

# Optimised electromagnetic stirring in melting and holding furnaces

By Joakim Andersson\*



## WHAT IS EMS?

Aluminium is typically melted using gas-fired burners. Without stirring, this would usually result in a very high meniscus top temperature and a very low bottom temperature (the temperature difference between the top and bottom of an unstirred bath is typically between 50 to 80°C). A very high surface temperature results in more rapid surface oxidation, with a resulting increase in dross formation.

An electromagnetic stirrer works by placing an induction coil beneath or at the side of the furnace, away from the shell and applying electrical power to the coil. This generates a magnetic force which travels through the stainless-steel plate and furnace refractory and into the melt.

The interaction between the magnetic field and the electrically conductive metal bath creates a stirring action

\*Metallurgist at ABB Metallurgy Products

For aluminium producers, increasing productivity while simultaneously reducing operating costs, energy consumption and dross volume during processing are business priorities. ABB's Joakim Andersson explains the crucial – and increasingly sophisticated – role of electromagnetic stirring in melting and holding furnaces.

Aluminium production is a multi-stage process, but efficient stirring of the aluminium melt is one of the most decisive factors in accelerating the kinetics of reactions while improving heat and mass transfer, with the ultimate aim of improving productivity, quality and cost-effectiveness.

Introducing a forced motion on the aluminium melt by applying electromagnetic stirring (EMS) is an elegant solution, as it dispenses with the requirement for mechanical contact between stirrer device and melt (with associated maintenance for moving parts) while improving key parameters such as melt rate and energy efficiency.

Of course, metals producers have been

using electromagnetic applications since the first induction furnaces were patented in the early twentieth century.

Today, aluminium manufacturers are increasingly turning to highly sophisticated EMS technology that combines stirring with automated process control to address three of the main challenges currently facing aluminium manufacturers using melting and holding furnaces: dross generation, environmental footprint and productivity.

#### ABB's experience in EMS for aluminium

ABB is the market's most experienced supplier of EMS systems for steel and aluminium production having completed more than 950 customer projects worldwide consisting of over 1850 stirrers, over 300 of which are for aluminium furnaces.

Leading-edge solutions from ABB offer rapid chemical and temperature homogeneity, and are proven to reduce dross formation, increase aluminium yield and prolong furnace lining life. In addition,

their usage results in lower energy consumption and reduced maintenance costs, and overall optimisation of the furnace process.

Customers using ABB's aluminium EMS (AL-EMS) solutions can expect to improve furnace productivity by up to 25%, reduce dross generation by up to 15% and benefit from up to 10% lower electrical energy consumption.

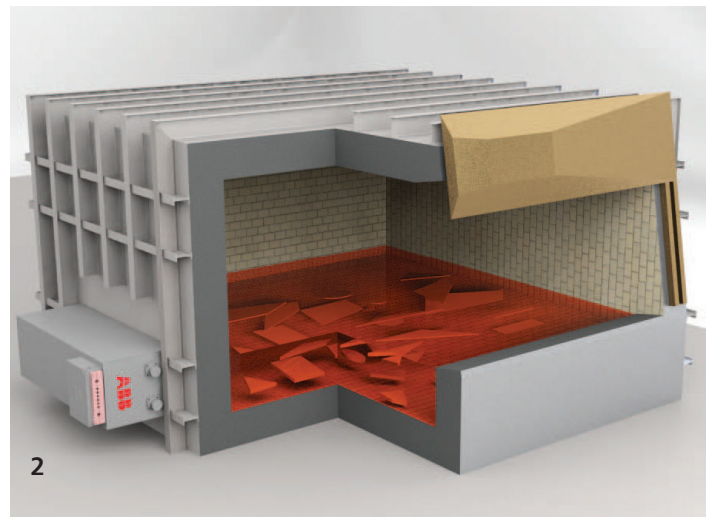
ABB continues to offer the widest range of AL-EMS solutions on the market including both bottom and side mounted models for furnaces of up to and exceeding 200tons. This comprehensive series of stirrers – together with many years of experience – enables ABB to easily recommend the right model to suit each customer, providing maximum added value for their particular process conditions.

#### Enabling the use of cheaper hard alloys

In addition to general efficiency gains from temperature harmonisation, EMS has additional benefit; namely, full



1



2

which increases the heat utilisation of the gas-fired burners and harmonizes the temperature in the bath (generally reducing the temperature difference between top and bottom to under 5°C roughly two to three minutes after stirring commences).

In so doing, EMS results in a higher driving force for energy transfer to the melt, improving the dissolution rate

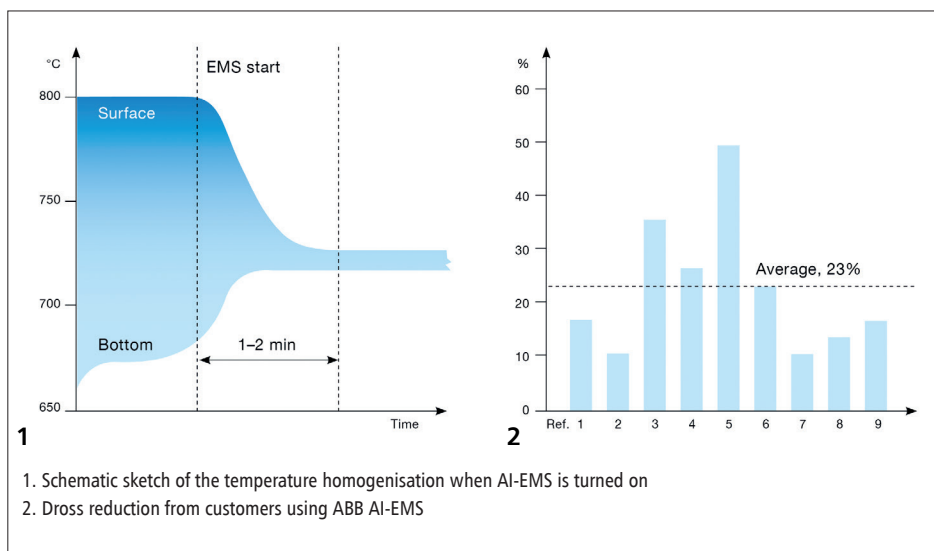
of alloys, reducing dross generation, producing a more uniform chemical composition and improving productivity.

Generally, all liquids that are electrical conductors can be stirred with EMS electromagnetic stirring in aluminium furnaces. AL-EMS efficiently mixes the entire melt with minimal operator involvement. Installation is simple and maintenance is negligible.

1. The forced convection generated by the ABB AL-EMS, here installed under the furnace, increases the heat utilization of the gas burners

2. ABB AL-EMS installed on the side of an aluminium furnace





power stirring that facilitates the use of 'hard' alloys with a high melting point for alloying. This has been implemented successfully by one of ABB's customers in Northern Europe.

The customer is a primary melter with a very small percentage of titanium in its products. Their furnace previously used a master alloy containing 5-10% titanium and then switched to a cheaper harder master alloy with an 80% titanium content.

This alloy has a very high melting point of around 1,600°C, compared to the melting point of 660–700°C for aluminium. The customer found that its mechanical 'robot' stirrer was resulting in the master alloy dissolving very slowly.

Frustrated by the limitations of the mechanical stirrer – which required extensive maintenance – the company replaced it with an ABB AL-EMS solution. This resulted in a much faster dissolve of the 80% titanium alloy in the furnace, with associated cost savings due to the significantly lower cost of the titanium master alloy.

Recent research summarised in my paper 'Optimized Electromagnetic Stirring in Melting and Holding Furnaces' recently published in the journal *Light Metals*, demonstrates that stronger stirring power in aluminium furnaces allows for more cost-effective alloying with hard, and traditionally cheaper, master alloys, as well as a safer and more consistent alloying praxis, with improved analysis accuracy.

#### What's next for AL-EMS?

In addition to the physical benefits of EMS, we are also exploiting the opportunities it affords for process automation.

ABB's latest EMS offering is AL-EMS Control. This solution collates data from sensors in the furnace itself with the

aim of fully automating operations and optimising electrical energy consumption and aluminium melt quality.

The system works by translating signals generated by the master programmable logic controller (PLC) of the furnace into data on burner flow which can be used to calculate when we should start the ABB AL-EMS, essentially facilitating dynamic interaction with the furnace. This allows for a more optimised stirring profile and helps reduce the energy consumption of the stirrer itself.

Without ABB AL-EMS Control, operators would typically run the stirrer on full power even when it's not necessary, resulting in higher energy consumption.

By analysing process data, we can optimize energy consumption and much more. For example, once the furnace contents are fully melted and we have reached a flat bath operation, we need to focus on homogenising temperature. Since this process step requires only very gentle stirring, power to the stirrer can be reduced. In summary, the AL-EMS Control's optimised stirring profile offers complete and automatic control of the AL-EMS, from starting to emptying of the furnace and provides a significant contribution to optimising furnace operations.

#### CASE STUDY: CENTRAL EUROPEAN ALUMINIUM PRODUCER

This Central European aluminium plant is operated by a global supplier producing aluminium plates, sheets and extrusions for multiple market segments including the aerospace, defense and automotive industries.

ABB collaborated with the customer to install a pair of ABB AL-EMS systems and then its ABB AL-EMS Control solution to give furnace operators the level of control they require during processing.

The installation included a bottom-mounted ORZ320 stirrer for one furnace and a side-mounted ORD24 stirrer for another. Initially the primary focus was the stirrer but then the scope was extended to include AL-EMS Control.

The aluminium producer was interested in this technology because they supply

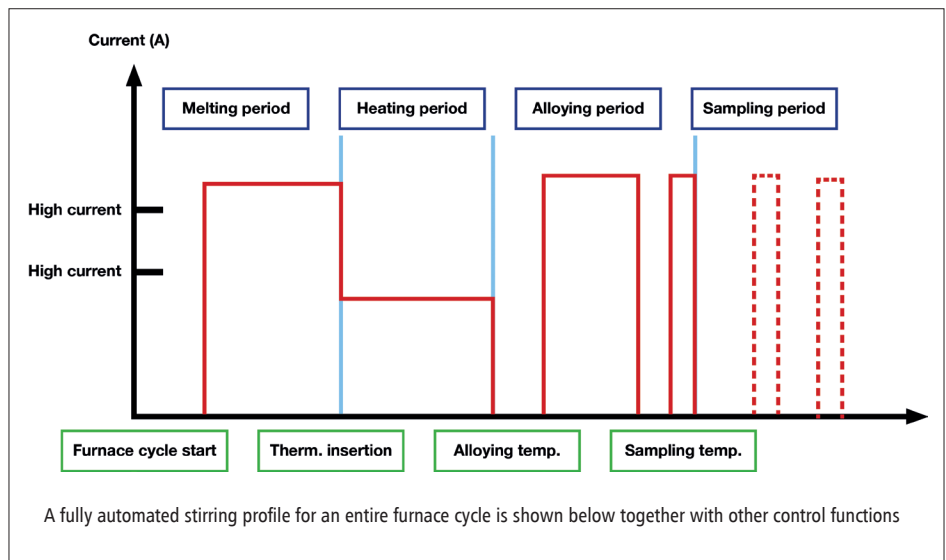


aluminium to the aerospace sector and therefore require a very high level of control during production, ideally increasing automated control and reducing manual operator intervention.

Using ABB AL-EMS Control, they were able to set parameters to run continuously, making it easy to optimise operations by monitoring data, leading to positive results in terms of stirring, as well as dross and cost reduction.

ABB used an IBA logger to monitor and collect process data from the stirrer and signals from the furnace. This was then analysed and used to calculate process parameters which formed the basis of a stirring profile, providing automatic control of the stirrer and allowing for gains in both process efficiency and safety.

ABB is currently developing this intelligent product into a remote service that analyses data and incorporates alarms that automatically detect anomalies and allow the customer to act before these unwanted events impact the furnace process negatively. This will enable ABB to support our customers remotely and contribute to further improvements in process efficiency.



### Conclusion

For the reasons outlined here, electromagnetic stirring for aluminium has become a well-established technology used to enhance chemical and thermal homogeneity in melting and holding furnaces, while also reducing both

cycle time and dross formation. Moving forward, bringing together AL-EMS technology with automation gives producers opportunities for unrivalled process control, with associated efficiencies, productivity gains and cost savings. ■