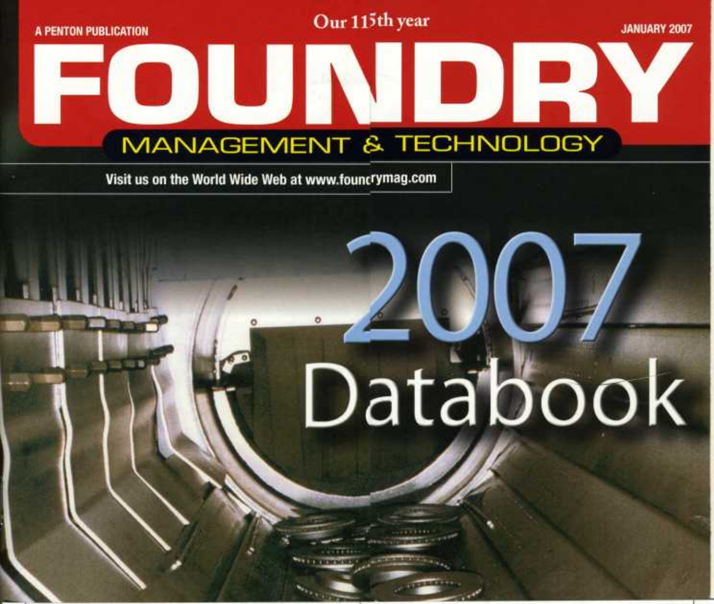

Improving Ladle Cleanliness
for Iron Foundries

Modern iron foundries experience a number of daily challenges when handling and pouring molten iron, including the continuous battle of keeping ladles clean and maintaining the original ladle capacity. Reduced ladle capacity from slag buildup directly translates into reduced production rates. For example, in ductile iron production, maintaining "the pocket" in the treatment ladle is critical for the proper treatment of the iron, as well as maintaining the original capacity of the ladle.

Past ladle cleaning methods traditionally incorporated relatively crude, mechanical methods to remove the insoluble buildup adhering to the refractory sidewalls and ladle bottom. Often this removal method is performed when the ladle is cooled to ambient temperatures. Severe damage can result to the refractory from

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cracking or gouging of the "hot face."

Often, to help prevent this, an expendable refractory coating based on magnesia-silicate is used to take the brunt of the damage. These coatings are usually replaced daily, after a de-scaling process has been performed. While such coatings represent an alternative to the main refractory wear, they may flake-off during use and cause casting inclusions.

Adding a suitable flux to either the transfer or treatment ladles is a proven method to help maintain the original capacity. However, it is imperative that "suitable" fluxing should be done in a controlled, prescribed manner from the flux manufacturer. Any overuse or improper addition of a flux can easily result in localized refractory erosion.

Ladle fluxing materials typically contain one or more of the following compounds: calcium fluoride, calcium oxide, or calcium carbonate to perform the cleansing activity. In some cases these compounds have successfully reduced insoluble buildup as well as reduced sulfur from the molten iron. In cupola operations, calcium carbonate is often used to condition the slag (reduce viscosity) generated inside of the cupola so that it can exit through the tap hole.

The active ingredient of most iron fluxes is the calcium ion, Ca+2. Unfortunately, this element can be extremely reactive against most ladle refractory systems. For iron applications, various mullite, bauxite, or flint-based aggregates are used in castable or dry vibratable products for ladle linings. All of the foregoing refractory systems have varying ratios of alumina to silica. Higher silica-containing castables would be more susceptible to chemical attack from these fluxes. Higher alumina-containing refractories may resist chemical attack better, but they will suffer from greater heat loss. The most suitable refractory system for transfer/treatment ladles would be a mullite-based product, 70% alumina, or an 85% alumina -bauxite castable with proper, thermally designed back-up insulation.

Newer iron flux technology incorporates sodium oxide-based constituents. Presently, proprietary sodium oxide-based fluxes are used very successfully in iron transfer and treatment ladles to maintain ladle capacity. These fluxes are available in 1-lb powder packs or in small, pressed briquettes.

The active ingredient in these fluxes is the sodium ion Na+1.

Proprietary sodium oxide flux in pre-weighed 1-pound bags (top) and pressed briquettes (bottom) weighing 15 and 45 grams.

Sodium ions do not appear as reactive as the Ca ion on the refractory systems. Currently, three different addition methods are being used with excellent and very noticeable results:

- The continuous addition of flux to the molten metal stream as the transfer ladle is being filled, followed by de-slagging.
- For ductile iron, a flux addition placed directly on top of the cover steel in a ductile treatment pocket. De-slagging is performed in the pouring ladle after the treatment and within five minutes of

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transfer of the treated iron.

• For ladles with severe sidewall build-up, a series of "wash heats," or taps, where the flux is added to the molten metal in each tap, and significant reduction of the sidewall buildup will be observed after five taps. During this wash heat practice, the ladle is de-slagged and the ladle is poured back into the furnace. The photos here illustrate a ladle with significant buildup that has undergone flux treatment.

Although each of these application methods greatly eliminated buildup, it is important to realize that the buildup must be removed by skimming and de-slagging. Also, most of the fluxing applications were done in transfer ladles and ductile-iron treatment ladles. Recent trials have shown great promise in reducing buildup in desulfurization vessels and downstream metal-holding vessels.

Environmentally, sodium oxide-based fluxes emit an opaque white smoke that may contain some sodium oxide and carbon dioxide, but no fluorine or chlorine gas. When proper ventilation is used, this smoke can be easily evacuated. The smoke that is generated is a minor nuisance, but it does not have the negative effects of the fluorine or chlorine gases, typically evolved from fluoride and chloride-based fluxes.

When compared to the calcium-bearing fluxes, the newer sodium-bearing fluxes will react slower but result in a milder reaction with refractories over time. Calcium-bearing fluxes, especially calcium-fluoride fluxes, are potent and can result in numerous problems, including rapid refractory erosion and inclusion contributions. Sodium-bearing fluxes, when used according to the producer's recommendation (typically 0.5 to 1.5 lb/ton) are far less likely to cause such problems.

Currently, these proprietary sodium-oxide based fluxes are used worldwide to reduce buildup in coreless furnace applications, channel induction melting/holding furnaces, desulfurization vessels, cupola ash-reduction, pressure pour furnace build-up, and Fisher converters. Other potential uses are boron removal from ductile iron, as well as sulfur removal.

When considering the financial benefits of ladle fluxing, the service life of ladles can be significantly extended. Instead of a 4-hour, 8-hour, or 24-hour production cycle, ladles have been kept in service longer because they maintain capacity. It has been observed that subsequent cleaning and repair of "flux conditioned" ladles greatly reduces ladle maintenance. However, it must be emphasized that more de-slagging will be required when using ladle fluxes.

A 2,000-lb ladle before fluxing (top) and after (bottom) being fluxed five times with one-pound of a proprietary sodium-based flux.

Insoluble build-up in iron transfer ladles and treatment ladles has caused problems for foundries worldwide. Development of newer fluorine and chlorine-free fluxes based on sodium-ion technology now provide a safer alternative for effective ladle cleaning. By applying these fluxes properly in iron transfer/treatment ladles, and using proper de-slagging techniques, foundries have gained a renewed confidence in the use of fluxes.

R.L. Naro is president and CEO, and David Williams is v.p.-technology, with ASI International. For more information, visit the website, www.asiinternational.com.