ArcSave®

Improve cost and energy efficiency in electric furnace

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ArcSave® improve cost and energy efficiency in electric furnace

What is ArcSave?
A new generation electromagnetic stirrer for electric arc furnace operation

For more than 80 years ABB Metallurgy has been committed to improving quality, cost and energy efficiency in metals via continuous development of market-leading electromagnetic stirring and braking devices (EMS) for steel and aluminium production.

In response to customer demand for stronger stirring power in electric arc furnace (EAF) we developed ArcSave®, a new generation of electromagnetic stirring technology now in operation at steel plants around the world.

Technology tailored to your needs—guaranteed
ArcSave is a non-contact technology that penetrates the furnace shell and refractory to create a stirring force in the molten steel, giving a homogenous temperature and chemical composition throughout the entire bath. We customize this stirring force to your needs with a tailored solution that controls stirring intensity, duration and direction for process steps such as scrap heating, homogenization, melting of alloys, decarburization, de-slagging and tapping. You can benefit from significant savings with ArcSave, and with our performance warranty you can be sure that we make promises we can keep.

Why ABB? Why ArcSave?
• Over 80 years’ experience developing electromagnetic stirrers (EMS) for the metals industries.
• Sole manufacturer of this high quality patented ArcSave technology.
• Stronger stirring for today’s high power EAF with a designed average melt volume flow velocity of 0.2-0.4 m/sec.
• Stirs the entire melt leaving no dead zones like competing technologies.
• Adjustable, automated stirring tailored to your process steps.
• Low maintenance and long lifespan; current record is 54 years in operation.
• Available for a variety of EAFs such as carbon, stainless and special steel as well as Consteel®.
Improve yield
Metallurgical conditions in EAF are generally far from optimal. ArcSave pushes the carbon-oxygen reaction closer to equilibrium. This, together with a reduction in scrap inside the dumped slag, increases steel yield to give a significant scrap and conversion cost saving. Lower iron oxide and steel content in the slag will significantly increase scrap yield.

Increase productivity
A higher scrap melt rate and shorter tapping cycle combined with improved yield will help increase EAF output. A more uniform temperature throughout the entire melt, including eccentric bottom tap hole (EBT) area, gives a higher free opening frequency, which reduces tapping delays and provides for smoother, more reliable EAF operation.

Enhance energy efficiency
ArcSave reduces electrode current swings and surface superheat, improves heat transfer from arc to melt, and increases scrap melting and decarburization rates, all of which contribute to lowering EAF energy consumption.
Success cases

To date we have sold 160 electromagnetic stirrers for EAF worldwide, including 149 first generation EAF-EMS stirrers and 11 new generation ArcSave.
Steel Dynamics Inc., USA
Stirring up a 6% increase in productivity

“ArcSave is a technology that is totally invisible but helps the melting process make liquid steel safer, quicker and at a lower cost”
Paul Schuler, Meltshop Manager at Steel Dynamics Inc., Roanoke, VA, USA

Steel Dynamics Roanoke Bar Division Inc. (SDI) in Virginia, USA, have a long-standing tradition of embracing new technologies to maintain their competitive edge, a tradition that’s just as essential today as it was in 1962 when they installed the United States’ very first commercial continuous caster. SDI firmly believe that every ton of steel produced should be done so as safely and efficiently possible. In EAF they wanted to improve scrap melt rates to enable the use of larger scrap sizes without compromising on performance. Other customer objectives included increasing arc stability, improving bath homogeneity, enabling more consistent tapping conditions and reducing oxygen content.

In April 2014 the world’s very first ArcSave was delivered to SDI for installation on their 90-ton arc furnace with a stirring profile tailored to their process steps. Using ArcSave, SDI has achieved a safer, more reliable and efficient EAF operation, and a range of benefits resulting in a 4-5 USD saving per ton of steel produced.

Process improvements at Steel Dynamics using ArcSave*

<table>
<thead>
<tr>
<th>Technical data</th>
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</thead>
<tbody>
<tr>
<td>Total cost saving</td>
<td>-4-5USD/ton</td>
</tr>
<tr>
<td>Productivity</td>
<td>+6%</td>
</tr>
<tr>
<td>Total electrical energy consumption</td>
<td>-5%</td>
</tr>
<tr>
<td>Iron yield</td>
<td>+0.9%</td>
</tr>
<tr>
<td>Tap oxygen</td>
<td>-114 ppm</td>
</tr>
<tr>
<td>Ferrosilicon consumption</td>
<td>-12%</td>
</tr>
<tr>
<td>Calcium carbide consumption</td>
<td>-15%</td>
</tr>
<tr>
<td>Lime (EAF and LF) usage</td>
<td>-5%</td>
</tr>
<tr>
<td>Electrode consumption</td>
<td>-3%</td>
</tr>
<tr>
<td>Furnace repair materials</td>
<td>-20%</td>
</tr>
<tr>
<td>Tapping temperature</td>
<td>-15°C</td>
</tr>
<tr>
<td>EBT free opening frequency</td>
<td>+20%</td>
</tr>
</tbody>
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* Based on data from 6 months without and 6 months with ArcSave.
Outokumpu Stainless, Sweden
Saving energy and solving problems

“We managed to solve our furnace bottom skull problem using ArcSave. The result is smoother, more predictable EAF operations at lower cost.”

Pär Ljungqvist, EAF Process Developer, Outokumpu Stainless, Avesta, Sweden

Leading stainless steel and high-performance alloy manufacturer Outokumpu Stainless runs one of the world’s most productive stainless-steel foundries in Avesta, Sweden. The company has a long history of innovation including the invention of duplex stainless steel here in 1930 and their global R&D is based in Avesta to this day.

Outokumpu’s 90-ton electric arc furnace is used for the production of special stainless-steel grades with a high chromium content, a process requiring the addition of ferrochromium which, due to its higher melting point, often settles unmelted on the furnace bottom to form skulls.

At Outokumpu this led to variations in tapping weight, higher electrode and energy consumption and even practical difficulties when charging scrap baskets, all of which had a negative impact on productivity. The company had previously tried bottom gas stirring (BGS), though this did not solve the problem.

ArcSave was installed in 2014 with the aim of increasing the ferrochromium melt rate and solving the bottom skull problem, reducing power-on time and energy consumption, and improving process conditions to facilitate even analysis and weight to the next process step (AOD). Outokumpu was able to achieve these goals using ArcSave.

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**Process improvements at Outokumpu Stainless using ArcSave***

<table>
<thead>
<tr>
<th>Technical data</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total electrical energy consumption</td>
<td>-3-4%</td>
</tr>
<tr>
<td>Electrode consumption</td>
<td>-8-10%</td>
</tr>
<tr>
<td>Power-on time</td>
<td>-4-5%</td>
</tr>
<tr>
<td>Tap temperature hit ratio</td>
<td>100% (+70%)</td>
</tr>
<tr>
<td>Tap temperature reduction</td>
<td>-20-30°C</td>
</tr>
<tr>
<td>Tap weight hit ratio</td>
<td>+24% (to 93%)</td>
</tr>
<tr>
<td>N₂ consumption</td>
<td>-70%</td>
</tr>
</tbody>
</table>

* Average savings comparing results from 3 months before and 3 months after installation.
SeAH, South Korea
Reducing skull formation and more

SeAH, the only stainless-steel pipe manufacturer in South Korea, installed ArcSave on its 70-ton EAF to solve the serious accumulation of furnace skulls which could reach a thickness of 1,000 mm.

The company first tried bottom gas stirring on their furnace, which is loaded with 90% scrap steel and 10% ferroalloy, though the results were unsatisfactory and involved increased maintenance work to drill out the bottom skulls using a refractory removal machine before lifting them out with a crane.

After installing ArcSave, furnace bottom skulls were reduced to less than 200 mm and melt temperature was homogenized. SeAH gained a full range of process benefits including 3-4% lower energy consumption, 3-4% reduction in electrodes, 4-5% shorter power-on time, 40-50% reduction in hot repair material and 6-10% lower refractory material costs.

Steel output per furnace heat increased by 3-5 tons, and overall productivity rose by 5-7%. Since ArcSave enabled the efficient melting of larger scrap pieces (up to 4 tons), scrap processing costs were reduced by a massive 70-80%.
Consteerrer
Tenova Consteel + ABB ArcSave

The Consteerrer™ concept was jointly developed by ABB Metallurgy and Tenova with the goal of making liquid steel safer, faster and at lower cost. Consteerrer combines Tenova’s Consteel® continuous charging system and ABB’s ArcSave electromagnetic stirrer for EAF, proven technologies from two experienced steel industry innovators.

With Consteerrer, the Consteel furnace includes an ArcSave stirrer designed specifically for the Consteel application. The stirrer coils are integrated into the furnace bottom under a non-magnetic (austenitic) stainless steel window, allowing ArcSave’s traveling magnetic field to penetrate the furnace shell and refractory, and generate a global stirring effect throughout the entire melt. To accelerate scrap melting, the coils are installed transversal to the Consteel furnace axis so that stirring direction can be directed towards the scrap charging area.

Tenova’s exclusive Consteel system loads the metallic charge directly from the scrap yard via charge conveyor, where it is automatically and continuously preheated and transferred to the EAF. Once preheated, the charge falls into the EAF where it is continuously melted by the liquid steel. This permits constant flat bath operation, a key advance over conventional batch processes where scrap is melted directly by the electric arc.

The strong preheating of the raw materials helps reduce energy consumption. At the same time, the energy from the electric arc and chemical reactions keeps the molten steel at the appropriate process temperature. After more than 30 years of ongoing development and supply of more than 65 furnaces worldwide, Consteel has become one of the most advanced technologies in high-efficiency steelmaking.

Consteel continuous charging system

- Improve temperature homogeneity throughout the melt
- Accelerate scrap melt rate by enhancing thermal convection and melt temperature homogeneity at the charging area
- Reduce tapping temperature by >20°C
- Increase decarburization rate, yield and productivity, shorten power-on time
- Reduce EAF energy consumption

Cold zone with solid scrap T=up to 150°C
FAQ

Effect of ArcSave on the EAF process

Q. Does ArcSave help with decarburization?
Yes, our results show that the stirring force generated by ArcSave can double the decarburization rate. This is particularly valuable for EAF processes involving the charging of hot metal, pig iron or where decarburization is currently a bottleneck and will help to shorten process time.

Q. Does ArcSave have any effect on steel quality?
Yes, ArcSave can help with the removal of phosphorus, sulphur and nitrogen which is particularly important in the production of high-quality steel grades. From installations like Steel Dynamics Inc. we have seen reductions in Phosphorus of about 8% or 10ppm, 20% or almost 20ppm for nitrogen and a reduction of 10ppm for sulphur levels in the ladle after tapping.

Q. How does ArcSave help reduce sulphur content?
At the Steel Dynamics Inc. installation, we saw a 10% reduction in sulphur. ArcSave contributes to this in several ways including reducing the oxygen content in the steel, improving slag/steel mixing and providing for less carryover slag.

Q. For stainless steel production can ArcSave help with chromium recovery?
If so, what is the typical % increase?
ArcSave has some stirring effect on the steel/slag interface and brings different parts of the slag and melt to this reaction zone. Via selection of a relevant stirring profile the slag/metal reaction can be enhanced to obtain a more efficient slag reduction. This should, of course, be optimized together with O₂ injection practice. Cr₂O₃ content in the slag has been reduced by an average of 3% after ArcSave together with a O₂ reduction of around 17% at one of our reference installations.

Q. Does ArcSave reduce carryover slag in the tapping ladle?
Carryover slag in the ladle, which is usually caused by vortex formation in the EBT area, results in higher ferroalloy consumption in the downstream ladle furnace process. ArcSave’s global stirring power moves the vortex away from the surface so that it cannot continue to form or suck the slag down into the melt. We measured slag thickness in the ladle as part of the installation at Steel Dynamics Inc. and found that carryover slag in the ladle after tapping was reduced by 40-50% using ArcSave. This provided for lower ferrosilicon and calcium carbide consumption in the ladle furnace process equivalent to a cost saving of 0.7USD/ton.

Q. What advantages does ArcSave have compared to BGS?
ArcSave is safer than BGS as it has no physical contact with the melt thus avoiding the inherent risk of breakthrough common to the use of gas plugs installed in the bottom refractory. ArcSave stirring power is also stronger, with resulting stirring energy around 5 times higher than BGS. ArcSave creates a global stirring effect throughout the entire melt with no dead zones or cold spots, whereas bottom gas stirring uses 3-5 plugs that deliver only localized stirring.

Yes, you no longer need BGS when you have ArcSave since its stirring profile is much more powerful and delivers a global effect which is also easier to control than the localized stirring provided by BGS plugs.

Q. Is it normal to stop using BGS or remove it entirely after installing an ArcSave?
ArcSave is easy to operate with a tailored and automated stirring profile and requires very little maintenance. BGS requires regular online maintenance and operation is complicated by clogging which also shortens plug lifespan. These are some of the reasons why 4 of 9 new generation ArcSave reference installations changed over from BGS to ArcSave.

Q. What is the difference in running cost between ArcSave and BGS?
Results from our reference installations in North America and Europe show operating costs for ArcSave to be 20-40% lower than for BGS.
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Safety and maintenance using ArcSave

Q. How does ArcSave contribute improved safety in EAF?
ArcSave helps reduce the risk of furnace wear, scrap cave-ins and carbon boiling out. It also increases the EBT free opening ratio and lowers the tapping temperature by approximately 20°C. For stainless steelmaking the risk of furnace bottom skulls is also significantly reduced. All of these factors contribute to a smoother, more predictable EAF process with less manual intervention and an overall safer working environment.

Q. How much maintenance is required?
The stirrer coil itself is maintenance-free, and the auxiliary equipment requires minor maintenance related to pump station or the water skid for instance.

Q. Does ArcSave increase refractory wear with increased stirring?
As long as we control the melt velocity and keep the electromagnetic current within a reasonable range, there is no increase in refractory wear on the furnace bottom using ArcSave. In most cases there is less refractory wearing in the slag-line area as a result of the reduction in surface superheat during the power-on period.

Q. Does ArcSave help stabilize the electrodes?
Yes, in several ways. Improved convection flow allows for faster scrap melting than without ArcSave and big scrap bundles charged into the bucket loading the furnace will have less scrap stratification effect and less cave-ins. From our reference installations we also found that electrode current swings were reduced by 50-60%, resulting in 6-8% lower electrode consumption. The resulting stabilized arc gives a higher power input which explains why the power-on time saving is often even higher than the electrical energy saving with ArcSave.

Q. Does ArcSave contribute to long-term decarbonisation?
ArcSave reduces CO₂ emission by an average of 3-6% by reducing consumption of electrical energy, electrodes and raw materials as well as improving the metallic yield.

Q. Does the strong electromagnetic field generated by ArcSave pose any safety risk to our employees?
No. Our measurements confirm that the exposed magnetic field around the stirrer is far below the EU safety standard threshold. If you have a pacemaker, however, you should not work in the vicinity of an EAF equipped with ArcSave.

Q. How does ArcSave contribute to EAF energy consumption?

ArcSave and EAF energy consumption

Q. Does the electrical energy saving of 3-5% include the energy that the ArcSave itself consumes? How much energy does the ArcSave actually use?
The energy savings quoted, both typical savings and those for specific case studies, are net energy savings i.e. we have already deducted the energy that the ArcSave uses in order to provide you with a figure for total electrical energy savings. The ArcSave coil itself consumes 2-3 kWh of electricity per ton of liquid steel.

Q. How does ArcSave affect reactive power?
Reactive power is reduced due to higher active power and increased arc stability in EAF using ArcSave.
Q. What size of EAF is suitable for ArcSave?
We have references for furnaces with capacities from 50 up to 450-ton though we can deliver ArcSave for all furnace sizes and types including bucket-charging, EBT and spout furnaces, and continuous scrap charging furnaces like Consteel etc.

Q. Do you have any references for revamp projects involving installation of ArcSave on an existing EAF?
Yes, we have extensive experience of revamp projects including 5 of our new generation ArcSave reference installations. For brownfield projects it may be necessary to replace the lower shell or install a stainless-steel window in the existing bottom shell to allow the electromagnetic force to penetrate the furnace melt.

Q. Can this technology be applied to furnaces other than EAF such as submerged arc furnaces (SAF)?
In principle, the ArcSave could provide similar benefits for SAF as it does for EAF, and we have ongoing discussions about its application for ferrochromium and ferro manganese SAFs. The main concern is the installation feasibility including free space underneath the SAF, since ArcSave needs 1.5 meters space, as well as the bottom refractory thickness.

Q. Do you have any experience of using ArcSave for DC furnaces?
Though our application is mainly for AC furnaces, and we currently have no reference installations for DC furnaces, we have carried out several case studies for DC furnaces at steel plants around the world. For GMH, Germany’s DC furnace, for example, we have done CFD simulations which showed that a symmetrical stirring profile was only feasible using two stirrers because of the bottom anode. Though a typical installation for a DC furnace is likely to be more complex than for AC, we would be able to develop this kind of application in line with customer need.

Q. What is the typical payback time (ROI) for ArcSave?
Around 12-18 months and this includes both the cost of the stirrer, auxiliary equipment and any necessary furnace modifications such as new furnace shell or stainless-steel window. The payback time varies slightly depending on the furnace volume and annual production and is generally shorter for larger furnaces. Our payback calculations do not include any potential productivity gains with ArcSave so payback can be even shorter in real terms when you factor in productivity improvement.

Q. What is the typical delivery time for an ArcSave?
Usually 8-10 months FCA. In general, bigger electromagnetic stirrers take a little longer to manufacture than the smaller sizes.

Q. How many days of arc furnace downtime are needed to install the ArcSave?
Based on experience from our reference installations 5-7 days of furnace downtime is required. By preparing certain parts in advance including electrical power, transformer, water station, routing of pipes and cables an ArcSave installation can easily be scheduled during your annual maintenance stop.