting of clean scrap, for example ingots, head and foot discards cut from rolling bars, edge trim scrap or complete coils.

These furnaces make an excellent fit for new, large plants like rolling mills. China above all has been an important sales region for such furnaces in recent years. China Zhongwang, one of the largest aluminium rolling plants in the world, has bought about 50 Gautschi round furnaces of various sizes, ranging from 45 to 120 tonnes, over the past years.

Currently, Gautschi is engineering the complete casthouse for the new rolling mill for Braidy Industries, planned in Kentucky, USA, including round melting furnaces and casting lines for rolling bars.

The round melting furnaces are equipped with high energy-efficient regenerative burners, developed by Gautschi and marketed under the name Varega. “Besides their high energy efficiency, our Varega burners are noted for comparatively long service life, so that the worn heat-store components need to be replaced less often,” explains Schmidt. “At present the burner head is being modified so that even strictest emission values planned for the future will be complied with.”

The regenerator is also being developed further by Gautschi. “We want to use our burners not only in large round melting furnaces, but also in smaller melting aggregates with capacities up to 20 tonnes, and to be able to deliver different types of regenerators.” On the burner development work Gautschi is collaborating with the Gas Technology Institute of Freiberg (DBI) and the R&D department of Ebner.

© Gautschi
Gautschi offers both oval and rectangular holding furnaces with a bath capacity of 20 to 140 tonnes. The oval variant has less free volume in the furnace chamber and has advantages in relation to temperature control, with Gautschi cold-air burners, giving very tight temperature tolerances.

For Novelis Pindamonhangaba in Brazil, which is currently increasing its capacity, Gautschi is supplying two 85-tonne round top melting furnaces, a holding furnace and the casting frame for the casting machine.

Gautschi supplied a rectangular 35-tonne melting furnace with some special features to Neuman Aluminium in Austria in 2019. With this furnace Neuman is able to melt internal scrap still containing small proportion of paint, chips and extra-long profile scrap. An extra-wide ramp for vaporizing organics, oxygen lances and a side box for chip melting are Gautschi features making this possible.

Cooperation with HPI and GNA

The special chip melting side box has also been installed at complete casthouses installed by Gautschi and its Ebner group sister company HPI, which is the number one supplier of horizontal casting units for forging billets. The chips, produced at peeling the casted billets, are conveyed to a closed side-well, in which a mechanical stirrer produces a vortex which draws the chips down into the bath. An electromagnetic stirrer under the furnace leads the molten chips out of the chip box into the main bath. A 20-tonne furnace of this type has recently been installed for a Chinese customer.

Since June 2019 the Canadian company GNA in Saint-Laurent, Quebec, is also part of the Ebner group. GNA also supplies melting and holding furnaces as well as heat treatment units to the aluminium industry. Schmidt explains that GNA is very well suited for the group. They add specific know-how on recycling contaminated scrap furnaces, both multi-chamber furnaces and rotary furnaces. They have a strong position in the USA for both smaller rectangular furnaces and homogenization box furnaces. “The combination GNA, HPI and Gautschi is in every aspect a full solution provider for the aluminium casthouse,” says Schmidt.

In the meantime, HPI and Gautschi have started building a Casting Technology Centre in Ranshofen, Austria, which will be operational at the beginning of 2020. Not only vertical and horizontal casting machines will be installed but in future also continuous casting of sheet and plate will be possible.

Schmidt points out that for work safety reasons many older casthouses will have to upgrade to hands-free casting in the foreseeable future. For hands-free casting both a mould which does not need any human interference during casting and 100% reliable automatic operation are necessary. “Nowadays that is technically not a problem. The control of the molten metal in the moulds can be carried out fully automatically. This not only ensures safety at work, but also improves the reproducibility and therefore the quality of the product,” says Schmidt. Such an automatic control system is a standard feature in Gautschi’s sales programme.

Together with HPI, which offers a broad range of casting equipment (e.g. charging machines, casting launders, horizontal continuous-casting units, ultrasonic testing equipment), Gautschi can supply complete casthouse equipment.

A further important step is that of bringing existing casthouses up to the latest state of the art. Gautschi also offers that possibility. In times to come such refurbishments will attract more and more attention.

Gautschi casting mould

Vertical D.C. casting machines for billets and rolling slabs are a core product for Gautschi. “The Gautschi mould, developed together with specialists from the industry including main aluminium rolling companies, is a fine example,” says Schmidt.

The request from Aleris for a 100% hands-free casting guarantee and a lower butt curl with hardly any butt swell enhanced the already start of Gautschi’s mould development programme. At the Aleris plant in Belgium the moulds have been successfully tested and are now used in normal operations. Next year another casting machine will be turned over to the Gautschi mould system. “Here, we have achieved outstanding results with our new moulds,” stresses Schmidt. “We have also already been able to demonstrate this to other noted aluminium product manufacturers.”

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A further important step is that of bringing existing casthouses up to the latest state of the art. Gautschi also offers that possibility. In times to come such refurbishments will attract more and more attention.
Heat treatment: advantages of the Compact Coil Furnace

For heat treatment equipment Gautschi is in competition with its parent company Ebner, as far as pusher-type furnaces and chamber furnaces for coils are concerned. Chamber furnaces for billets are supplied by GNA. Gautschi concentrates on pusher-type furnaces, soaking pit furnaces and the Compact Coil Furnace (CCF). For the new automotive line of Novelis in Guthrie, Kentucky, which will begin operating in 2020, Ebner will supply the floater furnace while Gautschi has been awarded the contract for a batch-type annealing furnace for aluminium sheet, including a charging machine.

The Compact Coil Furnace is a relatively new Gautschi product, designed as an alternative to both a multi-coil chamber furnace and the single-coil overhead furnace. Whereas a chamber furnace is charged with several coils, the CCF is a single-coil furnace which in its structure and mode of operation “offers economic advantages both when purchasing it and in operation,” says Schmidt.

“The Compact Coil Furnace is noted for its great flexibility. Coils of different sizes can be annealed, whereas in a chamber furnace the coils charged must all be of the same size in order to ensure uniform heat transfer. Due to the fact that its space utilization is optimally adapted to the coil, temperature control is improved. Energy savings of 75% in holding operations can be achieved, as has been demonstrated in trial annealing operations. The furnace is equipped with highly efficient recuperative burners, and circulation fans fitted on the end walls on both sides ensure uniform, all-round heat distribution,” explains Schmidt.

A further advantage of the furnace is the low weight of only around 25 tonnes; therefore it does not need any special foundation. The furnace can be charged with a normal indoor crane, therefore a charging machine needed for an overhead furnace is not necessary. Being a single-coil furnace, the annealing process can be started directly after charging and the next CCF is charged. Furthermore, the furnace can be operated fully automatically, which makes sense particularly when several furnaces are being used.

When several CCFs are being used the customer can also combine them optimally for different coil widths. “And during its lifetime: the coil width can be changed, by replacing the central portion and the CCF chamber enlarged with just a few additional adaptations,” he says.

Customer service: the face to the customer

Besides the sale of new equipment, Gautschi also offers the option of customer services. “In that way we can support the customers in a targeted manner,” says Schmidt. Particularly in new projects the casting test facility in Ranchofon will enable Gautschi in future to carry out casting tests and special casting training directly in a functioning plant. “This is a very important step for being able to introduce the customer to the whole field of casting in the best possible way,” he remarks.

These are exciting times for Gautschi, in which the company will score highly with its new developments.
New protections against potline freeze for aluminium smelters

M. Wiestner and W. M. Lauwrens, ABB

During the past years, many smelters have experienced incidents leading to damage to their potrooms or worse, total shutdown of the potrooms, leading to very high financial loss and insurance claims. To protect such costly assets, the installed and available protection systems have proven to be inadequate: smelters need independent redundant, state-of-the-art and standalone systems, meeting the highest standards of protection in order to safeguard their multibillion assets. ABB has developed new protection systems which can prevent such incidents, and can lift up the protection concepts to state-of-the-art with Industry 4.0 expansion capability.

Events leading to potline shutdowns

There are several different categories of events, which can lead to a potline shutdown.

- Loss of power generation or power supply from the utility for more than about five hours
- Short-term power disturbance, leading to potline trip and to restart issues
- Potline operation issues leading to open circuit in the potroom
- Auxiliary power failure supplying medium and low voltage to potline services
- Power conversion station failure.

The power supply, distribution and conversion area must be designed to provide uninterrupted power to the potline. This requires installing backup systems with automatic changeover on all levels from utility overhead line, power generation, and high voltage switchgear, all the way down to 220 VAC distribution redundant systems. State-of-the-art power systems even have an N-2 design for critical areas. N-2 operation means that two circuits or subsystems can fail, but there is still sufficient power for 100% production of the potline.

Standard protection design for smelter power systems

Following on of the concept of N-1 or N-2 backups in power circuits and power conversion rectifier, their sub systems, again have redundant protections circuits and overlapping protections. As an example, if the converter over-current fails to see the overcurrent, then the transformer protection would take care to clear the fault. But should both protections fail to operate, then the switchgear protection is set up to disconnect the unit from the substation.

In a utility grid, it is now standard to have redundant protection systems from different suppliers. Even when the input parameters and function description are the same, the purpose is to ensure that although one system may be disabled or hacked, the other will more likely survive.

Another example would be that if one has an voice-activated house door in the Artic, then one should still carry a key to open the door in case the voice activation has failed.

Weaknesses in the design and limitation of existing potline protections

A thorough review is called for if the current potline protection relies on any of the following situations:

- Only one protection system, no backup
- Dual system only looking at the same parameter
- Limited performance during potline restart. (This is the most important time

- N-1 and N-2 Rectifier
- 2 Servers
- Overcurrent and back up
- Zone 1 Zone 2
- Rectifier overload
- Rectifier Tx overcurrent
- Regulation Tx OC + back up
- SWG OC, Zone 1-2

Fig. 1: Power conversion station redundant protection design
when they should work!)

- Slow sampling rates, limited of data analyses and trending
- Limited ability to distinguish different operation and failure modes
- No standalone, independent protection
- OCP protection systems and ground fault detection not available or not optimized.

**Design requirement for open circuit protection (OCP)**

Many different potroom disturbances are possible, and one disturbance may lead to another. Industry feedback sums them up in following categories:

- Leaking pot with ground connection
- Leaking pot without ground connection
- Tapping error by human
- Pot control error
- Pot busbar connection failure
- Multiple anode disconnect
- Other.

The OCP needs to be able to detect any potroom disturbance, or the trend to one, as early as possible. At the same time no false alarms or even pot line trip shall be allowed, as operation staff then will not trust the protection. As most disturbances happen during restart or start-up of the potrooms the OCP needs to be active and reliable during this phase of potroom operation.

**New open circuit protection design**

ABB’s new protection detects changes of the potroom resistance within milliseconds, and distinguishes the different potroom disturbances. To be able to recognize and differentiate between the disturbances, the OCP needs to receive high quality input signals: potline voltage, potline current and ground resistance need to be available on the same time base and with a very high sampling rate per second. ABB’s potline DC measurement with Fibre Optic Current Sensor (FOCS) technology allows such high accuracy, same-time measurements. These signals then connect the I/O cards of the OCP high speed processor. Here again, the I/O cards are capable of the same high speed, same-time sampling rate. The processor then uses these signals to determine the current state of the potroom operation and differentiates the different disturbances. High speed and real-time data acquisition is required to predict risks of these anomalies, well before they develop into serious potroom disturbances.

© ABB
Potline simulation and event management OCP

The OCP has a built-in potline simulator which allows testing during normal operation as well as simulation of new operation points or of operation modes of the potline before these are implemented.

The new protection system detects changes of the potroom resistance within milliseconds. The graphs in the upper part of Fig. 4 show OCP reaction to the potline simulator input signals, with the master regulation set points and return loop signals already compensated. The graphs in the lower part of Fig. 4 show the tap up and tap down response to different step inputs. The dynamic functions of the OCP will override or complement/supplement the traditional potline current and voltage trip set points if they are seen as not compatible with the detected potline operation status. After the installation, the OCP will be run in the voltage and current mode, with the addition of a dynamic (potline operation) learning mode. The learning mode will send a trip signal to the data logger but will not activate a trip of the potline.

Tuning: After the learning period and templating has been completed, our commissioning expert will return to the plant (after 3-6 months). He will analyze the trip initiations and operation modes with the customer’s expert team and then implement the trip matrix selection.

OCP addition with ground protection

The Process Earth Resistance Monitoring System (PERMS) is a unique monitoring system to measure the earth impedance of a floating potroom system. With PERMS it is possible to continuously monitor the resistance between the process and earth. The system will give a warning if the resistance value drops below a defined level, and it interfaces with the OCP to identify which potroom disturbances may develop.

In addition to the OCP protection inputs, the PERMS can be used as a safe working area monitoring device to protect personnel and potroom equipment such as cranes.

To detect earth fault currents, it is necessary to measure the impedance between the DC voltage system and earth. The continuous monitoring also helps to plan for predictive maintenance of the potroom insulation system.

The resistance to earth depends on the dirt, dust and moisture between the DC process and earth. Leaking of hot metal (‘run out’) can cause low resistance paths to earth. The insulation between high current carrying busbars (‘collector busbars’) and earth is critical for the safe operation of the smelter. The resistance values are recorded in the OCP historical memory.

Metering design

The metering principle of PERMS is based on a modulated AC voltage. This measuring voltage is generated with help of the AC 800PEC controller, and it is applied between the process and plant earth without making an earth connection for the DC process. There is a very low and safe current flowing through the process, to earth and back to the measurement system.

The measured impedance and the phase shift allow PERMS to calculate the real resistance and capacitance.

Design parameter of the PERMS monitoring

- Monitors resistance and capacitance to earth in the potroom, with signal exchange to the OCP for detection and trending of any potroom distortion evaluation
- Can be used for process voltages up to 2000 V DC
- Can detect an earth fault behind the active components (AC part of the rectifiers)
- High speed location of the leaking pot or of the busbar to ground connection.

Conclusions

Potline open circuit and pot-to-ground monitoring is crucial to prevent potline damage or shutdowns ending up in outrageous financial cost. Smelters need to install redundant monitoring and protection systems to supervise all aspects of the process. This electric power security has not been supervised in the past to the level which has been standard for years in other systems at the smelters. Almost all other areas within the smelters have been given a redundant and back-up system design. However in the potrooms such redundancy and multiple monitoring and protection has not so far been implemented. Independent, redundant and standalone potroom protections and monitoring systems with industry 4.0 capabilities will help to prevent or reduce potline shutdowns.

Authors

Max Wiestner has been working with ABB since 1979. He has a degree in electro mechanics and project management from state college Switzerland and ABB Fläkt University. His current position is industry manager Aluminium. Previous positions included: global product group manager Aluminium, industry manager Primary Aluminium with ABB Switzerland, manager Rectifier Plants for the Americas’s, sales and product manager rectifier systems for steel plants, and sales manager HV substations ABB Zimbabwe.

 Wynand Lauwrens has been working with ABB since 1994 and as High Power Rectifier specialist since 2002. He has a degree in electrical engineering from the University of Pretoria. His current position is senior HPR engineer with ABB Switzerland. In this position he developed the potline grounding monitoring system PERMS and the potline simulator, based on open circuit protection OCP.
Furnace optimization through in-house improvements

T. Phenix, GNA

Irrespective of the process, whether continuous casting, direct chill casting, foundry casting or back yard sand casting, the one common thread that connects them all is the furnace. Furnaces are the workhorse in every casthouse. Because of the nature of the process, the furnace is also typically treated the most aggressively, and it receives the least attention compared to the rest of the systems in the operation. The result is that the performance, efficiency and overall condition of the furnaces often deteriorate over years in service.

When casthouse optimization is considered, most companies will look at the bottleneck in the process, and so will focus their attention on improving the performance of that critical path system. When the bottleneck is the furnace, it is not uncommon for producers to focus on upgrades or modernization of the furnace, rather than on considering the drop in performance since the furnace was first installed. Many furnaces in operation today are decades old, but with the correct utilization and practices, they can still operate efficiently, even without investing in enhancing devices like stirrers and state-of-the-art burner systems.

Closing on metal-covered sills: all of these lead to deterioration of the furnace refractory, especially around door sills, lintels and jambs. It is not uncommon, when walking into any casthouse, to see gaps between doors and their seating damaged refractory and emissions or even flames pushing out around the door. Typically this situation does not receive attention until there is a planned shutdown, so the furnace may operate for many months in a bad, or typically, a gradually worsening state of repair. Not only does this bad condition lead to a less efficient furnace, lengthened cycle times and increased melt losses, but furthermore, the hot spots around the door can cause localized deformation of the door and of the furnace structure itself, leading to poor sealing, even after a repair of the refractories.

Many plants will attribute the blame for mechanical abuse on the operators, saying they are heavy-handed and clumsy when charging the furnace. Although true in some cases, it is not typically the mentality of the operator to cause undue damage to equipment. Rather, they are simply trying to do the best with the tools and the conditions they have available. Using a fork truck to operate a boom that may be as long as 6 metres, with the associated flex and bounce, in order to try and skim or clean a furnace: that already takes a skilled operator to master it. Add a potentially uneven floor, with scrap and debris on it, and a tool that maybe only a few centimetres less high than the door opening, and it becomes clear how damage can occur. Charge cars, custom charging machines and automated skimming machines can minimize or even eliminate this form of mechanical damage. However, these machines are expensive, and the layout of the furnace bay may not give enough space to install automated machines.

In these cases, re-evaluation of the existing furnace tending practices and developing in-house solutions can provide an effective alternative. A furnace bay floor that is regularly maintained and kept clean of scrap and debris minimizes tool bumping. Tools that are correctly designed can also minimize bounce and flex. Typically, the channels on the tools that mate with the truck forks are oversized to ease engagement. However, this loose fit also loosens control of the tool when in operation, so it is important to consider whether tool engagement or its use is most important.

The correct geometry of the tool head can also improve the simplicity of the furnace tending process, and can minimize the risk of unintentional impact on refractories.

A common argument heard recently is that natural gas prices are at a historical low, so
producers are not concerned about burner efficiency, as this is considered to have a minimal impact on the operation’s bottom line. This may be a valid argument when considering fuel cost alone, but it fails to take into account the indirect costs and the lost opportunities associated with poor burner operation, control and maintenance. Reduced burner power can often increase furnace cycle times and so reduce the number of production cycles on the downstream equipment. Today it is surprisingly common to hear experienced operators say that in the past they used to be able to get more cycles from their furnace than they do. The blame is typically placed on the furnace crews now operating the equipment. Gaining an extra cast, or even a portion of a cast a day, equates to a considerable production increase over the entire year, and for minimal expense. This is possible simply through burner maintenance and proper practice in a 24/7 operation.

Less easy to calculate, but still a critical factor in any casting operation’s profitability, is the effect of burner tuning on melt loss. A wide range of products and services are available today to recover a good percentage of the aluminium trapped in the dross. But typically to little attention and time is spent focusing on reducing the amount of dross generated in the first place, compared with the effort to recover metal from the dross sent to recyclers. Irrespective of the type of furnace charge, the amount of dross generated in a furnace can be directly associated with the overall combustion system efficiency and with the operating practice. This efficiency itself is a combination of the burner air-fuel ratio control, the damper system for furnace pressure control, the furnace sealing, burner condition, control strategy and refractory condition. All of these parameters are readily controllable by operating crews, maintenance crews and burner service technicians.

Metal quality is another factor impacted by poor burner efficiency. In addition to increased melt losses, the quality of the molten aluminium is directly influenced by burner performance. In one GNA installation using regenerative burners and producing high quality products, the quality control department noticed that the hydrogen content in the metal as it left the furnace could be used as a reliable indicator of the condition of the media beds, and indicated when the beds needed cleaning/changing. As with all in-line degassing systems, the hydrogen removal efficiency is influenced by the amount of hydrogen entrapped in the incoming metal. Therefore, if the incoming levels can be minimized by optimized furnace operation, then the final product will have a lower hydrogen content, which can be a significant factor in critical end-use products.

Existing, older furnaces can significantly benefit from an upgrade to a modern PLC control system. A PLC-based control system can improve all aspects of the furnace operation, including operation, efficiency, maintenance, safety and monitoring. The modern PLC can monitor and control the air-fuel ratios and the burner control parameters to automatically regulate burner operation, to change control modes as required, to prevent furnace or bath over-temperature, and to enhance safety through flame detection and associated monitoring capabilities. Linked to an inline pressure and temperature compensated gas meter and to a Scada system, the historian capability of the PLC system can determine whether changes in furnace performance are operator-influenced or result from maintenance or burner-related situations.

Standard operating practices tend to change over the years; some of these changes are good, but often they have more of a negative than positive impact on furnace performance. Despite changes in casthouse management, and the need to best adapt charging methods to scrap types, nevertheless production requirements and numerous other reasons can freeze furnace operation practices into the “well this is the way we have done this for years” category. Similar to safety training, there should be refresher courses and training / retraining adopted for furnace operators explaining the latest techniques and best practices. The benefits are seen not only in furnace efficiency. Also the safety aspects and potential hazards of furnace operation justify conducting regular, scheduled training of operators and crews.

As identified in the opening paragraph of this article, any casthouse operation depends entirely on the availability of the furnace. If the furnace is out of operation for any reason, this directly impacts production. The melting furnace is exposed to the most arduous duty and toughest environment, there is a significant probability that failures (whether mechanical, electrical or otherwise) will occur. Preventative maintenance is a critical need with prolonged furnace operation. Failures with the furnace are often the result of hot spots on the furnace, where refractory construction has been compromised through wear, damage or movement. These hotspots can burn control or power cables, or hydraulic lines, or they can even cause catastrophic failure of the overall furnace integrity, resulting in metal leaks and representing a potential explosion risk. Regular inspection of the furnace casing to detect hot spots is a practice that takes only a few minutes. In the same way that a commercial pilot inspects the exterior of the aircraft prior to flight, in many ways this furnace inspection is equally critical.

Despite inspections and a robust preventative maintenance program, there is still a risk of downtime from mechanical damage, refractory failure or hydraulic, fan or electrical failure. It is essential to have an inventory program with critical spare parts, so as to prevent lengthy downtime. The furnace supplier, the
refractory installer and the plant’s own maintenance and operating crews can readily develop a list of recommended spare parts, and it is then the role of management, purchasing and warehousing to ensure a sufficient stock and the correct storage of these parts, especially temperature-critical refractory parts.

In conclusion, the furnace-enhancing devices available on the market today are well proven and valuable tools to improve casthouse efficiency. In many cases, it is advisable to review existing furnace practices before investing in new systems. In many cases considerable improvements can be made without major investment, so these improvements should be benchmarked and used as a basis to implement further improvements. Without this preliminary step, the advantages of new systems may not be fully realized, and they may not achieve the expected return on investment.

Here is a list of ideas and activities that have proven to give positive results, and they should be considered in the operation of melting and holding furnaces:

- Regular casthouse review for operator and maintenance personnel safety and comfort
- Self-evaluation process to determine the best practice for your operation
- Execution of the best practice, so instilling self-discipline and motivation in the operators
- Review thermocouple choice and location for bath, roof, flue system and hearth refractory temperature control and monitoring
- Review of tools, strategies and frequency for furnace charging, skimming and cleaning
- In-house support and planned maintenance activities, with check that critical spare parts are on hand
- Re-profiling the furnace refractory lining; this can readily increase the furnace capacity, for example upgrading a 55-tonne melting/holding furnaces to 60 tonnes
- Challenges for management – how to face them and how to convince the operating and maintenance staff of the benefits that changes can bring to the casthouse
- Monthly BBQ for the casthouse staff.

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First attempt to break the 10 kWh/kg aluminium barrier using a wide cell design

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In his last year ALUMINIUM article [1], the author selected breaking the 11 kWh/kg cell energy consumption barrier as short-term design goal, as a step toward ultimately breaking the 10 kWh/kg cell energy consumption barrier. In the study presented in that article last year, the lowest value of 10.85 kWh/kg Al was obtained using the 100% downstream side current extraction cell design. In his upcoming TMS 2019 paper [2], the author continues working exclusively on that 100% downstream side current extraction cell design, and this time he reached 10.44 kWh/kg Al. In the present study, the author this time shifted to working exclusively on the wide cell design, as presented in an ALUMINIUM article two years ago [3], in this first attempt to break the 10 kWh/kg cell energy consumption barrier.

The modeling and design work presented in this article is part of a continuing effort to design a cell operating at the lowest possible cell energy consumption. The initial results were first reported in a TMS 2017 paper [4] and were then reported in [1], [5] and soon in [2].

As discussed in the section Comparison of the two very low energy consumption cell design options in [5], at the same ACD and anode current density, the 100% downstream side current extraction cell will operate at a lower cell voltage than the wide cell. That could be considered as an advantage to produce the lowest possible cell energy consumption cell design.

Yet, as first reported in [3], the wide cell reduced the heat loss per unit production. So at a given cell ACD, anodic current density and corresponding cell internal heat per unit production, the wide cell design will systematically produce a cell operating at the highest cell superheat for the same lining design.

Technically, there is nothing preventing the reduction of the anode current density that would correspond on a cell operating at 10 kWh/kg. Using the 100% downstream side current extraction cell presented in [4], that anode current density was calculated to be about 0.64 A/cm².

On the other hand, there is definitively a limit on the lowest possible cell superheat a cell can be operated at. Not surprisingly, it turned out that this cell operation parameter is one of the key parameters limiting the reduction of the cell energy consumption. In that context, the wide cell is the better of the two cell design options to attempt to break the 10 kWh/kg cell energy consumption barrier.

Modelling and design methodology

Since the very beginning of this effort to design a cell operating at the lowest possible energy consumption, and even before that, the author relied on four different modelling tools: HHCellvolt, Dyna/Marc, MHD-Valdis and 3D ANSYS based thermo-electric anode and cathode models to perform his studies.

HHCellvolt developed and commercialized by Peter Entner [6] is the best modelling tool available to very quickly produce a cell layout, such as the one presented in Fig. 1 for the current wide cell design. HHCellVolt is also the perfect tool to calculate directly from enthalpy data how much more energy is
required to operate the cell compared with the minimum energy required to produce the metal. That subject was recently covered in [7], and will be discussed again in [2]. HHCellVolt is also the most up-to-date tool to compute the cell voltage, based on inputs for the anode, cathode and busbar ohmic resistances, and on the choice of ACD, bath chemistry, bubble model and cell amperage. HHCellVolt finally computes the cell internal heat, based on the calculated cell voltage and energy requirement to operate the cell. It reports this numerically and graphically, generating a Haupin Diagram such as the one presented in Fig. 2 for the initial wide cell design operating at 762.5 kA [3].

The next tool required is the steady state part of the Dyna/Marc cell simulator, developed and commercialized by the author [8]. Dyna/Marc is for solving the cell heat balance. It is based on additional inputs including: the anode panel heat loss, the cathode bottom heat loss, the bath and metal level, some lining material thickness and thermal conductivity. From these, Dyna/Marc will calculate the cell superheat as well as the bath and the metal ledge thickness.

3D ANSYS-based thermo-electric anode and cathode models developed and commercialized by the author [9] are used to compute the anode and cathode voltage drop and the anode and cathode heat losses. The 3D ANSYS-based thermo-electric cathode model also calculates more accurately than the Dyna/Marc the cell ledge profile using the user-defined cell superheat.

Finally, MHD-Valdis, the MHD cell stability solver (developed by Valdis Bojarevics from Greenwich University and commercially available through the author) is used to design the cell busbar and to analyze the corresponding cell stability. MHD-Valdis will directly compute the busbar voltage drop, but the busbar network generated by MHD-Valdis can also be converted into an ANSYS model to compute the busbar voltage drop.

**Reducing the metal pad thickness from 20 to 10 cm**

It is quite well known that reducing the metal pad thickness is a very efficient way to reduce the cell heat loss at a constant cell superheat. Because the initial wide cell design was operating at a quite high anode current density, a typical value of 20 cm was selected for the metal pad thickness. All the 3D ANSYS-based thermo-electric runs and MHD-Valdis cell stability runs up to now were done using that metal pad thickness value.

It is also well known that reducing the metal pad thickness reduces the cell stability because it increases the metal pad horizontal current. Yet, since there is a need to reduce that cathode side wall heat loss without further reducing the cell superheat, we decided to investigate the effect of reducing the metal pad thickness from 20 to 10 cm. By using huge copper collector bars there is essentially no horizontal current in the metal pad, and so there is a minimum risk of destabilizing the cell by reducing the metal pad thickness, but this of course must be confirmed by an MHD-Valdis cell stability analysis.

**MHD-Valdis cell stability analysis at 570 kA and 10 cm of metal pad thickness**

At 762.5 kA, the amperage selected for the initial wide cell design two years ago, the anode current density is 0.93 A/cm². At 650 kA, the amperage selected last year, the anode current density is 0.81 A/cm² and the cell energy consumption is at 11.0 kWh/kg Al. It is clear that further decreasing the cell energy consumption requires further decreasing the cell amperage. To run the MHD-Valdis cell stability with 10 cm of metal pad thickness, we selected a cell amperage of 570 kA which corresponds to an anode current density of 0.71 A/cm².

The resulting metal pad horizontal currents are presented in Fig. 3, and the corresponding metal pad flow field in Fig. 4. The busbar drop is calculated to be 112 mV.

**3D ANSYS-based thermo-electric results at 570 kA**

On the anode side, the only change to the design was a refinement that limits the anode stubs heat loss. This feature will be revealed in the author’s TMS 2019 paper [2] but not in this article. Using that anode design at 570 kA, together with the new boundary of the cell described in [2], the model predicts an internal anode drop of 207 mV and an external anode drop of 78 mV. The heat loss of the internal part of the anode is predicted to be 221 kW.

On the cathode side, three changes were made: the metal pad thickness was decreased to 10 cm; the ramming slope was decreased accordingly; and the design feature that is limiting the collector bars...
heat loss was also refined. Using that cathode design at 570 kA, and with the new boundary of the cell, the model predicts an internal cathode drop of 97 mV and an external cathode drop of 49 mV. The heat loss of the internal part of the cathode, at 7 °C of cell superheat, is predicted to be 417 kW.

**Dyna/Marc global analysis of the wide cell design at 570 kA**

Using many of the above results as inputs, Dyna/Marc is used to calculate the steady-state cell conditions at 570 kA and 2.8 cm ACD. Table I presents the Dyna/Marc results summary. This predicts the cell voltage to be 3.36 V, the cell internal heat (using Haupin’s equation to calculate the equivalent voltage to make the metal) is 613 kW at the calculated current efficiency of 94.4%, and the cell superheat is predicted to be 7.5 °C. Finally, the cell power consumption is calculated to be 10.61 kWh/kg, still quite far from 10 kWh/kg!

**MHD-Valdis cell stability analysis at 530 kA and 10 cm of metal pad thickness**

The good news is that, when compared with the solution at 650 kA presented in [1], the reduction of the metal pad thickness decreased the cell internal heat from 804 to 613 kW, while maintaining about the same cell superheat around 7.5 °C. Assuming that it is possible to operate the cell at 5.0 °C of cell superheat, the next step is to simply reduce the cell amperage until we reach that value of cell superheat. That cell amperage turned out to be about 530 kA, which corresponds to 0.66 A/cm² of anode current density. Fig. 5 shows that the busbar drop at 530 kA is calculated to be 104 mV. There is no need to report the rest of the MHD-Valdis cell stability results, as an operation at 530 kA would be more stable that an operation at 570 kA, unless the ledge toe growth gets problematic, which is not the case.

**3D ANSYS-based thermo-electric results at 530 kA**

Using exactly the same anode design at 530 kA, the internal anode drop is predicted to be 191 mV and the external anode drop, which includes the studs outside the crust, the yoke and the rod is predicted to be 72 mV. The internal anode heat loss is 218 kW, which includes only the heat loss of the crust surface by convection and radiation, and the heat loss of the studs by conduction where they exit the crust.

### Table 1

<table>
<thead>
<tr>
<th>Steady State Solution</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell amperage</td>
<td>570.8 [kA]</td>
</tr>
<tr>
<td>Anode to cathode distance</td>
<td>2.80000 [cm]</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>966.064 [°C]</td>
</tr>
<tr>
<td>Ledge thickness, bath level</td>
<td>8.90869 [cm]</td>
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<tr>
<td>Ledge thickness, metal level</td>
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<tr>
<td>Bath chemistry:</td>
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<tr>
<td>Cryolite ratio</td>
<td>2.28470 [mol/mol]</td>
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<tr>
<td>Bath ratio</td>
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<tr>
<td>Conc. of excess aluminum fluoride</td>
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<tr>
<td>Conc. of dissolved alumina</td>
<td>2.80000 [¥]</td>
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<tr>
<td>Conc. of calcium fluoride</td>
<td>6.00000 [¥]</td>
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<tr>
<td>Heat balance:</td>
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<tr>
<td>Superheat</td>
<td>7.1492 [°C]</td>
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<tr>
<td>Cell energy consumption</td>
<td>10.6072 [kWh/kg]</td>
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<tr>
<td>Total heat loss</td>
<td>612.952 [kW]</td>
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<td>Electrical characteristics:</td>
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<td>Current efficiency</td>
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<tr>
<td>Anode current density</td>
<td>0.708110 [A/cm²]</td>
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<td>Bath resistivity</td>
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<td>Cell pseudo-resistance</td>
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<td>Bath voltage</td>
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<td>Electroylsis voltage</td>
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<td>Cell voltage</td>
<td>3.35849 [V]</td>
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<tr>
<td>Voltage to make the metal</td>
<td>2.06522 [V]</td>
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### Table 2

<table>
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<tr>
<th>Steady State Solution</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Cell amperage</td>
<td>530.0 [kA]</td>
</tr>
<tr>
<td>Anode to cathode distance</td>
<td>2.80000 [cm]</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>961.560 [°C]</td>
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<tr>
<td>Ledge thickness, bath level</td>
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<td>Ledge thickness, metal level</td>
<td>9.09283 [cm]</td>
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<td>Bath chemistry:</td>
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<tr>
<td>Cryolite ratio</td>
<td>2.20470 [mol/mol]</td>
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<tr>
<td>Bath ratio</td>
<td>1.40253 [kg/kg]</td>
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<td>Conc. of excess aluminum fluoride</td>
<td>11.50000 [¥]</td>
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<tr>
<td>Conc. of dissolved alumina</td>
<td>1.80000 [¥]</td>
</tr>
<tr>
<td>Conc. of calcium fluoride</td>
<td>6.00000 [¥]</td>
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<td>Heat balance:</td>
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<tr>
<td>Superheat</td>
<td>3.8367 [°C]</td>
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<td>Cell energy consumption</td>
<td>10.2313 [kWh/kg]</td>
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<tr>
<td>Total heat loss</td>
<td>516.205 [kW]</td>
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<td>Electrical characteristics:</td>
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<tr>
<td>Current efficiency</td>
<td>94.3021 [%]</td>
</tr>
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<td>Anode current density</td>
<td>0.658418 [A/cm²]</td>
</tr>
<tr>
<td>Bath resistivity</td>
<td>0.450650 [Ω·cm]</td>
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<tr>
<td>Cell pseudo-resistance</td>
<td>2.99443 [micro-Ωm]</td>
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<td>Bath voltage</td>
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<td>Electroylsis voltage</td>
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<td>Cell voltage</td>
<td>3.21787 [V]</td>
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<tr>
<td>Voltage to make the metal</td>
<td>2.03436 [V]</td>
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</table>
The cathode design also remained the same. Fig. 6 shows the cathode side slice model mesh with the converged ledge profile at 5 °C of cell superheat, while Fig. 7 shows the corresponding temperature solution. The model predicts an internal cathode drop of 90 mV and an external cathode drop of 45 mV. The heat loss of the internal part of the cathode at 5 °C of cell superheat is 311 kW. About 40% of that cathode heat loss is going through the ledge, 35% escapes by conduction in the collector bars and the remaining 25% is going out down thought the cell lining.

**HHCellVolt model results at 530 kA**

At that stage, HHCellVolt can be used to calculate the cell voltage and the cell internal heat, assuming a value for the cell current efficiency. Fig. 8 shows HHCellVolt busbar panel where the user enters the anode, cathode and busbar voltage drop. That figure illustrates clearly the new boundary between the internal voltage drop and the external voltage drop. The external section goes from the site where the collector bars exit the cell to the site where the stubs enter into the anode cover material. Fig. 9 shows the HHCellVolt bath voltage drop results, these employ user inputs for the ACD, the bubble model, and the anodic current density, which is calculated from the anode layout presented in Fig. 1 at 530 kA cell amperage. Finally, the main HHCellVolt panel presented in Fig. 10 shows the global results corresponding to that user-assumed current efficiency.

**Dyna/Marc global analysis of the wide cell design at 530 kA**

Finally, using the same inputs (except for the cell current efficiency that is part of the solution), Dyna/Marc calculates the steady-state cell conditions at 530 kA and 2.8 cm ACD. Table II summarizes the Dyna/Marc results: it predicts the cell voltage to be 3.24 V, the cell internal heat (using Haupin’s equation to calculate the equivalent voltage to make the metal) to be 516 kW at the calculated current efficiency of 94.3%, and the cell superheat to be 5.0 °C. Finally, the cell power consumption is calculated to be 10.23 kWh/kg, not quite 10 kWh/kg unfortunately!

**Discussion and future work**

Table III summarizes the results of the four wide-cell designs presented so far, all using the same wide potshell platform. The cell operating at 530 kA, 0.66 A/cm² and 10.23
kWh/kg dissipates only 39% of the heat dissipated by the cell operating at 762.5 kA, 0.94 A/cm² and 12.85 kWh/kg. Both HHCellVolt and Dyna/Marc can easily predict the cell amperage needed to operate at 10.0 kWh/kg, assuming no other changes: the answer is 505 kA, 0.63 A/cm² and 436 kW of cell internal heat. This 436 kW represents only 33% of the heat dissipated by the cell operating at 762.5 kA and 12.85 kWh/kg, and only 84% of the heat dissipated by the cell operating at 530 kA and 10.23 kWh/kg.

This 15% extra reduction of the cell heat loss must be achieved without further reducing the cell superheat. It is also fair to assume that it would not be safe to further reduce the metal pad thickness. Yet, as can be seen in Fig. 6, after the reduction of that metal pad thickness there is now plenty of spare cell cavity. This cavity provides space to increase the thickness of the cell lining below the cathode block, and now new semi-insulating lining materials which resist sodium vapour have also become available. This combination represents an opportunity to design a more insulating cathode lining, and hence to reduce the cathode heat loss at constant cell superheat, with no risk of degrading the cathode lining by exposing it to high temperature and sodium vapour.

### Conclusions

Two extra steps towards the design of a cell operating at 10.0 kWh/kg Al have been presented in this article. The last step is the design of a wide cell operating at 530 kA, 0.66 A/cm² and 10.23 kWh/kg Al. That cell operates at the assumed lowest ACD of 2.8 cm, the lowest assumed metal pad thickness of 10 cm, and the lowest assumed cell superheat of 5 °C. That cell also operates at 25 cm of anode cover thickness, which may not be the thinnest possible, but must be quite close to it. Despite these steps, and together with refined design features to limit the studs and collector bars heat loss (more details on this will be presented in [2]), in the current study it was not possible to design a cell operating at 10.0 kWh/kg Al. Yet this milestone goal is getting more and more accessible, and should be reached quite soon now, still using the wide cell design option.

### Table 3

<table>
<thead>
<tr>
<th>Amperage</th>
<th>762.5 kA</th>
<th>650 kA</th>
<th>570 kA</th>
<th>530 kA</th>
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<tr>
<td>Nb. of anodes</td>
<td>48</td>
<td>36</td>
<td>36</td>
<td>36</td>
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<tr>
<td>Anode size</td>
<td>2.6 m X 0.65 m</td>
<td>2.6 m X 0.86 m</td>
<td>2.6 m X 0.86 m</td>
<td>2.6 m X 0.86 m</td>
</tr>
<tr>
<td>Nb. of anode studs</td>
<td>4 per anode</td>
<td>12 per anode</td>
<td>12 per anode</td>
<td>12 per anode</td>
</tr>
<tr>
<td>Anode stud diameter</td>
<td>21.0 cm</td>
<td>16.0 cm</td>
<td>18.0 cm</td>
<td>18.0 cm</td>
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<tr>
<td>Anode cover thickness</td>
<td>15 cm</td>
<td>25 cm</td>
<td>25 cm</td>
<td>25 cm</td>
</tr>
<tr>
<td>Nb. of cathode blocks</td>
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<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Cathode block length</td>
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<td>Type of cathode block</td>
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<td>HC10</td>
<td>HC10</td>
<td>HC10</td>
</tr>
<tr>
<td>Collector bar size</td>
<td>20 cm X 12 cm</td>
<td>20 cm X 15 cm</td>
<td>20 cm X 15 cm</td>
<td>20 cm X 15 cm</td>
</tr>
<tr>
<td>Type of side block</td>
<td>HC3</td>
<td>HC3</td>
<td>HC3</td>
<td>HC3</td>
</tr>
<tr>
<td>Side block thickness</td>
<td>7 cm</td>
<td>7 cm</td>
<td>7 cm</td>
<td>7 cm</td>
</tr>
<tr>
<td>ASD</td>
<td>25 cm</td>
<td>25 cm</td>
<td>25 cm</td>
<td>25 cm</td>
</tr>
<tr>
<td>Calcium silicate thickness</td>
<td>3.5 cm</td>
<td>6.0 cm</td>
<td>6.0 cm</td>
<td>6.0 cm</td>
</tr>
<tr>
<td>Inside potshell size</td>
<td>17.02 X 5.88 m</td>
<td>17.02 X 5.88 m</td>
<td>17.02 X 5.88 m</td>
<td>17.02 X 5.88 m</td>
</tr>
<tr>
<td>ACD</td>
<td>3.0 cm</td>
<td>2.8 cm</td>
<td>2.8 cm</td>
<td>2.8 cm</td>
</tr>
<tr>
<td>Anode current density</td>
<td>0.93 A/cm²</td>
<td>0.81 A/cm²</td>
<td>0.71 A/cm²</td>
<td>0.66 A/cm²</td>
</tr>
<tr>
<td>Metal level</td>
<td>20 cm</td>
<td>20 cm</td>
<td>10 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Excess AlF₃</td>
<td>11.50%</td>
<td>11.50%</td>
<td>11.50%</td>
<td>11.50%</td>
</tr>
<tr>
<td>Anode drop (A)</td>
<td>347 mV (T)</td>
<td>252 mV (T)</td>
<td>207 mV (I)</td>
<td>191 mV (I)</td>
</tr>
<tr>
<td>Cathode drop (A)</td>
<td>118 mV (T)</td>
<td>109 mV (T)</td>
<td>91 mV (I)</td>
<td>90 mV (I)</td>
</tr>
<tr>
<td>Busbar/External drop (A)</td>
<td>300 mV (B)</td>
<td>170 mV (B)</td>
<td>227 mV (E)</td>
<td>221 mV (E)</td>
</tr>
<tr>
<td>Anode panel heat loss (A)</td>
<td>553 kW (T)</td>
<td>339 kW (T)</td>
<td>221 kW (I)</td>
<td>218 kW (I)</td>
</tr>
<tr>
<td>Cathode total heat loss (A)</td>
<td>715 kW (T)</td>
<td>482 kW (T)</td>
<td>417 kW (T)</td>
<td>311 kW (I)</td>
</tr>
<tr>
<td>Operating temperature (D/M)</td>
<td>968.9 °C</td>
<td>966.5 °C</td>
<td>964.1 °C</td>
<td>961.6 °C</td>
</tr>
<tr>
<td>Liquidsus superheat (D/M)</td>
<td>10.0 °C</td>
<td>7.6 °C</td>
<td>7.5 °C</td>
<td>5.0 °C</td>
</tr>
<tr>
<td>Bath thickness (A)</td>
<td>6.82 cm</td>
<td>14.25 cm</td>
<td>18.36 cm</td>
<td>21.38 cm</td>
</tr>
<tr>
<td>Metal thickness (A)</td>
<td>1.85 cm</td>
<td>4.58 cm</td>
<td>6.88 cm</td>
<td>7.60 cm</td>
</tr>
<tr>
<td>Current efficiency (D/M)</td>
<td>95.1%</td>
<td>94.9%</td>
<td>94.4%</td>
<td>94.3%</td>
</tr>
<tr>
<td>Internal heat (D/M)</td>
<td>1328 kW</td>
<td>804 kW</td>
<td>613 kW</td>
<td>516 kW</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>12.85 kWh/kg</td>
<td>11.0 kWh/kg</td>
<td>10.6 kWh/kg</td>
<td>10.2 kWh/kg</td>
</tr>
</tbody>
</table>

### References

[2] M. Dupuis, How to limit the heat loss of anode studs and cathode collector bars in order to reduce cell energy consumption, TMS Light Metals, 2019, to be published.

### Author

Dr Marc Dupuis is a consultant specialized in the applications of mathematical modelling for the aluminium industry since 1994, the year when he founded his own consulting company GeniSim Inc (www.genisim.com). Before that, he graduated with a Ph.D. in chemical engineering from Laval University in Quebec City in 1984, and then worked ten years as a research engineer for Alcan International. His main research interests are the development of mathematical models of the Hall-Héroult cell dealing with the thermo-electric, thermo-mechanic, electro-magnetic and hydrodynamic aspects of the problem. He was also involved in the design of experimental high amperage cells and with the retrofit of many existing cell technologies.
HHCellVolt: an improved software tool for aluminium smelting

P. M. Entner, Naters

The classical Hall-Héroult process produces aluminium by electrolysis using carbon block anodes and a liquid aluminium cathode. For several years MS Windows PC programs (ElysePrg [1], AlPrg [2]) were used to investigate the essential parameters to operate such an electrolysis cell, including the cell voltage, cell layout (dimensions of anode table, target current intensity), operational factors (electrolyte composition and mass) and electrolyte properties (temperature, gas bubbles under the anode). These programs let you optimize these parameters, for instance, concerning energy consumption or heat loss. HHCellVolt is an enhanced version of this software that contains new features. This publication describes these extensions and improvements.

Electrolysis cells with four anode rows

Recent publications [3, 4] consider the construction of electrolysis cells with four anode rows. With HHCellVolt you can investigate the design options and corresponding cell voltage of such an electrolysis cell.

HHCellVolt contains adapted panels and diagrams to handle this extended anode table layout. Also the algorithms, calculating the anodic fanning factors or bubble voltage, for instance, are adapted to include this new anode panel layout.

Extended energy balance

The Basic Energy Balance considers the electrolysis reactions, the heating of alumina as well as of the anodes, and the heat produced by the internal resistance of the bushbars. ElysePrg and AlPrg used this type of balance to investigate the effects of replacing the consumable carbon anodes by inert non-consumable anodes.

The Extended Energy Balance considers in addition to the Basic Energy Balance more events and chemical reactions that happen in the electrolysis cell. These processes produce either energy (exothermic reactions, heat sources) or consume energy (endothermic reaction, heat sinks).

In the literature and on the Internet, you can find several publications that describe applications and programs that treat the behaviour of a Hall-Héroult electrolysis cell [5-11]. Some of them [6-8] examine especially the extended energy balance of an electrolysis cell. HHCellVolt separates the chemical reactions and events that are relevant for the energy balance into the following categories: alumina, anode carbon and other processes. The contribution of processes at the cathode (aluminium carbide formation or reaction of sodium with the bottom carbon blocks, for instance) are considered to be insignificant for the energy balance (Fig. 2).

Warren Haupin was the first to published diagrams [12] that showed the components of cell voltage and their relation to energy consumption. He used these diagrams [13] to study the influence of replacing the consumable carbon anodes of an electrolysis cell by inert non-consumable anodes.

Fig. 1: Electrolysis cell with four anode rows: the figure shows the adapted panels and diagrams to handle a cell layout with four anode rows. The anodes contain two transversal slots.

Fig. 2: Diagram of energy sources and sinks. HHCellVolt shows the processes and their values that take part in the extended energy balance. The difference of the extended minus basic energy balance is indicated.
HHCellVolt draws similar diagrams (Fig. 3). On the left side you see the main panel with input fields and value sliders. You change the value either by conventional keyboard input into the field or by dragging the thumb of the corresponding value slider. On the right side, HHCellVolt draws a Haupin diagram showing the components of the cell voltage and of the energy balance.

To make the determination of the extended energy balance transparent as possible, HHCellVolt shows on the Theoretical Background sliding page which reactions take place and how they determine the components of the energy balance (Fig. 4). The user finds on the panel ‘The Relations for the Energy Balance’ and the details of how HHCellVolt determines the thermodynamic values. Linear interpolation or Shomate relations are applied using the JANAF tables.

The user of HHCellVolt can adjust parameters on the Electrolysis Data Page of HHCellVolt to define the extent of these processes, for instance, to see how much the entire air burn of the carbon anodes contributes to the energy balance.

Saved data sets

The user may save the state of HH-
CellVolt’s active memory as a data set in the internal memory of HHCellVolt.

Finally, the user can save the collection of data sets as an xml-file on his computer.

**HHCellVolt on Microsoft Store**

The user will find HHCellVolt on Microsoft Store, and from there can easily download and install a Microsoft certified version of HHCellVolt. In this way the user can be sure that HHCellVolt does not contain any harmful procedures (viruses, for instance) and does not collect any sensitive data on the user’s PC. Please see the download page [14] of the author’s website.

**Conclusions**

HHCellVolt contains the following new features:

- HHCellVolt is able to study the performance of electrolysis cells with four anode rows.
- HHCellVolt determines the values of the Extended Energy Balance in a very transparent way concerning the relations and values it is using. The user adapts the extended energy balance to his needs and ideas by changing the input values.
- HHCellVolt stores and recalls different cell layouts with modified parameters like target current intensities.
- HHCellVolt stores and easily recalls different data sets as an xml-file.
- The user who has installed HHCellVolt from Microsoft Store can be sure that the software is not harmful to his computer concerning viruses or other harmful routines, and is not collecting any sensitive personal data.

**Acknowledgement**

The author would like to thank Dr. Jacques Antille for reviewing and verifying very carefully the relations and values that HHCellVolt is using. The author is especially thankful to Dr. Marc Dupuis [15]: Marc has contributed essential aspects to the new layout and performance of HHCellVolt through his comments, ideas and propositions. Marc also performed the very complex, extensive and tedious task of testing HHCellVolt in a very careful and systematic way.

**References**


**Author**

Peter M. Entner has worked on R&D projects in aluminium smelting with Alusuisse, which later became Rio Tinto Alcan. Though he is now retired, Peter’s passion for bytes and pixels keeps him busy working on software that might be useful to the members of the aluminium smelting community.
Online magnetic optimization of a full potline

L. Bugnion, Kannak; R. Düssel, Trimet

Busbars modifications were realized online over a full potline in less than six months. The MHD stability margin of the cells was enhanced in order to facilitate power modulation. The magnetic optimization at Trimet Aluminium in Essen, Germany, is the result of a 4-year project including measurements, numerical modelling and trials on a group of boosted cells before extension to the full potline.

The Trimet Essen smelter has been pursuing the objective of flexible power consumption. The capability of large electricity consumers, such as aluminium smelters, to modulate their power consumption on a short timescale represents a value for the power grid, in particular in view of the growing proportion of renewables in the energy mix.

Power modulation is already a reality for a number of smelters in Europe; however, the power variations take the form of either small current fluctuations (centred around nominal current) or short power outages (usually less than 1 hr). In the case of Trimet Essen, the objective is to be able to vary the current and the cell voltage rapidly and operate for some hours or days at power levels ranging from 75-125% of the nominal power.

During power modulation (upwards or downwards), the goal is to minimize specific energy consumption and to keep a thermal balance that ensures a good ledge protection. The smelter will face two types of constraints:

- **Magnetohydrodynamic (MHD) constraints:** when the line current is increased, magnetic forces increase as well, affecting cell stability and further deforming the bath-metal interface. Likewise, when the line current is increased, the ACD is generally squeezed and cells become unstable due to less uniform anode current distribution.
- **Thermal constraints:** if the internal heat generation changes but the heat removal at the cell boundaries or the cell thermal insulation are unchanged, the thermal balance (i.e. the temperature field and ledge shape) will shift.

The approach of Trimet Essen is to tackle both types of constraints: 1) the MHD constraints by modifying the busbars in order to compensate the cells better magnetically and 2) the thermal constraints by installing heat exchangers on the shell sides, working as thermal insulators during downwards modulation and enhancing heat removal during upwards modulation.

In the following the magnetic compensation implemented online over a full potline at Trimet Essen is presented.

**Magnetic compensation**

Electrolysis cells at Trimet Essen are end-to-end cells with risers at both upstream and downstream ends and with an asymmetrical busbars system. The main constraints for the busbars modifications were the following: 1) keep the actual risers and 2) do not perturb the passing of vehicles in the potroom (pot operations) or below the cells (transport of cells).

In April 2014, a number of cells were measured and a 3D model of the existing cell was built based on the operating parameters and on the lining and busbars drawings (see Fig. 2.1). The existing cell TE and MHD stationary state was computed using MONA software [1].

A number of alternative busbars topologies and current distributions were modelled and computed. The models included a 3D model of the studied cell and of the neighbouring cells and a 3D filiform model of the neighbouring lines. For each scenario, the MHD stationary state and the MHD stability were computed. The objective was to minimize the growing factor of the oscillation modes of the metal pad at 162 kA and 185 kA (at constant internal heat generation) i.e. to make the cell more robust against MHD instabilities. Using that approach, an optimized busbars topology and current distribution could be selected. The main changes are an increased current in the downstream riser and a T busbar below the cell. The maximum growth factor for the existing and optimized busbars is shown in Fig. 2.3 as a function of line current. The maximum growth factor at 185 kA with the optimized busbars is lower than at 162 kA with the existing busbars.

By performing thermal-electric analyses with MONA software, a basic engineering solution was found (see Fig. 2.2). Additional

---

**Fig. 2.1:** 3D model of existing cell

**Fig. 2.2:** Optimized busbars with existing busbars in violet, new busbars in green, modified busbars in blue and disconnected busbars or busbars used for shortcut in red

**Fig. 2.3:** Maximum growth factor for the existing and optimized busbars as a function of line current (at constant internal heat generation)
busbars amount to five tonnes of metal to be compared to the 20 tonnes of the existing busbars. With the optimized busbars, the external resistance is decreased from 2.22 to 1.95 µΩ which represents an immediate specific energy saving of 0.15 kWh/kg Al. The calculations also predict an impact of the optimized busbars on the metal velocity field and on the shape of the metal-bath interface as shown in Fig. 2.4. The maximum metal velocity is reduced from 15.8 to 5.8 cm/s at 162 kA and to 7.1 cm/s at 185 kA. The metal upheaval is decreased from 8.9 to 4.7 cm at 162 kA and to 6.3 cm at 185 kA. Low metal upheaval variations are of interest in the prospect of fast current changes in the line since the anode shape needs time to adjust to the new metal-bath interface.

**Installation**

The detail engineering and the installation of the optimized busbars were done in two steps. Between June 2015 and March 2016, 16 cells were installed online with optimized busbars and shell heat exchangers out of which 12 are in a booster section. Power modulation trials were performed to validate the operational range predicted by the calculations.

In April 2018, the modification of the rest of the cells started with some modifications to the detail engineering and to the online installation procedure and was completed by August 2018. Only short power outages were needed to weld some of the busbars connections. However due to the repetition of the power outages, a heat recovery procedure was implemented.

**Conclusions**

Magnetic optimization can reduce the cell external resistance and helps at making the cell more stable from a MHD point of view. As a result, metal velocity field and metal upheaval are decreased allowing for current creep and/or ACD squeeze without affecting the cell performance. The full process of a magnetic optimization implemented online was described from numerical modelling to the routine required to modify more than hundred cells.

**References**


**Authors**

Dr. Louis Bugnion obtained a master in Physics at the Swiss Institute of Technology Lausanne in 2007 and his PhD at the Swiss Institute of Technology Zurich in 2012. He joined Kannak SA in 2013, a consulting company with special know-how in numerical modelling of electrolysis cells. He has been involved in the retrofit of several reduction technologies. His present position is manager Sales and Projects and head of modelling. Contact: louis.bugnion@kannak.ch

Dr. Roman Düssel, started his career at Trimet Aluminium SE in 2005. After his education as an industrial mechanic and mechanical engineer, he worked as a trainee in the electrolysis department in Essen. Following his Trainee period, Roman attended the Technical University of Berlin to complete a master of science. He returned to Trimet in 2010, and from then to 2014 was in charge of the Process Control Department of the aluminium smelter in Essen. In 2011 he successfully acquired the Postgraduate Certificate in Aluminium Reduction Technology at the University of Auckland. Contemporaneously he started the ‘Virtual Battery’ project, an integration of heat exchangers and magnetic field compensation to allow aluminium electrolysis cells to operate with variable energy input and output. In 2015 Roman became production manager. In 2016 he finished his PhD at the University of Wuppertal. He is presently department manager, Reduction Area at Trimet Essen. Contact: roman.duessel@trimet.de
The Virtual Battery – a solution for Germany and a contribution to the global aluminium industry

A. Lützerath, Trimet Aluminium

After several years of continuous and dynamic growth, the aluminium industry currently finds itself in a very challenging situation. Trade conflicts, sanctions against the owners of key raw material suppliers, and – especially in Europe – unexpected production adjustments in the automotive industry have increased market volatility, so disturbing the balance between production costs and sales prices. As challenging as these problems are, they will not affect the aluminium industry’s long-term prospects. Experts around the world agree that demand for our light metal will continue to rise worldwide in the coming years. Its specific properties make aluminium the ideal material for the electrical and mechanical applications that will be used in future technologies: electromobility needs lightweight construction. The spread of decentralized renewable energy sources requires expanded energy networks, and digitalization is transforming production methods and processes.

However, this positive view on the prospects of the global aluminium industry must recognize the longer term challenges that aluminium producers will face in individual markets and regions. Even if the global market disregards national borders when setting prices for aluminium, its physical production will still be carried out in aluminium smelters. After the immense investments to set up a smelter at a particular location, the producer must take account of the local conditions, and must also adapt as a local situation changes. This applies especially to medium-sized family businesses such as Trimet, which are firmly rooted in their region and which form a stable value chain with their clients and business partners there.

Aluminium production costs are determined by three key factors: the cost of anodes, of alumina, and of energy. The costs of anodes and alumina are mainly decided by the world market and they are similar for all market participants. Local advantages and disadvantages result mainly from local energy prices.

Three of Trimet’s four aluminium smelters are located in Germany. Together, they produce around 385,000 tpy of electrolysis aluminium, together with some 250,000 tpy of recycled aluminium. This may not seem like much compared to the leading global players, but with a capacity of 635,000 tpy, we are the largest aluminium producer in Germany. Thanks to our proverbial and literal proximity to customers, and to solid, long-term planning, we have developed into a highly valued tier 1 supplier to the world’s leading automobile manufacturers and to other partners.

Traditionally, electricity costs in Germany are relatively high by international standards. We did not build the Trimet aluminium smelters, but instead took them over from competitors – following their closure in some cases. The previous owners did not see any strategy to achieve their targets with German production for the respective markets. Since 2011, this situation has worsened considerably. In the wake of the Fukushima nuclear accident following a tsunami in Japan, the German government decided to phase out nuclear energy completely within just a few years. The government’s adherence to the ambitious goals of also gradually phasing out coal-fired power generation, and of reducing national CO2 emissions, also remain in place. The goal has been to fill the resulting electricity supply vacuum through renewable energy sources – pinning hopes mainly on wind and solar energy. Germany is in the midst of what is known as the ‘energy turnaround’ and is completely changing its electricity market. The base load supply is at risk. Only thanks to German integration into the European electricity grid, and to the resulting continuous availability of electricity from base load-capable power plants in our neighbouring countries, have we escaped several far-reaching blackouts in Germany in recent years. In order to stabilize the grids, electricity-intensive companies such as Trimet are briefly taken off the grid dozens of times a year. As an energy-intensive company that continuously uses more than one percent of all available electricity in Germany, this poses enormous challenges.

The German public’s perception of energy-intensive industries is also particularly important when compared internationally. The country is proud of its successful and globally respected industry. Local companies meet emission, environmental and safety standards that are among the strictest in the world. Nevertheless, industrial production and, in particular, the most energy-intensive processes are generally criticized by large sections of the public and by relevant interest groups.

Trimet sees itself as a constructive partner for the energy transition. The company is showing politics and society that domestic aluminium producers are not part of the problem but are part of the solution. They can make a decisive contribution to solving problems that a business location faces – irrespective of the existence of energy-intensive industries. At first glance, the issue seems to be efficiency. If electricity consumption is the problem, this must be reduced as much as possible. The global aluminium industry has made great progress in this area in recent decades. Even though the Hall–Héroult process has not changed much over the past 130 years, today’s energy consumption can hardly be compared with that of previous eras. The costs of marginally reducing electricity consumption are constantly increasing. In view of the in-
creasing demand for aluminium in the future, we are continuously working to optimize efficiency. However, at least in Germany’s specific situation, pure electricity consumption is not the decisive criterion.

In Germany, the quantity of electricity is not the biggest problem. There is regularly a risk of blackouts on windy summer days because too much electricity is fed into the grid. In addition to solar plants and wind farms, also base-load power plants are then taken off the grid, or, in the event of short-term fluctuations, sometimes even our aluminium smelters. On the other hand, when the sun does not shine and there is no wind, the quantities of available electricity are often insufficient, so Germany imports electricity from neighbouring countries. An independent base load supply cannot be steadily guaranteed at present.

We as aluminium producers can greatly contribute to the success of the energy turnaround. Not by further reducing our energy requirements, but instead, by making our production significantly more flexible. There is enormous potential in flexible demand-side management, which quickly adapts to the quantities of electricity available from volatile energy sources such as wind and sunlight. Within certain limits, this flexibility is already possible today in many aluminium smelters. However, we are currently pushing these approaches even further. With our Virtual Battery project, we would like to be able to increase or decrease production by up to 25% for a period of up to 48 hours, while still maintaining a current efficiency level of 95%. After successful smaller tests, we are currently reconfiguring one of our production lines with 120 electrolysis cells to test and refine the process on an industrial level.

We have overcome major technical hurdles in the Virtual Battery project. With newly developed heat exchangers, we dissipate heat from the electrolysis cells when the energy supply increases. Conversely, in the event of lower energy supplies, we insulate them from temperature loss. Modified busbars enable us to stabilize the magnetic fields in the cells even with fluctuating power consumption. We are using a completely new process control concept with innovative measurement and control technology, as well as with extensive process models to optimize the electrolysis performance. These systems ensure that all this takes place smoothly and without disturbances during production, even under conditions of rapid load shifts. This complete package brings nothing less than a revolution in fused-salt electrolysis for aluminium production. At the Essen aluminium smelter alone, this series of tests offers a capacity of around 1,120 megawatt hours as a buffer for the power grid. This buffer is comparable to that of a medium-sized pumped storage power plant.

In addition to the Virtual Battery, we are also using other projects to adapt to conditions in Germany. Together with local partners, we offer surplus thermal energy from anode and aluminium production as district heat, e.g., to run cold storage facilities in the food logistics sector. In addition, we take part in balancing the energy market with our existing load management capabilities, so contributing to grid stabilization with the option of completely shutting down our electrolysis plants at short notice.

With our various projects to make aluminium production more flexible, we are demonstrating to policymakers and to society that the aluminium industry can be a partner in the success of the energy turnaround. It is important to avoid misunderstandings: Trimet is not a research institution; the family-owned business naturally pursues entrepreneurial interests. We compete at an international level, and we strive for global success. To ensure that our project is implemented in regular operation, and that we recoup our high investments, we must also be reasonably compensated for the offers we develop. To this end we are in a constant dialogue with politicians and society.

The specific situation in Germany strongly motivates our efforts to make aluminium production more flexible. We have identified flexible load management as a decisive success criterion that we will pursue. Manufacturers in other countries, on the other hand, face the major challenges of further improving their efficiency in their use of energy and of raw materials, and of mastering a range of other issues. Although we all operate on a global market, each producer makes a range of contributions to develop the aluminium industry step by step, finding clever and sustainable answers to a large number of issues. This is an evolutionary process that is making the entire industry more resilient and robust.

Despite the intense competition that prevails between us, our fascination for aluminium and our belief in its great potential unites us. Forums like the TMS meeting provide us with an outstanding opportunity to exchange new ideas and concepts that will bring benefits to the entire industry.

**Author**

Dr.-Ing. Andreas Lützerath has been board member of Trimet Aluminium SE since November 2018. He previously held positions as chief technical officer and plant manager of Trimet in Essen, Germany.
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