



Maximizing Iron Melting

Ferrous foundries can do more to recognize the chemistry and manage the processes that improve casting productivity and quality.

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Harmful Effects of Molten Metal Oxidation

Ferrous foundries accept free oxygen as an unfortunate byproduct of their work, but melting iron can be simpler and more cost-effective when free-oxygen atoms are under control.

The oxygen atom's presence in molten iron produces many harmful effects, nearly all unknown to iron foundries. Few, if any, countermeasures are taken to address oxidation during melting. The industry simply accepts free oxygen as a normal part of molten iron.

A basic fact is that molten iron is oxidized by atmospheric contact. The steel industry goes to great lengths attempting to stop oxidation via tightly shrouding molten steel, but this action fails in the end. Steelmakers treat the critical steel

grades with aluminum, which ties up the free-oxygen atoms chemically in inert oxide molecules, thereby controlling the oxygen atoms' harmful effects.

This simple solution is effective in steel casting too, but it cannot be used in iron casting: Elevated aluminum levels (0.03-0.04% Al) are associated with pinhole defects in iron casting.

Free oxygen atoms do not enter the molten iron bath directly. The first step is that iron oxide is formed on the iron bath surface, where contact with the atmosphere happens. Then, iron oxide instantly establishes the chemical equilibrium equation, $\text{FeO} = \text{Fe} + \text{O}$. The "O" is the free-oxygen atom and it quickly enters the iron bath.

When free-oxygen atoms are released into molten iron baths, the Laws of Thermodynamics determine which element in the bath they react with: At temperatures above 2,600°F, carbon is oxidized; below 2,600°F, silicon is oxidized.

But, the oxidation of carbon and silicon is only the tip of the iceberg. Iron, manganese, and other elements are continuously oxidized too. Iron oxide is reformed and distributed throughout the bath.

The lifespan for free-oxygen atoms in molten iron is very short. The oxygen atom is a high-energy particle that is highly reactive. It aggressively seeks out and combines with other elements, and most of the newly formed "oxide" molecules are nearly chemically inert, which should help maintain a less active molten metal state. Unfortunately, iron oxide contacting the molten bath continually resupplies free-oxygen atoms to the bath, replacing the atoms forming oxides.

One of the consequences of free-oxygen atoms entering



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the molten bath is nanosized oxides precipitating throughout the bath. These oxides trigger further chemical reactions and formations and create physical impairments within the liquid and solidified iron.

Multi-point analysis — Several quick points illustrating the adverse effects of oxide precipitation are:

1. Oxidation of carbon and silicon causes the loss of these elements to metal chemistry – and significant financial loss.

2. Precipitated nanosized oxides act as thickeners to metal flow, decreasing fluidity.

3. Precipitated nanosized oxides provide crack initiation sites in the metal matrix, reducing strength and ductility.

4. Iron oxide distributed throughout the bath causes spinel formations, directly responsible for inductor loop plugging, furnace spout, inlet plugging, and sidewall furnace buildup.

5. Continual precipitation of nanosized oxides during casting produces casting defects that account for 30-70% of a foundry's current scrap rate.

6. Precipitation of oxides in the matrix significantly decreases the casting machinability index.

7. Free oxygen atoms cause magnesium fade in ductile iron.

8. The free-oxygen atom level in the base iron directly affects the volume of magnesium necessary to make ductile iron.

There are many more adverse effects, too, and these will be addressed in further detail in subsequent reports.

There also is much to be said about the improved quality of molten metal created with “oxygen-free” iron. And, much can be said concerning iron oxide in cover slag:

1. Iron oxide instantly forms on molten iron surfaces in contact with the atmosphere.

2. Iron oxide in slag causes the crustiness some slags exhibit.

3. Iron oxide-free slag is manageable, non-sticky to refractory, does not form blockages, and should not be removed

4. Full slag cover should be used to create a barrier to atmospheric contact once iron oxide is removed.

4. Iron oxide in slag overwhelms refractory, causing refractory to be chemically eroded regardless of refractory quality.

5. Iron oxide-free slag allows refractory quality to be the main controller of refractory performance and service life.

6. Iron oxide-free slag eliminates slag line erosion in furnaces.

7. Iron oxide-free slag stops sulfur reversion in ductile iron.

8. Iron oxide present in slag must be chemically reduced by special materials added to the slag mass. It cannot be physically removed.

9. Removing cover slag, exposing clean molten metal to the atmosphere, causes higher levels of iron oxide in the newly formed slag.

Molten metal deoxidation — Once oxygen atoms have been released into the iron bath, nothing can be done to keep them from “oxidizing” some element.

The Laws of Thermodynamics prevail, always.

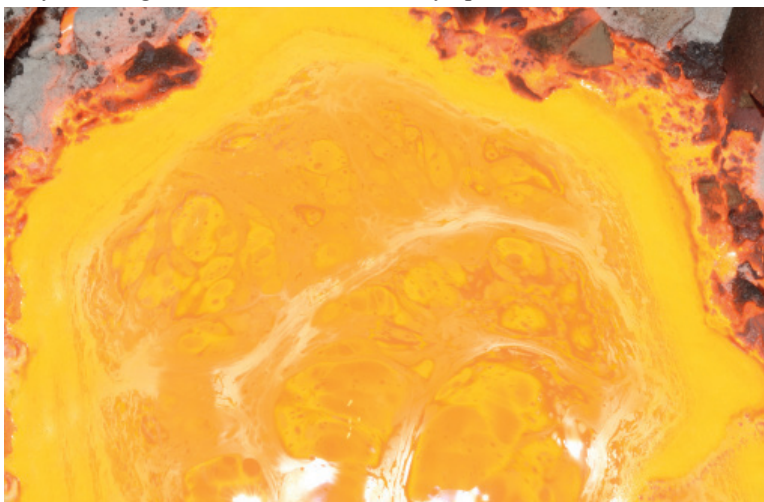
Because oxygen atoms cannot be removed, Mastermelt engineers determined to reduce iron oxide chemically, using silicon carbide. However, silicon carbide's reactivity with iron oxide is dependent on certain properties developed during its manufacture. Not all silicon carbide is the same and not all silicon carbide reacts with iron oxide.

Their goal was to develop a de-oxidizing material that would reduce iron oxide by converting its harmful nature into inert by-products. After a long process of testing and research, Mastermelt identified certain grades of silicon carbide that are highly reactive with iron oxide and incorporated these into the DeOX de-oxidation product for electric furnace or cupola melting.

In electric furnaces, DeOX is added with the furnace charge, or with the initial charge if multiple charges are made. Normal melting practice is maintained thereafter. DeOX simply reduces all iron oxide inside the furnace. All carbon and silicon loss is stopped.

Only one melt practice change is required. Slagging at the end of melt cycle should be prolonged to occur just prior to transport, which is designed to reduce the cleaned bath's contact time with the atmosphere.

In cupola melting, DeOX is injected through one or two tuyeres, and reduces all iron oxide produced in the tuyere raceways. Because iron-oxide formation begins when melting commences, DeOX injection should begin at or before tap-out. Tap-out chemistry, which represents the true cupola charge chemistry before iron oxide formation in the race-



In molten iron, at temperatures above 2,600°F, carbon is oxidized; below 2,600°F, silicon is oxidized. Iron, manganese, and other elements are continuously oxidized too: Iron oxide is reformed and distributed throughout the bath.

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way causes its decline, will be maintained throughout the melt campaign. All carbon and silicon oxidation losses are stopped.

The carbon losses stopped are those that occur in the tuyere raceway area. Most of these carbon losses went unnoticed in the past, so DeOX provides an instant jump in carbon level — from 0.35% C to 0.90% C depending on the loss that had been occurring. This increase in carbon recovery produces significant coke rate reductions. Each cupola operation can determine the carbon pickup that DeOX will provide simply by checking the tap-out chemistry as compared to that after several hours melting.

During iron melting, in both cupolas and electric furnaces, free-oxygen atoms enter the molten iron mass. Unrestrained, they accrue to the level of 4 to 9 parts per million. These extremely low levels of contamination show the tenacity of the oxygen atom (5 PPM = 0.0005 %.) The inert level of oxygen, the level where oxygen no longer causes harm, nears 1-2 PPM, and is dependent on metal temperature. Higher metal temperatures correspond to higher oxygen inert levels. Metal chemistry also influences the inert level.

Typical cupola melting foundries test at 5-9 PPM oxygen. In cupola melting, the free-oxygen level is directly related to the coke rate, but seldom lower than 5 PPM.

In EF melting, the free-oxygen level is more dependent on metallic scrap selection and iron oxide contamination

present within the furnace charge. In cupola melting, iron oxide is produced within the cupola with metallic-charge contamination seemingly unimportant.

Two methods are available to determine free oxygen's influence on a foundry's casting products. One calls for measuring the actual free-oxygen content in the molten iron. This requires the oxygen meter commonly used in steelmaking but never found in the iron-making industry. (One of these meters has been made available by Reno Refractories and its use can be scheduled for analyzing a specific foundry's iron quality.)

The second method is to determine the iron-oxide level in the cover slag or melting/holding/pouring furnace slag, which can be correlated to a free-oxygen level based on the extensive testing we have performed over years of testing.

Cost Savings — Removing free oxygen from molten metal produces significant savings. At one large cupola operation, oxidation losses exceeded \$50,000/day, which is easily saved. Oxidation losses make up a significant and important portion of an iron foundry's operating costs. These oxidation losses can be stopped using DeOX product.

Melting personnel need to be relieved of the burden produced by the free-oxygen atoms in molten iron. Iron melting is much simpler, less frustrating, and less strenuous when the free-oxygen atom, is under control. DeOX makes free oxygen control a very easily attained goal. 🛡️



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Controlling Iron Oxide to Stop Carbon and Silicon Losses

Iron foundries must address and eliminate the effects of oxidation by controlling FeO in slag contacting the molten metal.

Carbon and silicon oxidation losses always occur in iron melting. The losses are costly, but they can be prevented easily with newly available technology. Free-oxygen atoms present in the molten iron cause oxidation: These unwanted atoms are supplied by iron-oxide molecules contacting the molten metal surface. Oxygen atoms cannot be “removed” effectively from molten iron. Nothing can be done to stop the “oxidation” process once they enter molten iron.

Oxygen atoms seek out and combine with other atoms present in the molten iron, i.e., carbon, silicon, and manganese. They are oxidized according to the Laws of Thermodynamics, which identifies the primary element or elements oxidized according to the existing conditions of the molten bath, based primarily on the molten metal’s temperature.

The secret to stopping oxidation losses is to cut off the supply of free-oxygen atoms. Iron oxide (FeO) contacting the iron surface establishes an equilibrium chemical reaction: $\text{FeO} = \text{Fe} + \text{O}$. So, stopping the supply of the oxygen atom becomes stopping iron-oxide contact with molten iron. It sounds easy but in fact it’s very difficult, and it has been the basis of Mastermelt’s +20-year project.

Primary steelmakers simply change the slag containing unwanted FeO, a step they call “cleansing the slag”. A clean, lime-based slag, free of iron oxide, replaces the unwanted slag. The new, FeO-free slag creates a barrier to atmospheric contact, preventing new iron-oxide formation.

In iron melting, few special precautions are taken to prevent iron-oxide formation, and up to now ferrous foundries have accepted the consequences of its presence. That is changing with DeOX and DeOX de-oxidation technology.

Mastermelt engineers have determined FeO contacting the molten iron surface produces numerous detrimental effects in molten iron. The first step to controlling the problem is to determine the current extent of those oxidation losses, and assign costs to them. Then, a plan can be selected for halting the losses.

The two most common iron melting methods – cupola melting and electric furnace melting – need to be addressed separately, as each has its own sources for iron-oxide contamination during melting.

Cupola Melting — In cupola operations, metallurgical tests soon after the tap-out indicate the metal chemistry before FeO has built up inside the cupola; before that, iron oxide has had a chance to reduce carbon and silicon levels dramatically. It takes about an hour of melting before levels of FeO inside the cupola reach steady state. Once iron-oxide levels stabilize, carbon and silicon loss in the cupola will stabilize somewhat. Hence, tap-out chemistry indicates the conditions “before” oxidation’s effect, and metal chemistry an hour or so following tap-out indicates the condition “after” oxidation has taken hold.

It is important to realize that in cupola melting the descending molten-iron droplet is exposed to atmospheric oxygen in the tuyere raceway, forming FeO at that point. Free-molecular oxygen is available only at tuyere level.

Iron-oxide formation on the molten droplet’s surface at tuyere level cannot be stopped; it forms as soon as the molten iron surface is contacted by oxygen-laden blast air. The iron oxide, formed at tuyere level, systematically spreads throughout the cupola (and described in greater detail here.) Understanding cupola oxidation technology is critical to solving cupola oxidation loss.

1. Silicon oxidation takes place throughout the melt zone and retained slag layer.
2. Carbon oxidation occurs primarily in the tuyere raceway section, where the higher temperatures favor its oxidation. In



the lower temperature areas of the cupola, silicon oxidation preferentially occurs.

Overall oxidation losses go hand-in-hand with the iron-oxide level in the cupola. In turn, blast-air humidity levels influence iron-oxide levels significantly. Water contained in blast air accelerates iron-oxide formation many times over. Consequently, high-humidity summer days wreak havoc on cupola melting. Mastermelt's experiences with the "summertime" problems for ferrous foundries could be the basis for a novel.

Determining cupola oxidation losses. Compare tap-out chemistry with metal chemistry after the first hour or so of melting. Both carbon and silicon levels gradually decline after tap-out to points determined by the melting "conditions of the day."

The chemistry change correlates to the oxidation losses occurring. Losses reach a steady state, leveling out when FeO contained in the slag exiting the cupola equals the amount of FeO continually forming inside the cupola. Iron-oxide levels within the cupola control the severity of the losses.

In some cupolas, the oxidation losses are consequential. Silicon loss can exceed 40-50%. In better cupola operations, silicon losses near 20-30%. Actual carbon loss can exceed 1.20% C in some cupolas but typically it nears 0.70% C. The lowest carbon loss recorded has been 0.40% C.

Silicon loss can be avoided with elevated coke rates combined with treatment of FeO in the retained slag layer. Carbon oxidation loss, however, cannot be eliminated without de-oxidation in the tuyere raceway via tuyere injection of a de-oxidation material.

In all cupola operations, both silicon and carbon oxidation loss can be eliminated easily, without requiring minimal coke rates. DeOX tuyere injection stops FeO formation in the tuyere raceways. Because no iron oxide is vaporized to spread throughout the cupola, coke rates can be adjusted primarily based on the metal's temperature exiting the cupola. This fact opens the door to numerous cupola design and operating techniques (to be addressed in future entries to this series.)

Oxidation mechanisms. Carbon oxidation in the cupola occurs in the tuyere raceway, the area of extreme high temperature within the cupola. Iron oxide forms when blast air containing the oxygen molecule (O_2) contacts the molten iron droplet. Iron oxide instantly forms on the droplets surface: $2Fe + O_2 = 2FeO$. Temperatures reach near 5,000°F in this area.

This high-temperature zone ends up vaporizing a portion of whatever is present there: molten iron, FeO, and coke ash. The vaporized gas ascends the cupola, rising to above

the upper melt zone where temperatures cool it, initiating condensation of the gas into a liquid. The liquid formed is a combination of liquid iron, liquid iron oxide, and liquid coke ash (SiO_2). The liquid coats the descending charge materials.

Steelmakers have documented this vaporization phenomenon extensively in literature on blast furnace operations. Cupola operation differ from blast furnaces: while BF combustion gas products contain primarily carbon monoxide (CO), cupolas are operated with much less CO in the combustion gasses.

The operational difference between blast furnace and cupola combustion gasses determines the fate of the FeO descending from the upper melt zone of a cupola. Iron oxide will remain intact and will not be chemically reduced by CO, if low levels of carbon monoxide exist.

Coke rates in cupola melting determine combustion gas ratios: CO / CO_2 . Mastermelt engineers suggest a 12% minimum coke rate is required to produce adequate carbon monoxide to effectively chemically reduce FeO levels produced by blast air containing the humidity levels typically recorded in the continental U.S.

Thus, when FeO continues to exist in the upper melt zone, where temperatures are much lower than at the tuyere level, silicon will be

preferentially oxidized there. If adequate carbon monoxide is available, iron oxide is chemically reduced in the upper melt zone and silicon oxidation is forestalled. When this occurs, the only silicon oxidation possibly taking place will be silicon lost to iron-oxide chemical reactions in the retained slag layer.

Returning to the tuyere raceway: Iron oxide is formed in the raceway, which instantly reacts with the descending molten metal droplet, and because of the high temperature, oxidizes some of the carbon in the molten metal. A portion of the FeO formed at tuyere level is vaporized with the remaining FeO descending with the droplet to the cupola's retained slag layer. Slag adhering to descending metal droplets is wiped clean as the droplet travels downward through the slag layer, exiting through the taphole as cleaned metal. Slag accumulates in the retained slag layer, eventually gaining enough mass and forcing all molten metal to exit the cupola while allowing some slag to exit the same taphole.

So the picture develops: Silicon is oxidized at times in the upper melt zone; carbon is oxidized always in the tuyere raceway. Silicon is oxidized sometimes in the retained slag layer.

Once the metal droplets have descended past the high-temperature zone, they descend through the retained slag layer located above the cupola's taphole. Slag/metal reactions always occur in the retained slag layer. The length of time that droplets

In all cupola operations, both silicon and carbon oxidation losses can be eliminated easily, without requiring minimal coke rates

are exposed to these slag/metal chemical reactions depends on the depth or volume of slag in the retained slag layer.

Time, temperature, chemistry. Chemical reactions, such as the slag/metal reactions, are greatly influenced by time and temperature. The time of contact between the iron droplet and slag significantly controls the extent of the chemical reactions. High retained-slag amounts inside the cupola extend the contact time between the slag and the metal droplet, which can significantly increase silicon oxidation losses.

Another way of stating this: If high iron-oxide levels in retained slag cannot be prevented, silicon oxidation losses will be reduced if the retained slag level is minimized within the cupola. Minimal retained-slag levels will minimize the time molten iron is exposed to the FeO present in the retained slag. Mastermelt's operational plastic cupola model demonstrates retained slag's relationship to operational variables (also to be addressed in future entries to this series.)

Minimizing the slag/metal contact time effect is demonstrated several ways. Consider: When the metal dam height is reduced, silicon levels increase; or, when the taphole "blows", indicating no retained slag in the cupola, silicon levels also increase. Less slag or no slag reduces the slag/metal reactions occurring in the cupola, reducing loss and causing the silicon level to rise.

The slag/metal chemical reactions occurring in the retained-slag layer are determined by the chemical composition of the slag layer. Iron oxide resides in the slag layer, and this causes a new round of chemical attack on the key elements in the molten iron, namely carbon, silicon, and manganese.

Mastermelt engineers have controlled the iron-oxide level in the retained-slag layer and in doing so have controlled silicon-oxidation loss. Cupolas have been operated with no silicon loss only to have the silicon loss occur unfortunately as the humidity in the blast air increases.

Mastermelt tuyere injection in a southern U.S. cupola reduced silicon oxidation to zero for a portion of a day until humidity rose, posting a 74°F dewpoint. Then, the silicon-oxidation rate in the cupola rose to 45%. The following day, operating under the same conditions, but increasing the coke rate from 10 to 12%, silicon oxidation loss was eliminated throughout the day. The 12% coke rate produced enough carbon monoxide to chemically reduce the iron oxide causing silicon oxidation in the upper melt zone. In this cupola, Mastermelt tuyere injection neutralized the iron oxide in the retained slag layer, but needed the assist of CO to neutralize the FeO in the upper melt zone.

The solution to carbon and silicon oxidation in cupola

melting is to chemically reduce iron oxide, which is produced continuously throughout melting. But, iron oxide is always produced in tuyere raceways, and cannot be prevented. To stop carbon- and silicon-oxidation losses: DeOX must be injected with blast air so that as FeO forms, it is chemically reduced to inert by-products.


Electric Furnace Melting — EF melting has always incurred some silicon and carbon loss. The carbon loss is typically attributed to "poor graphite." Most EF experts declare the silicon loss to be inevitable and unavoidable. Mastermelt engineers disagree.

Electric furnace melting is less susceptible to iron-oxide formation during the melting process than is cupola melting, which results in less silicon and carbon oxidation loss. Electric furnace melting is more susceptible to FeO-contaminated steel scrap than is cupola melting. Overall, oxidation losses in EF melting are less than cupola melting. Typical cupola silicon-oxidation loss is 25-30%, compared to EF silicon loss of 10-15%.

Mastermelt engineers have proven nearly all carbon and silicon-recovery issues in EF melting occur due to FeO present in the furnace slag. It is the same technology as described above for cupola melting: FeO in the cover slag adds oxygen atoms to the bath, which causes the oxidation reactions. Molten metal temperature determines whether carbon or silicon is oxidized.

When iron oxide in cover slag is eliminated in EF melting, no oxidation losses are encountered. Simple addition of DeOX to a coreless furnace charge will produce full recovery of both carbon and silicon. In one example, carbon recoveries nearing 75% with standard melting practice increased to full 100% recovery, and silicon recovery of nearly 85% also increased to full 100% recovery with DeOX treatment. It is a new technology, and simple to evaluate.

In typical EF melting, some FeO is produced by exposing molten iron to atmospheric contact during the melting and superheating stirring process. Typical slag levels in coreless melting are near the 15 to 25% FeO range. Typical free-oxygen levels of EF melted iron exceed typical cupola free-oxygen levels. But, with small amounts (0.25% - 0.40%) of DeOX added with the furnace charge, the iron-oxide level in the resulting EF slag is typically less than 0.5% FeO, which is similar to cupola slag's FeO content during full carbon- and silicon-recovery periods.

The new de-oxidation technology means iron foundries' carbon and silicon losses can be eliminated by controlling iron oxide in slag contacting the molten iron. 

Mastermelt engineers have controlled the iron-oxide level in the retained-slag layer and in doing so have controlled silicon-oxidation loss.

Controlling Molten Iron Chemistry and Metal Fluidity

Using metal cleanliness to prejudge molten iron's fluidity is a breakthrough technology. It substantially reduces the risk for scrapped castings.

The ingredients of a furnace charge, whether it is an electric furnace or a cupola melter, are formulated to produce the final chemistry required for the castings to be poured. Unfortunately, formulating the charge does not determine the final chemistry or quality of the molten iron. Melting is not simply the process of re-melting existing metallic materials: Slag-induced influences during the melting process — caused or produced by the slag/metal chemical reaction — have a consequential role in iron chemistry and finished metal quality.

Molten iron chemistry variations result from two primary sources:

1. Accuracy of the weight of individual metallic and alloy ingredients in the charge; and,
2. Chemical reactions (slag/metal reactions) that occur during the melting process and cause unpredictable and widely varying loss of C, Si, Mn and other necessary elements.

Oxidation losses cause 99% of all chemistry variations in molten iron. Unwanted weight variations in charge ingredients, which frequently are assumed to lead to chemistry variations, in fact are a minor influence in most melting operations. You must experience melting without oxidation loss to appreciate the significance of this.

The wide variations in metal chemistry faced by some ferrous foundries are caused by oxidation loss of the key elements. It is a simple analytical comparison: Chemistry will vary by 50% when a 50% oxidation loss occurs. Oxidation must be controlled in order to attain "straight-line" chemistry.

Can carbon be controlled to produce straight-line chemistry? Unequivocally, yes. One-hundred-ton-per-hour cupola furnaces

have been operated for entire daylong campaigns with carbon variation of 0.01% C, and such exceptional chemistry control is possible with any melting operation.

Tuyere injection can be used to counter oxidation losses in a cupola, in addition to supplementing carbon and silicon in molten metal exiting the cupola. First, oxidation must be resolved. Then, silicon and carbon can be injected in any amounts needed to trim the chemistry.

The materials to be injected must be "injection-grade" and "injection-quality": Standard-grade silicon carbide (SiC) and graphite do not qualify. Simply, lower-quality materials do not work and using them discredits tuyere injection as a reliable melting tool.

SiC must possess a high dissolution rate in the molten iron, and only a few grades of SiC qualify. Carbon must possess an equally high dissolution rate in molten iron and no commonly available graphite carbon raisers meet this qualifying standard.

Trimming chemistry

Both carbon and silicon-carbide can be injected to trim the cupola metal chemistry. Mastermelt engineers spent two years developing the technology and skill needed to determine the specific materials that can be injected effectively.

It is pointless to inject SiC and carbon materials that do not provide full carbon or silicon recovery. Without full recovery, chemistry control deteriorates further.

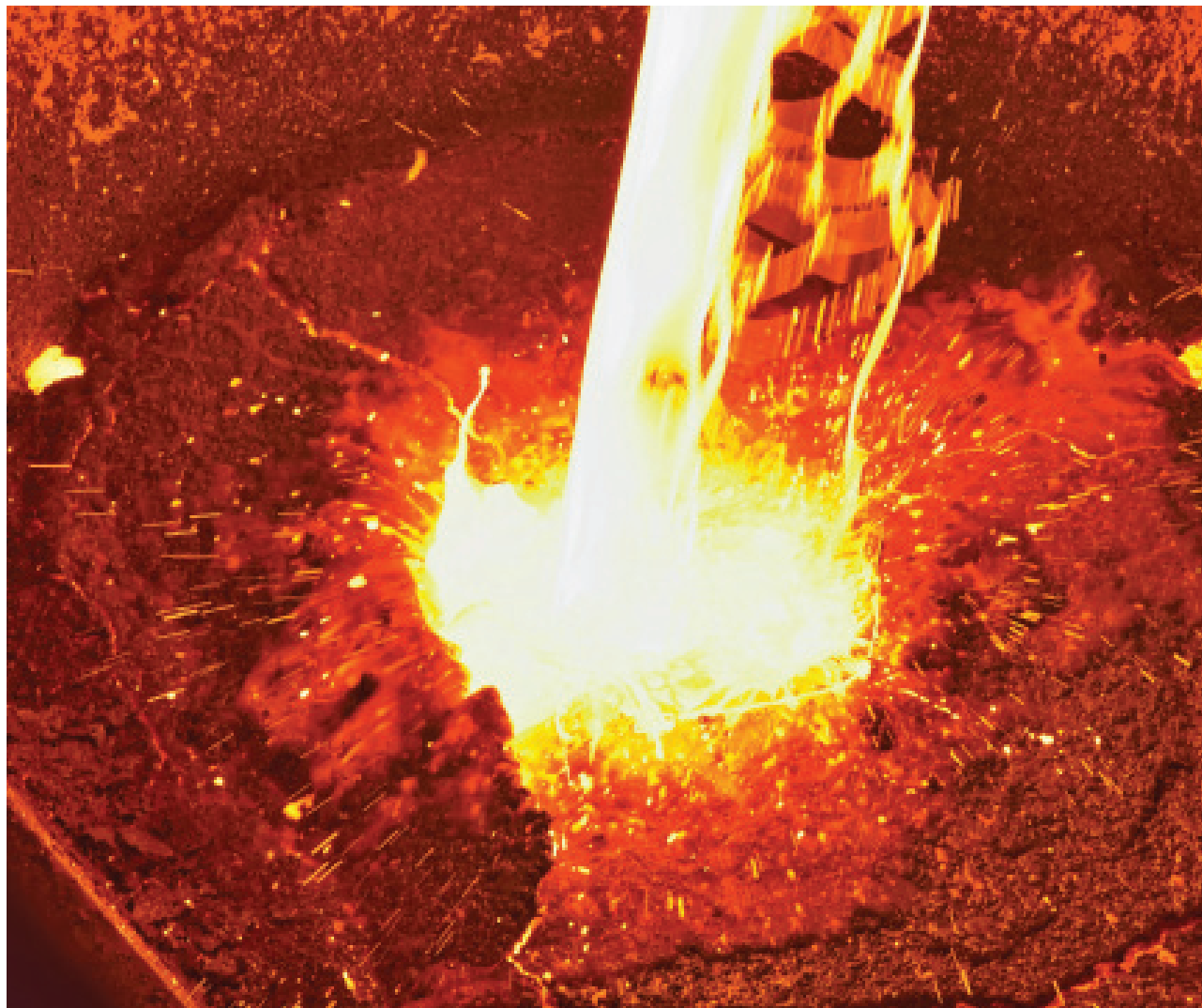
Both carbon and SiC are commonly tuyere-injected, and both materials are unique: They do not melt but enter into molten iron via an atomic exchange at the molten-metal interface. The governing forces controlling the rates these materials enter into molten iron are complicated, best left to scientists and crystallographers. Carbon and silicon-carbide's entry rates into molten iron are inherent properties of the material. The properties develop during production of the material and are reset when production concludes.

When Mastermelt first introduced SiC tuyere injection many suppliers and foundries followed suit and start injecting; none of the competing SiC injection systems proved successful. Many of those systems injected "injection carbon," which turned out to be coke breeze. Unfortunately, many (if not all) of those users proved unequivocally coke breeze is ineffective for controlling iron chemistry, though some suppliers still recommend it.

When injected carbon or silicon carbide produces full recovery in molten iron, melting personnel are afforded a very viable tool for trimming chemistry precisely. One melting supervisor reported Mastermelt DeOX tuyere injection puts the cupola on "cruise control" for chemistry control throughout the melt campaign.

Misunderstanding chemistry

Many explanations surface when molten iron chemistry is out-of-spec. In cupola melting, the classic excuse for low carbon and silicon levels is "the cupola is oxidizing today" or a "dou-



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ble charge must have happened.” In electric furnace melting, “poor carbon” or “low-purity silicon carbide” are the standard explanations.

None of these excuses are accurate. Chemistry variations, heat to heat, result from oxidation loss. DeOX stops both carbon and silicon oxidation by stabilizing chemistry in both EF and cupola operation. Neutralizing all iron oxide in the cover slag stabilizes chemistry because Iron oxide is converted into inert by-products. Oxidation processes are stopped.

Small amounts of iron oxide (e.g., 1.5% FeO) appear to be inconsequential for causing negative effects on molten iron, but that is far from true: FeO content must be less than 0.2% FeO.

A typical acceptance level of 1.5% FeO in cupola slags produces 20-30% silicon oxidation loss, which is not acceptable. At the 0.2% FeO level, silicon-oxidation losses are eliminated and unimaginable iron quality results.

Iron-oxide content must be reduced to near zero for oxidation losses to be stopped. Many foundries check slag chemistries, but few if any realize iron oxide must be controlled at less than 0.2% FeO.

Slag color indicates the level of iron-oxide contamination: the typical black or very dark slags indicate trouble. A greenish color indicating lower levels of FeO begins to appear at the 1.0% level and progresses to light green at 0.2% FeO content.

Slag color provides a great rating system for judging melting processes. In EF melting, slag color indicates the oxidation loss that has occurred. In cupola melting, slag color suggests iron oxide forming tendencies of the blast air in addition to severity of oxidation loss occurring. Slag color checks are an integral part of all molten iron-quality systems.

Metal fluidity

In the past, metal fluidity typically would be controlled by regulating the pouring temperature. Adding “superheat”, meaning the iron’s temperature above the solidification temperature, increased the fluidity of the metal. When the temperature increase proved inadequate to control fluidity, small amounts of ferro-phosphorous were added to the iron.

Poor fluidity creates many headaches for foundries. Increasing pouring temperatures causes many quality issues in the

casting process. Things like burn-on and increased shrinkage lead to big problems.

The metal's chemistry is important to establishing melt fluidity. Iron develops a eutectic, its lowest melting point, as chemistry nears the 4.3% CE (C and Si percentage calculated in a unique manner). Iron chemistry varying above and below 4.3% CE have higher solidification temperatures. At times, minor chemistry variations can reduce fluidity enough to cause "mis-run" defects.

Up to now, chemistry control or change and phosphorous additions, along with pouring temperature increases, were the only tools available to the casting engineer to fight the mis-run issue. Now, DeOX provides an entirely new and effective way to improve metal fluidity.

As noted in a previous report, removing free oxygen atoms from molten iron stops the oxidation process. The oxidation process produces "oxides" that end up suspended in the metal matrix. Solid oxides like SiO₂ and MnO, and gaseous oxide CO, accrue in the matrix and eventually combine with other like oxides, achieving critical mass, which allows the oxide particle to "float out" of the melt.

No more free oxygen

This coalescence process of the precipitated oxides produces cleaner metal. An important discovery by Mastermelt engineers was that once the supply of free oxygen atoms is cut off, it takes near two minutes for the suspended oxides to float out of the molten iron bath. This fact correlates with steel melting practices, which allow the same two-minute interval between de-oxidation and pouring.

One significant feature of lower-oxide-containing, much cleaner metal is that fluidity improves dramatically. An almost unbelievable increase in fluidity occurs when the metal is cleaned: It is an almost night-and-day difference. Phosphorous additions are eliminated, pouring temperatures can be reduced, and mis-run defects disappear.

In one casting application producing two-inch diameter cast iron pipe, which is cast in long thin-walled sections, mis-run or lack of filling the entire length of the metal mold was eliminated as a scrap defect. The casting supervisor of the pouring floor could not believe his eyes. Full-length, two-inch pipe castings were completed consistently.

There is no need for a "fluidity spiral" test when casting two-inch-diameter, cast iron pipe in a spinning metal mold.

The casting application serves as the best test of all, but it is costly when fluidity is poor.

The improved fluidity referenced in the two-inch diameter, cast iron pipe transferred to ductile-iron pipe manufacturing, too. For years, the plant manager of a Midwestern pipe foundry touted the improved fluidity of Mastermelt tuyere-injected cupola iron in all sizes of ductile iron pipe.


In another application, the need for the phosphorous supplement was eliminated with Mastermelt SiC tuyere injection. When that injection technique stopped after seven years and a different injection material was injected, mis-run defects immediately appeared and phosphorous additions resumed. The replacement SiC material did not neutralize iron oxide within the cupola, hence free-oxygen levels were higher, producing higher levels of suspended oxides and reduced fluidity.

Thus, metal cleanliness becomes a new and very important molten iron property.

Examining how your favorite cook makes gravy can simulate metal cleanliness. Gravy starts as a clear, very thin and fluid broth to which a thickener is added. The end result is a thickened, slow-moving liquid. Nano-sized oxides suspended in the molten-iron matrix are the thickening agent in molten iron. The metal's cleanliness correlates to fluidity. "Dirty" iron is difficult to cast successfully, but when the free-oxygen atom supply is cut-off, cleanliness can improve by a 10X factor or more; fluidity skyrockets accordingly.

Metal cleanliness can be measured and compared by determining the oxygen content in a solidified metal sample. All oxides contain the oxygen atom with total oxygen content representing the overall oxide level. Total oxygen results can be compiled to establish a fluidity rating system for the specific foundry's casting applications.

It is necessary to determine the level of oxide contamination in the molten metal, which produces fluidity-induced defects. Oxygen content readily relates to iron fluidity and can be assigned limits similar to chemistry and metal temperatures in a foundry's overall quality-control program.

Now temperature, metal chemistry, and cleanliness can be used to prejudice molten iron's fluidity, substantially reducing scrap-casting risk potential. Every iron foundry's quality program must consider this technology in its overall quality-control practices. 

One significant feature of lower-oxide-containing, much cleaner metal is that fluidity improves dramatically.

Treating Oxidation to Reduce Iron Casting Scrap

The chemical process that leads to surface defects, inclusions, pinholes, slag, dross, and misruns is continuous and ongoing.

The only way to stop it is to cut off the supply of free oxygen atoms.

Steel producers have long recognized the role that free oxygen atoms play in the formation of defects in their finished products. Appliance-grade steels, deep-draw can steels, and many other grades cannot tolerate surface blemishes or defects. Steel industry metallurgists determined the defect-formation is directly correlated to free-oxygen content in steel, prompting them to go to extremes in their efforts to shroud molten steel from atmospheric contact.

Despite the effort, iron oxide tenaciously formed and steel became contaminated, leading the steelmakers to add aluminum to tie up oxygen in critical applications.

Iron foundries are prevented from using aluminum to minimize defects because the 0.03% Al level needed to tie up all free oxygen atoms in steel production will lead to gas porosity in cast iron.

Many foundry metallurgists simply disregard free-oxygen levels in molten iron: They do not have the technology to remove free-oxygen atom contamination, so they let it be. Free-oxygen removal has been accomplished only by vacuum treatment. No practical general process or technique has been available to remove free oxygen atoms from molten iron, until the introduction of DeOX Metal Treatment.

Free-oxygen levels — Oxygen atom levels nearing 1 part-per-million (PPM) in steel reach oxygen's inert behavior level, the point at which no "oxidation" occurs. Steelmakers have proven oxygen levels exceeding 1 PPM cause surface defects; 2 PPM oxygen produces a 2% defect rate; and 3 PPM oxygen produces 4% defects.

In iron, oxygen's inert level nears 2.4 PPM, which is higher than the inert level for steel, the elevation being due to the higher chemical composition of iron. However, common levels of free oxygen in iron typically cast into molds by iron foundries exceed 5-8 PPM. These high levels of free oxygen cause defect formation, a detail that unfortunately is unknown to foundry technologists worldwide.

There are many consequences of free-oxygen atom contamination, all are profound and all are bad. They range from producing surface defects, producing oxidation losses during the melting process, reducing iron fluidity, reducing mechanical strength and elongation, drastically decreasing machinability, and many, many more. The oxygen atoms' presence in molten iron is always detrimental, never beneficial.

Free-oxygen atoms are highly charged and highly reactive, and aggressively combine to form oxide molecules throughout the molten iron bath. Oxide formation is a continuous and ongoing process, stopping only when the oxygen atom supply is depleted or solidification occurs. Once the oxygen atom is liberated into the iron bath through the



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iron-oxide equilibrium reaction, its oxidation of other elements within that bath cannot be stopped. All elements within the bath are subject to oxidation. The Laws of Thermodynamics control each element's reaction rate with the oxygen atoms present.

Instant reaction — Oxide formation occurs at the nano or atomic level. The oxides formed are very small, but these oxides agglomerate or coalesce quickly into much larger masses. When they reach a critical size, the agglomerated mass floats to the metal surface. That entire sequence, ending in oxide flotation, occurs in seconds. If the floating action occurs in the furnace, transfer vessel, or pouring ladle, silica-rich slag forms on the molten metal's surface. If the oxide flotation occurs in the casting mold, casting surface defects form.

This oxide flotation phenomenon is illustrated by iron melting in coreless furnaces. Overall slag volume occurring during iron melting is reduced by 75% when low free-oxygen metal is produced. The startling reduction in slag volume results from elimination of silicon oxidation in the metal. The SiO_2 , which was normally formed, is absent, which reduces any slag produced to simply melting of dirt and surface contamination in the charge materials.

Oxide formation, the "oxidation" process, is a continuous and ongoing process. The only way to stop it is to cut off the supply of free oxygen atoms.

Mastermelt's DeOX Metal Treatment cuts off the supply of oxygen atom by chemically reducing iron oxide to inert by-products. Iron oxide contacting the molten iron supplied the free oxygen atoms. Once iron oxide is dealt with effectively, free-oxygen atom contamination levels in molten iron quickly lowers to the inert level of oxygen activity. No oxides are formed at oxygen's inert level. DeOX Metal Treatment neutralizes iron oxide, curtailing free-oxygen atoms' deleterious effects.

Low free-oxygen-level iron is typically free of surface defects. Common defects of iron castings, such as sand inclusion, dirt, slag, dross, blow, pinhole, and misrun, disappear from the scrap charts.

Low free-oxygen iron is a new material, never encountered by most foundry technologists. You must encounter it to believe it.

Low free-oxygen iron, DeOX-treated iron, eliminates that



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Low free-oxygen-level iron is typically free of surface defects. Common defects of iron castings, such as sand inclusion, dirt, slag, dross, blow, pinhole, and misrun, disappear from the scrap charts.

portion of casting scrap associated with surface defects. DeOX commonly lowers casting scrap levels to 1%-2.5%. Several examples are cited below:

- *Foundry A:* +1500 tons iron cast per day; Scrap level before low-free-oxygen iron = 3.0%; Scrap level with low-free-oxygen iron = 1.0%.

- *Foundry B:* 500 tons heavily cored iron cast per day; Scrap level before low-free-oxygen iron = 7%; Scrap level with low-free-oxygen level iron = 3%

- *Foundry C:* 200 tons iron cast per day; Scrap level before low-free-oxygen iron = 7%; Scrap level after low-free-oxygen level iron = 2.5%.

- *Foundry D:* 400 tons iron pipe cast per day; Scrap level before low-free-oxygen = 7.5%. Scrap level with low-free-oxygen iron = 2.5%.

Case by case — In each of these cases, when the low-free-oxygen iron supply was stopped or altered, casting scrap rates immediately responded, increasing and returning to previous scrap-rate levels. In the case of the 1,500-tpd foundry, low-free-oxygen iron was restarted and casting scrap level instantly returned to the low 1% level. That foundry has run at the very low scrap rate thereafter — for 15+ years.

In every case involving casting scrap-rate improvements brought on by DeOX Metal Treatment low-free-oxygen iron, foundry managers attributed the low scrap rates to their managerial expertise and knowledge.

In every case, large foundry to small foundry,

when low-free-oxygen iron reverted back to normal elevated oxygen levels, casting scrap rates jumped back to their original levels. Surface defects appeared and diminished in direct correlation to free-oxygen atom levels. Steelmaking experience was duplicated in the iron casting industry.

At the foundry pouring heavily cored castings, the managers understood the significant effect reduced casting scrap rates would produce for the bottom line, and therefore had in place a high-reward cash payback program when scrap rates were reduced. With low-free-oxygen iron, the payback resulted in an extra paycheck equal to one week's normal pay, for every employee each month.

However, when low-free-oxygen iron was replaced with normal, high-free-oxygen iron due to the managers' claim that "iron quality was unrelated to the scrap-rate decline," the scrap reductions ceased, scrap rates returned to "normal" levels, and the extra monthly paycheck ceased. To this day, the casting scrap



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rate remains at the “normal” level of the past at this foundry.

In ductile iron production, molten metal is treated by adding magnesium, which has a high affinity for free-oxygen atoms. Hence, the level of normal oxygen atoms in ductile iron is lowered from parts-per-million to parts-per-billion, an extremely low level of oxygen-atom contamination.

However, slag-containing iron oxide contacting the treated ductile-iron surface continues to add oxygen atoms to the molten iron. Magnesium atoms present in the ductile iron instantly combine with the oxygen atom, forming MgO , eliminating the oxygen atom’s reaction with other elements present.

This oxidation process causes oxide flotation and possible defect formation, but the probability of defect formation is lessened in comparison to cast-iron defect formation. Magnesium reaction with free-oxygen atoms however does reduce magnesium concentration, which leads to nodularity fade.

Mastermelt’s claim — “low free oxygen levels in molten iron reduces casting scrap rates” — is controversial. However, the claim is easy to prove. Scrap rates are instantly reduced when low free oxygen levels are achieved. DeOX Metal Treatment immediately reduces free oxygen to inert levels of reactivity, which is

followed immediately by lower scrap rates. Casting results prove the controversial claim in one to two days.

A sure way to determine an iron’s defect forming potential is to check its free oxygen level. Have a Reno Refractories representative check it with an oxygen meter commonly used in the steel industry but not typically available in the iron melting industry. This specialty instrument and test is only available through Reno Refractories and Mastermelt at this time.

Millions of dollars are saved when casting scrap rates are reduced. DeOX Metal Treatment can be evaluated quickly and at no cost to the foundry. In electric furnace foundries, DeOX is simply added with the furnace charges. In cupola furnace foundries, DeOX is injected into the tuyere raceways. The results appear instantaneously.

Foundry metallurgists and operators are helpless to reduce casting scrap rates when high levels of free-oxygen atoms exist within the iron. The mechanism of free-oxygen atoms’ influence on iron’s properties is unknown. DeOX Metal Treatment launches foundries upward into a new level of technology and casting expertise. 🚀

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Treating Molten Metal to Reduce Refractory Erosion

Chemical treatment technology is making it possible to extend a furnace's lining performance while achieving clean iron.

Refractory erosion in iron melting is seldom attributable to mechanical wear. Erosion generally is the aftermath of slag's chemical attack – chemical reactions between slag and refractory – producing reaction byproducts that enter the slag. The overall effect is refractory's effective protection layer, the thickness of the refractory lining, is continually eaten away, eventually leading to failure.

Refractory industry ceramic engineers have long used a very precise, real-time method to observe refractory-molten metal

interactions via X-ray, and to evaluate refractory resistance to slag attack

The Sessile Drop Test consists of placing a drop of molten iron on a refractory material to be tested, and placing the apparatus into a precisely controlled, high-temperature furnace containing an inert atmosphere where the interface between the droplet and refractory can be continuously viewed by real time x-ray. Initial reactions between the metal and refractory are minimal due to the inert atmosphere. Then, oxygen is added to the atmosphere, which instantly causes iron oxide (FeO) to form on the molten droplet's surface. Once iron oxide is present, rapid interactions between the molten iron and the refractory begin.

Without iron oxide, chemical reactions between the refractory and the molten iron are very subdued, almost non-existent. Iron oxide is the catalyst that changes everything, which demonstrates iron oxide's far-reaching role in initiating refractory chemical erosion.

Two-pronged attack — Refractory erosion results from two sources. First, iron oxide overwhelms the refractory's individual constituents, quickly reacting with those ingredients and converting them into useless slag. This type of iron-oxide attack simply overwhelms refractories regardless of their quality or purity.

Next comes a chemical attack of silica or other impurities within the refractory that affects its overall performance. The precise nature of these attacks is beyond the scope of this analysis, but the chemical reaction's overall effect on the refractory's service and performance pales in comparison to iron oxide's gruesome attack.

Refractory erosion can be effectively stopped, and refractory



DAVID TADEVOSIAN | DREAMSTIME

service life extended to unimaginable lengths, if iron oxide is controlled. Iron oxide-induced attack must be solved before the material's designed refractoriness can benefit the specific application.

Refractories are blended to incorporate the specific properties of each ingredient. When iron oxide doesn't steam-roller the application, the specific refractory properties designed into new refractories enhance service life beyond current performance, raising it to new levels.

Cupolas operating with low iron-oxide slag and with specially formulated refractories are setting benchmarks for service life, and the melting personnel endorse this great improvement. With the new refractory and low iron-oxide slag, cupolas can be drained at the end of major campaigns and require no refractory repair. Slag has not built up anywhere, and the small metal-line slag clumps are chipped off quickly and easily. No overnight or weekend repair is needed — unheard of for normal cupola operation.

DeOX Metal Treatment is designed to chemically reduce iron oxide in slag, effectively stopping iron oxide's reactions with refractory. It chemically converts iron oxide into inert byproducts and shields the molten bath with a type of surface barrier, thereby preventing contact with the atmosphere and stopping iron-oxide formation.

DeOX Metal Treatment accomplishes exactly that when added to electric furnaces or other molten iron baths. It does not melt but rather mixes into existing cover slag masses, eventually reacting with iron oxide as iron oxide enters the slag layer. DeOX instantly neutralizes iron oxide formed during the melting stage in electric furnaces, similar to what it accomplishes in cupolas.

In cupola melting, iron-oxide formation cannot be stopped. It always forms in the tuyere raceways. The secret to DeOX Metal Treatment is that it effectively neutralizes iron oxide as it forms. Tuyere raceways are the only location in the cupola where oxygen molecules exist, and iron oxide forms only in the tuyere raceway. Immediately above the raceways, oxygen molecules have been converted into carbon monoxide and carbon dioxide by the coke combustion process. Iron oxide will not form without the presence of oxygen.

DeOX Metal Treatment is the only process and/or material that neutralizes iron oxide in the raceway, and it effectively eliminates iron oxide throughout the cupola.

Harmful levels of iron oxide — Iron oxide levels in cupola and electric furnace slags vary from over 50% all the way down to 0.2% FeO. The 0.2% FeO nears the inert level of FeO's refractory erosion tendencies. Cupolas and EFs operating with 0.2% FeO show almost no refractory erosion. As a result, there is unprecedented refractory service life.

The taphole refractory shows no erosion after 80,000 tons of melted iron. Cupola front-box refractory shows no erosion, no slag build-up, and requires no repair after many weeks of melting.

Two adjacent foundries — a gray iron foundry side-by-side with a ductile iron foundry — both using 35-ton vertical channel furnaces, showed dramatic differences in furnace refractory service life. One furnace was skimmed on a daily basis to maintain a "slag free" molten iron surface, and the other was allowed a full slag cover with low-FeO content in the cover slag.

The cover slag in the latter furnace was seldom removed during a three-year comparison study. The low-FeO slag furnace showed an eight-times minimum service-life improvement over the "slag-free" iron surface furnace.

It has been found that furnaces holding or melting low free-oxygen iron produce 75% less slag than what is typical of standard melting and holding furnaces. This goes hand in hand with maintaining a cover slag barrier to prevent re-oxidation and seldom removing any of the protective cover slag barrier.

Once iron oxide is controlled, little additional slag is produced because silicon and manganese are not oxidized. This simplifies maintenance of a protective cover-slag barrier. Low iron-oxide slag is physically different from normal slag, forming clumps that do not stick together or to refractory sidewalls, inlets, or outlets. It forms a "dry" cover-slag barrier.

The theory that SiC added to refractory improves service life due to its hardness and inertness to chemical attack has been disproven. In fact, SiC used in refractories is chemically reactive with iron oxide — the exact opposite of that old theory.

Furnace manufacturers and some refractory suppliers maintain that cover slag should be removed daily from furnaces and pour vessels, so that the molten metal surface will be clean of slag. This is misguided.

Slag continually forms when molten iron contacts the atmosphere. Because this is unavoidable, daily cleaning of the molten metal surface will produce a higher level of iron oxide in the freshly formed slag layer than if the slag simply accumulated. Freshly formed slag contains 70-90% iron oxide and the balance is SiO₂. Over time, the silica component in the slag increases due to oxidation of silicon in the molten iron.

The iron oxide component in cover slag promotes the slag's crustiness characteristic, making temperature monitoring and chemistry sampling difficult. Penetrating slag crusts for sampling can damage the refractory and lead to personnel injuries. It is troublesome that "green poling" is still used today to break up hard slags. 🚫

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A Molten Iron Improvement Strategy

Clean, quality molten metal should be the goal of every ferrous foundry, and the technology is available to achieve it — but the results depend on you.

The development of high-quality iron castings begins with melting processes and techniques. You control how it is melted, giving you the final call in determining its quality. Everything depends on you.

Molten iron contains desirable and undesirable elements. In a ferrous foundry, you control both of these.

From the scrap metal that is the raw-material source for much of the melt come residual elements like chrome, manganese, nickel, aluminum, etc., that may compromise the quality of finished castings. The effects of these elements can be offset at times, but scrutiny of their presence must be the foundry's top priority. Everyone involved in the iron-melting process is responsible for controlling the levels of carbon and silicon levels in their melted heats. It's their daily duty.

In practice, very few foundries make the effort to control the critical, free-oxygen level in molten iron heats. Free-oxygen levels have remained an unknown, quality-compromising factor in the molten iron matrix. Very tiny amounts of free oxygen, measured in parts per million (PPM), have a significant influence on the iron melting process and the finished quality of iron castings.

You control the presence of free-oxygen atoms in the molten iron. Those oxygen atoms come from iron oxide (FeO) present in the slag that forms a cover atop the iron bath. If iron oxide exists in the cover slag, free-oxygen atoms will be transferred to and exist within the iron bath. Because you must control free-oxygen levels you must eliminate iron oxide in the slag.

Once oxygen atoms enter the molten iron bath, nothing can be done to stop the oxidation process. In addition, molten iron exposed to the atmosphere instantly forms iron oxide, so atmospheric contact must be avoided. You accomplish this by



establishing a full cover-slag barrier atop the bath.

Cut off the supply of those free oxygen to the bath by eliminating iron oxide in the cover slag.

You can create an FeO-free slag simply by adding DeOX Metal Treatment to the slag blanket. DeOX mixes into the slag and chemically reduces any iron oxide present — effectively stopping oxidation losses and the multiple extenuating issues instigated by free-oxygen atoms.

Decisive steps are needed to address years of inaction that has been the norm for ferrous foundries. It has long been the case that oxidation losses are accepted as inevitable; refractory erosion was tolerated as standard operating practice; crusty slag was the norm; “green poling” cover slag was OK; poor fluidity was a fact of life; poor machinability could not be avoided; inductor-loop plugging always occurs; casting scrap due to oxide flotation surface defects could not be avoided; and so on. The technology is available to you to change all of it. DeOX Metal Treatment is proven effective, but you must take the step improve the quality of iron cast, and change the direction of your foundry operation.

Your action plan — First, you must determine the extent of the problem of ferrous oxidation in your melting operation. What are the current melting oxidation losses? What portion of casting scrap-rate results from surface defects? What metal

chemistry declines are occurring over holding periods? What magnesium-fade rates are encountered? What customer complaints have been registered in regard to casting machinability? What fluidity issues are occurring on the pouring floor? Is plugging occurring on furnace spout, inlets, inductor loops, ladle pouring lips? What volume of slag is being produced? What furnace sidewall buildups are occurring? How is slag removed from furnaces? How often is slag removed?

You must carefully and closely analyze the melting operation, so prepare a checklist: What melting oxidation issues will you address with DeOX Metal Treatment? For example, what are the levels of silicon and carbon lost to oxidation, how is this reflected in cast-iron quality, and what are the costs to the foundry for these losses?

Typically, the savings achieved once carbon and silicon losses stop far exceed cost of the DeOX addition. All other DeOX benefits are “in addition” savings.

Your process plan — It is very easy to evaluate DeOX Metal treatment, but it takes your action to get the process started, and you must start it.

DeOX is a formulation of pet coke and SiC, neither material is harmful. Excess DeOX carries over to the next heat or continues “as-is” without any concerns or issues. It forms a non-sticky, dry type slag that flows out of the furnace into the transfer ladle when the furnace is tapped.

It is a harmless slag that will not cause casting defects if it is not removed. All this means that slagging the furnace can be a thing of the past.

You can launch DeOX Metal Treatment several ways: It can be added to an auto-pour before adding in any other area in the melt operation. If you start DeOX Metal Treatment at the auto-pour, add DeOX to the main furnace bath inside the auto-pour and to the inlet. The spout receives carryover from the main bath. It takes hours for DeOX to show results.

Remember, if metal chemistry inside the auto-pour declines when held for any length of time, more DeOX is needed. No chemistry decline occurs when all iron oxide inside the auto-pour has been reduced and neutralized.

Once the iron oxide has been neutralized inside the auto-pour, inductor loop-plugging ceases: The loop or channel will not open up but new plugging formations will cease immediately.



**Everyone involved
in the iron-
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**It's their daily
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No flux is needed or wanted during DeOX treatment.

In coreless furnace operation, start with two bags of DeOX (50#) for the first two to three heats: This will clean the furnace sidewalls. Then, reduce DeOX to one bag per heat, for up to 15,000# heat size. The theoretical chemistry of the charge will be achieved. Be sure to reduce carbon and silicon additions accordingly.

In vertical channel furnaces, slag cover should be initially converted to FeO-free slag. This may involve adding four to six bags of DeOX at the start. Once DeOX treatment has begun, do not remove slag from the furnace unless the volume is excessive. DeOX stops oxidation of silicon in the melt, decreasing slag volume by 80%, and making slag removal unnecessary.

Your expectations — The need for additional DeOX is determined by the amount of iron oxide on the charge materials. Unlike coreless furnace melting where iron oxide is formed due to agitation of the molten iron and the resulting exposure to the atmosphere, vertical channel furnaces melt without severe metal agitation. This makes the FeO coatings on the charge materials the primary source for iron oxide as long as a full slag cover is maintained.

Because FeO presence is reduced in vertical channel furnaces, less DeOX is needed to maintain low iron-oxide levels in the cover slags. The cover slag layer in vertical channel furnaces needs to be maintained:

It should not be removed. Minimal slag is produced during melting after oxidation stops. The best of all worlds is realized.

DeOX added to vertical channel furnaces remains active until it reduces iron oxide. Its reactivity with iron oxide doesn't decrease over time.

The only concern to be anticipated with DeOX Metal Treatment will come after oxidation is stopped, as melt chemistries rise to the theoretical chemistry of the charge materials. This must be foreseen and allowed for in the first DeOX furnace charge. Calculate the theoretical metal chemistries and make adjustments based on full carbon and silicon recoveries.

All of this improvement can be planned for, but you must make the plan. You can chart a new course for your foundry and yourself, with a cost-saving, future-oriented technology available now. 🚀