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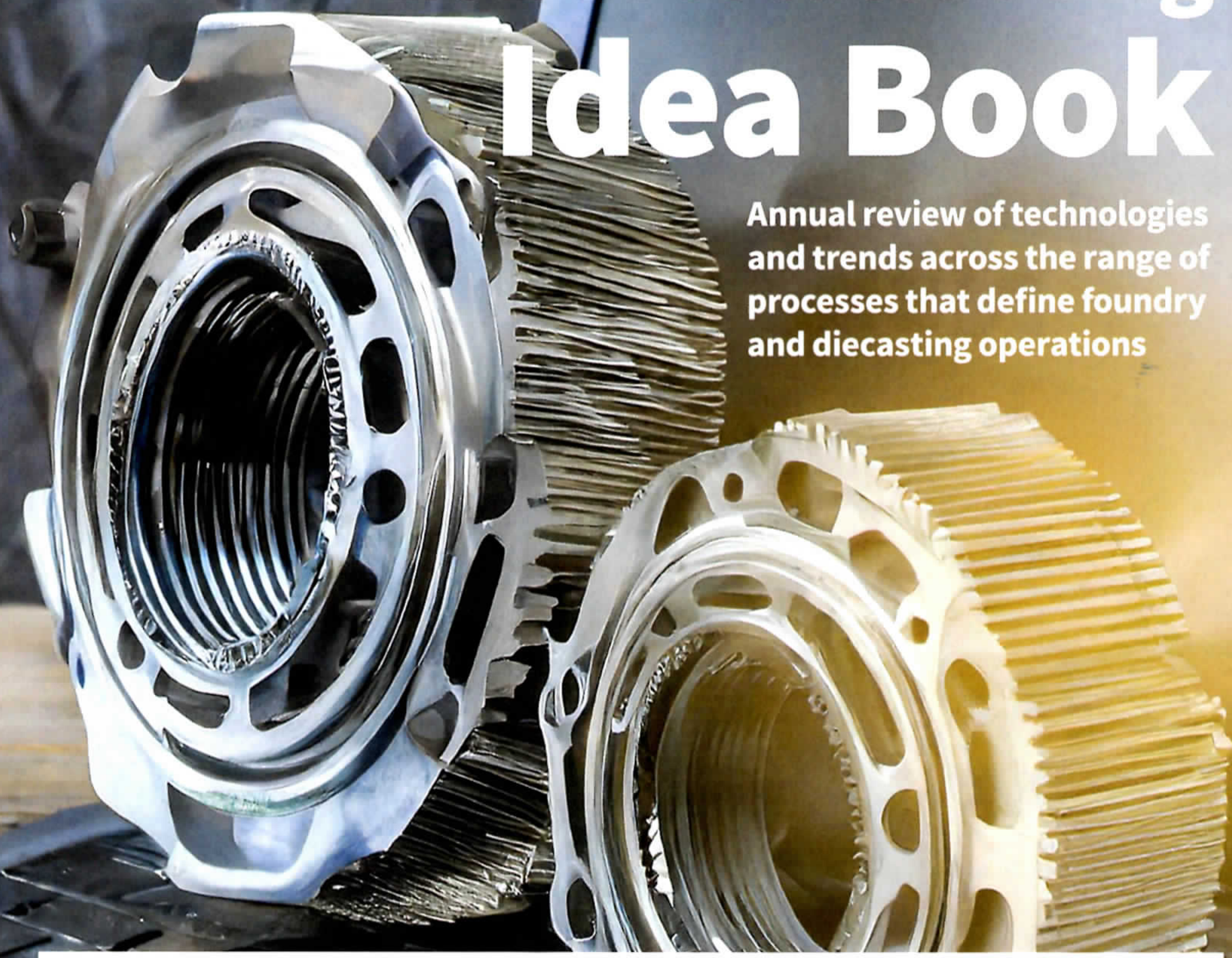

Managing Induction Furnace Slag Build-up - p. 18-19

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Managing Coreless Induction Furnace Slag Build-Up

Fluxing will eliminate build-up on sidewalls, improve slag fluidity, improve electrical efficiency, keep furnace volumes and ladles constant, and extend refractory life.

by Rod Naro

Typical slag build-up in a coreless induction furnace.
ASI INTERNATIONAL

In the past 60 years, melting methods of ferrous charge metals in coreless induction furnaces have changed dramatically. In today's foundry industry, a major economic driver is to reduce melt costs and improve operating efficiency. These two approaches do not always yield the same result. For example, buying relatively inexpensive scrap metal units can reduce overall raw material costs, but can at the same time have a significant and deleterious effect on furnace efficiency. Slower melting rates and less efficient use of the coreless induction furnace result.

Slag-related melting problems have always been a problem and most often are associated with mediocre quality scrap. So, the formation of slag in the melting of ferrous metals with coreless induction furnaces is inevitable. The cleanliness of the metallic charge, often consisting of sand-encrusted gates and risers, or rust- and dirt-encrusted scrap, significantly affects the type and quantity of slag formed during melting.

Iron foundries have long thought that adding a flux is harmful to the furnace refractory. Indeed, fluorspar-based fluxes are harmful to refractories. However, over the past 20 years sodium-based fluxes (Redux EF40) have been shown to significantly minimize and eliminate slag build-up in coreless induction furnaces and in inductor/throats of channel furnaces and pressure pour furnaces, as well as reduce casting inclusions.

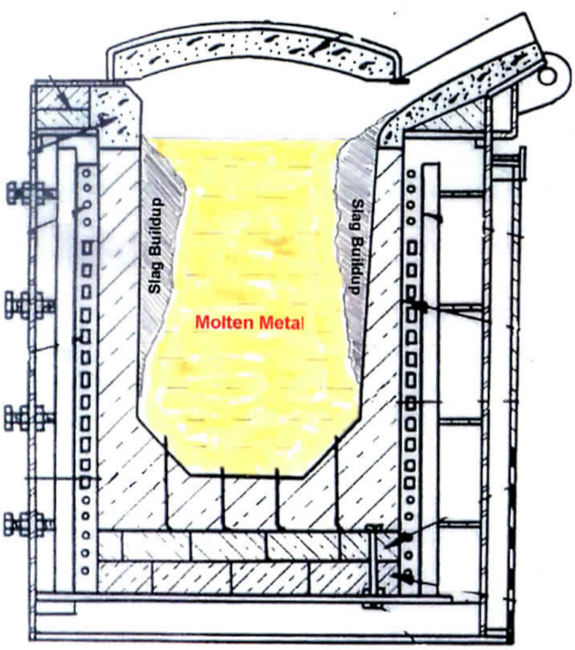

Fig. 1. Actual slag build-up in a coreless induction furnace.
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Fluxing is a chemical process used in the melting of metals that reduces or minimizes oxidation, coagulates the by-products of oxidation, reduces the melting point of generated slags, and assists in the removal of harmful emulsified slags by allowing such slags to float to the surface of the molten metal for removal. Fluxing of melting furnaces will eliminate slag build-up on coreless induction furnace sidewalls, improve slag fluidity, reduce melting costs by improving electrical efficiency, keep furnace volumes and ladles constant, and improve refractory life.

What fluxes do is analogous to soap and water: Water alone will not clean grimy hands. Soap acts like a flux, loosening dirt, grease, and oil. Fluxes do the same thing to slags, loosening their hold on refractory linings, reducing the viscosity of slags, and allowing slag to float out of the liquid metal to be removed.

Redux flux additions will prevent slag deposits on the sidewalls by removing these emulsified non-metallics. The formation of build-up on refractory walls is a classical nucleation-and-growth process. Shortly after the first liquified slag phases precipitate as a thin solid film or substrate on a refractory surface, build-up can proceed quite rapidly because the liquified slag phases can easily grow on the deposited build-up since it is crystallographically similar. Thus, preventing this first build-up layer is paramount to minimize ensuing slag build-up.

The formation of slag during melting is inevitable. An example of severe build-up in a 3-ton coreless furnace is shown as the cross section in Figure 1 (left.) In this example, slag build-up reduced the working volume of the furnace by 20%. Unless removed, slag build-up will continue to reduce volume, significantly affecting daily and weekly production.

Figure 3: Removed slag build-up illustrating the progressive layering effect. ASI INTERNATIONAL

In all induction furnaces, there is an "ideal" refractory wall thickness that is carefully calculated by the manufacturers to offer the optimal melting performance. Designed into this calculation are safety considerations, electrical characteristics of the coil, metallic charge electrical conductivity, structural and refractory considerations, operational constraints, and production needs. When the furnace melt diameter is reduced by build-up, the melting process becomes compromised. Traditionally, to remove the build-up, furnace operators are forced to mechanically scrap the lining that may also damage the refractory face.

Slag build-up increases the effective refractory wall thickness and decreases coil efficiency, as shown in Figure 2.

Furnace and refractory manufacturers recommend a lining thickness of 4 inches for a 3-ton furnace. An optimal lining thickness of 4 inches provides 82% coil efficiency and the rated power in kilowatts (kW) is 100%. In this example, if slag build-up thickness approaches 2.5 inches (lining thickness effectively 6.5 inches), a 25% increase in kW's will be required to melt. Slag build-up can be managed or eliminated with a continuous addition of Redux EF40L fluxes.

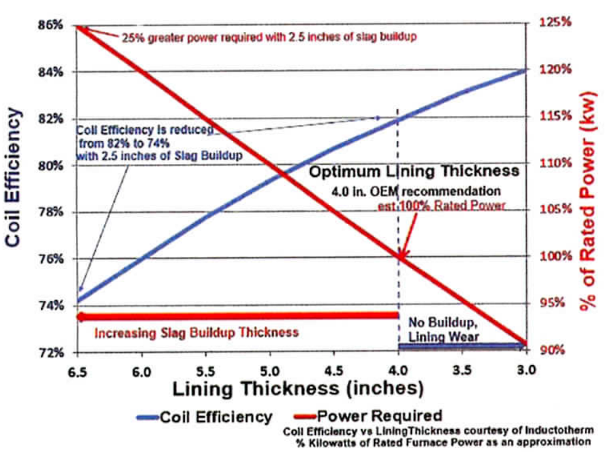

Fig. 2 The effect of lining thickness on coil efficiency and percentage of power requirements for a 3-ton coreless induction furnace. ASI INTERNATIONAL

Foundry G is an excellent example of a North American foundry managing slag build-up. The foundry heel melts in a 3-ton, 6,000-kW medium frequency coreless induction furnace lined with a silica dry vibratable refractory.

During melting, slag generation and accompanying build-up reduced furnace capacity and contributed to increased power consumption. After 48 hours of operation, it was common for three inches of slag build-up to occur, like the example shown in Figure 1. A section of build-up removed by chipping is shown in Figure 3. Figure 3 clearly shows that once slag started to attach to the refractory, it became easier for progressive layers of slag to form until the thickness reached 3 inches.

Foundry G initially incorporated two pounds of Redux EF40L flux per ton of charge, added to each back-charge to determine its effect on build-up. Redux EF40L was placed in the furnace before back-charging on top of existing molten metal to ensure excellent mixing, (a minimum 50% molten metal bath.) Immediate improvements were seen and build-up along the sidewalls was essentially eliminated.

Without fluxing, build-up would occur along the sidewalls of the furnace, including in the active power coil. This caused delays in charging, reduced furnace capacity, and longer downtime for scraping the lining, adding an additional 5 to 15 minutes per heat. Prior to adding Redux EF40 flux, the normal 45-minute melt cycle increased to 60 minutes.

Energy savings have been estimated to approach $14,400/month, or $174,000/year based on electrical usage of 550 kW/ton and an electrical rate of $0.069 per kilowatt, the result of a 25% rated power reduction (125% with build-up compared to 100% with no build-up.)

Elimination of slag build-up from the furnace walls has resulted in: reduced "bridging" tendencies due to cleaner refractory walls; reduced power consumption during each melt; hourly maintenance from scraping greatly reduced, slag easily peeled off; consistent furnace capacities and charge weights; improved "electrical coupling," with improved temperature control; no adverse effects on the dry vibratable silica refractory linings.

In summary, insoluble build-up and slag-related problems have become serious issues for today's foundrymen. These problems will likely only increase as scrap quality continues to deteriorate. However, using fluxes properly can go a long way to alleviate these challenges while increasing melting efficiency and saving foundries time and electricity, and most importantly improve profitability.

Worldwide use of Redux EF40L has shown it to be acceptable for reducing slag viscosity and eliminating slag build-up in coreless and vertical channel induction furnaces, pressure-pour furnaces and ladles while having no negative effect on silica-based refractories when used as prescribed.

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