Ductile Iron News

Ductile Iron Society

To Promote the production and application of ductile iron castings *Issue 1, 2004*

FEATURES

DEPARTMENTS

American Foundry Society and the Ductile Iron Society Combine to Promote the Use of Castings at the 2004 SAE Show

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Ductile Iron and Wind Energy :
A Symbiotic Relationship

by Martin Gagne, Manager - Sorelmetal Technical Services
Rio Tinto Iron & Titanium Inc.

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New Process of Ductile Iron Production without Nodulizing Treatment

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Since late 1940's when it was invented, ductile iron is one of the materials that enjoyed the most rapid growth in industrial applications because of its attractive combination of the mechanical properties and excellent cast-abilities. In commercial practice, ductile iron has always been produced by treating a base iron melt with nodulizing elements such as magnesium, cerium or other rare earth elements. The conventional production method consumes a lot of natural resources. Tight process control is needed to prevent quality fluctuations due to variations of nodularization and inoculation. It has certain difficulties also in producing thick wall and thin wall castings.

Recently, VTT (Technical Research Centre of Finland, www.vtt.fi) has discovered that nodular graphite can be obtained from industrial grade iron melt by spray forming without adding any nodulizing or inoculation agent. Spray forming is a rapid solidification process, in which metal melt is atomized by gas into droplets of 10 - 200 microns in size, flying at subsonic speed onto a deposition substrate. The cooling rates are between 100 to 100,000 degrees per second, much greater than those in conventional casting solidification processes. Such high solidification rates lead to nodular graphite formation from normal grey iron melts. Experiments were carried out with an Osprey type spray forming plant. The plant consists of a 50-kg induction furnace, an open tundish with a melt nozzle at the bottom and protruded into a 2-stage nitrogen atomizer, a spray chamber, and a cyclone for collecting over-spray powder. In the spray chamber, a horizontal ram manoeuvres a substrate, i.e. a ceramic mould to receive the spray deposition, as shown by Fig. 1. The sprayformed iron pieces are about 80 mm thick.

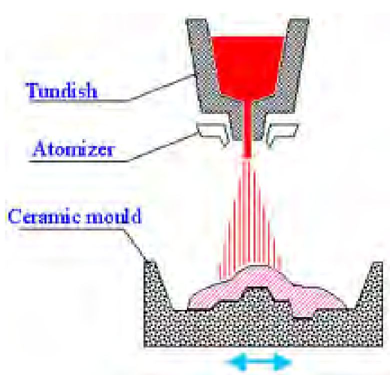

Fig. 1. Principle of sprayforming technology

Wide ranges of melt compositions have been tested, as listed in

Table 1. The melts were made from commercial grades of pig iron, steel scrap and ferro-alloys, melted in an induction furnace with N2 protection. No any melt treatment was carried out before tapping into the tundish for sprayforming. A typical microstructure of the sprayformed iron is shown in Fig. 2.

Table 1. Composition (wt%) ranges of the cast iron melts

C	Si	Mn	P	S
2.80 - 3.80	1.20 - 2.10	0.45 - 0.60	0.02 - 0.03	0.006

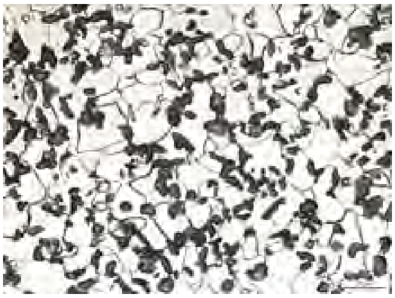

Fig. 2. Microstructure of an as-sprayformed eutectoid iron, nital etched.

The graphite nodules shown in Fig. 2 are about 3 µm thick, and 10 µm long, evenly distributed in a ferrite matrix. The nodularity is not as good as typical ductile iron, but it is much better than that of compacted graphite iron. Compacted graphite is, for example, about 10 µm thick, and 100 µm long.

The nodular graphite structure can be stably obtained, insensitive to the carbon equivalent and to the thickness of the deposition pieces, for the graphite nodules are formed due to the high cooling rate in the solidification achieved through the tiny droplets quenched in the atomising gas. There are potentials that the nodularity can be adjusted by changing the cooling rates and composition.

The invention created a new process for ductile iron production. It does not need any addition of nodulizing elements. It is more environmental friendly, and for certain applications, it has potential of economical benefits, too. Features of the process suggest many potential industrial applications, such as continuous production of cylindrical parts, bars, plates and pipes. The process could be combined with squeeze casting or semi-solid forging for mass production of automobile components, etc.

VTT intends to organize an international research program to extend the invention to mass production processes. The work contents include:

- To explore the limits of processing parameters: the impurity limit, cooling rates, atomizing gases.
- To develop different mass production methods and equipment for different types of products.

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Melt Cold and Pour Hot - What is This?

By James D. Mullins
Mullins Professional Services

This was a phrase quite frequently used by old time foundry men to describe the often-misunderstood science of metallurgy and founding of cast irons. At first glance this seems a contradiction in terms, but as one realizes what happens to the metal during melting and the casting, following these guidelines, it should begin to make good sense.

How can you melt cold?
What this really means is that the metal should never be superheated any more than necessary to dissolve the carbon, whether it is in the form of a carbon raiser or from virgin charge materials, and other alloying elements. The reasons for this are several; superheating destroys nucleation in the melt, which in turn allows the carbon to form as carbide rather than graphite. This changes the nature of a cast iron from a softer graphitic material with less shrinkage to one that is more brittle and very sensitive to the cooling rate (section sensitivity) of the casting. This all happens without any appreciable change in the chemistry, so looking at chemistry alone will not give a clue to nucleation changes. Secondly, at higher superheat temperatures oxidizable elements will be lost, the reaction of the metal to inoculation can be poor or erratic, while refractory and energy costs increase. These same changes will happen at longer holding times even though the metal temperature does not seem to be excessively high. Therefore holding should always be done at as low a temperature as possible, especially over weekend and holiday periods. This holding temperature may be as low as 2400 F for some foundries.

Measurement of changes to the nucleation condition should be done for each heat of metal on a continuous basis. Not only does this give information about the melting process, but can also indicate changes coming from charge materials and alloy additions. Using chill wedges or some type of thermal analysis for measurement of the nucleation condition of the melt, should be done when the chemistry is checked, just prior to readying the metal for pouring. In either case we are looking for is the amount of undercooling present in the melt. Undercooling is defined as cooling below the normal solidification starting temperature. Even a small amount of undercooling can change the type of graphite formed, while more will increase the likelihood that carbides may form. This is easily seen as an increase in chill value of a wedge. Variable undercooling and nucleation values can be the reason why response to inoculation can be erratic. Certainly more undercooling in the melt requires increased inoculation to achieve the same end result. Also note that undercooling can be increased, by increasing certain elements such as Cr, V, etc. in the melt.

So how do we pour hot, when we melt cold?
Of course preheating refractory lined ladles is important to pouring

hot, but so is removing impediments and other time delays in the metal transfer system. Another way is to use insulated ladle linings and definitely cover all ladles to retain as much heat as possible.

Pouring hot usually reduces or totally eliminates any cold iron type defect. These are low fluidity problems like misrun, cold shuts, cold shots, some slag defects, and short pours due to cold metal and backpressure. Other metal defects aggravated by low pouring temperature are most gas blows, pinholes and improper feeding from risers. Cold metal can trap gases at or near the upper surfaces. Cold metal and gating only into the heavy sections can produce large temperature gradients in a casting, causing feeding problems and certainly microstructure variations.

You have probably noticed that the exact temperatures of superheating and pouring have not been defined. This is because these temperatures are specific only to a single foundry/line or even each separate casting operation in one consolidated foundry.

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Most of the above discussion has been primarily about gray iron, but the rules certainly apply to most ductile iron operations as well. Additionally, tapping colder (from lower melt temperatures), when making ductile iron, will increase the magnesium recovery from the treatment reaction and when using MgFeSi, increases the amount of nucleation sites. The treatment reaction especially with pure Mg removes many of the nucleating particles and increases undercooling. This iron is then most often in need of serious inoculation, so temperatures must be higher to insure dissolving larger additions. Lower temperatures have one benefit though and this is that the fading of the Mg and inoculation is usually reduced. One more issue to keep in mind when making ductile iron is that colder pour temperatures invite more slag and dross to form. This slag can react with carbon in the iron forming small CO gas holes.

So melting cold and pouring hot requires balancing the good with the bad. However the benefits of following these rules - increasing quality, while reducing scrap and processing costs are obvious. See if your operation is doing all that can be done to follow this old axiom.

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AFS Signs Alliance Agreement with OSHA

Washington, D.C. On March 22, leaders from the American Foundry Society Inc. (AFS), Des Plaines, Ill., met with leaders from the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) in Washington, D.C. and signed a new alliance agreement to continue joint efforts to promote safer and more healthful workplaces in the U.S. metalcasting industry.

Pictured: AFS President ***Arthur Edge*** *(seated l), OSHA Administrator* ***John Henshaw*** *(seated r) signing the alliance agreement between AFS & OSHA in front of members of the AFS Environmental, Health & Safety Committee.*

The agreement states: "OSHA and AFS hereby form an alliance to provide AFS members and others, including small businesses in the metalcasting industry, with information, guidance and access to training resources that will help them protect employees' health and safety, particularly focusing on workplace issues, including personal protective equipment, ventilation, and reducing and preventing exposure to silica."

According to the agreement, AFS and OSHA will work together to achieve the following training and education goals:

- develop training and education programs to address hazards in the workplace and review and provide input into the AFS Safety in the Foundry seminar;
- assist OSHA's Office of Training and Education in providing education and training regarding hazards in the foundry workplace.
- According to the agreement, OSHA and AFS will work together to achieve the following outreach and communication goals:
- develop and disseminate information through print and electronic media;
- speak, exhibit and/or appear at OSHA and AFS conferences, local meetings and other events;
- cross-train OSHA personnel and industry safety and health professionals in metalcasting best practices or effective

approaches;

- promote and encourage AFS member worksites to participate in OSHA's cooperative programs;
- work with other alliance participants on specific issues and projects regarding silica, personal protective equipment and ventilation;
- encourage AFS chapters and worksites to build relationships with OSHA's regional and area offices.

In addition, AFS and OSHA agreed to work together to raise others' awareness and demonstrate their own commitment to workplace safety and health whenever AFS leaders address groups.

This agreement is scheduled to remain in effect for two years and is a continuation of a cooperative AFS-OSHA relationship that has grown since the 1970s. Other notable cooperative efforts include: professionals from federal and state OSHA groups have been active with AFS safety and health committees since the 1970s and staff from the OSHA Training Institute instructing during AFS's OSHA Compliance Seminars since 1990.

For more information contact Gary Mosher, AFS vice president-environmental, health and safety, at gem@afsinc.org or 800/537-2437. Headquartered in Des Plaines, Ill., AFS is a not-for-profit technical and management society that has existed since 1896 to provide and promote knowledge and services that strengthen the metalcasting industry for the ultimate benefit of its customers and society.

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AFS Aims to Unite Metalcasting Industry Following Rejection of Section 421

AMERICAN FOUNDRY SOCIETY

Des Plaines, Ill.…In a March announcement to the metalcasting industry, American Foundry Society Inc. (AFS), Vice President Chuck Kurtti, Neenah Foundry, Co. (retired), called on metalcasting leaders to take an active approach to unite and shape the future of our industry. Continuing to fight against unfair trade practices in fragmented, uncoordinated actions will only result in defeats, said Kurtti, who also serves as the chairman of the AFS Trade Commission. The call for unification comes on the heels of President Bush’s determination that import relief against ductile iron waterworks fittings (DIWF) from China was not in the national economic interest of the U.S. This unification will be critical as AFS continues its push for a Section 332 trade investigation on the metalcasting industry by the International Trade Commission (ITC).

President Bush’s ruling came after the ITC conducted a Section 421 investigation that found the DIWF imports from China increased rapidly and had caused both a market disruption and material injury to the domestic metalcasting industry. Despite a 6-0 vote by the ITC to back a Section 421 (which could result in tariffs against imported DIWFs), the Bush Administration rejected it.

“We believe the Waterworks 421 met all the criteria for which the rule was written by the fact that it received unanimous backing by the ITC and was passed along to the Administration with a recommendation for relief based on the proven criteria of harm,” Kurtti said. “We, as an industry, must find a way to unite, create a balance and define our future without expecting any support from new or existing rules and regulations available to govern our trade activities.”

Kurtti called the ruling a “defining decision” and said it sent a clear signal, “that our trading partners may use any practice necessary to gain market penetration without fear of retribution by this Administration enforcing new or present agreements, rules or regulations put in place to ensure a level and fair trade environment. The days of just ‘window dressing’ are over, and we now look to our leaders for positive direction to help us define the future and value of not only our industry, but also the critical mass of manufacturing in this country.”

In October 2003, the ITC instituted the 421 investigation at the request of McWane Inc., Birmingham, Ala., to determine whether DIWF from China were causing a market disruption. If instituted, the 421 would provide relief to U.S. industries if the investigation finds that Chinese products are imported into the U.S. in such increased quantities as to cause a market disruption.

President Bush's reason for ruling against the Section 421 was based on evidence that concluded U.S. companies would gain little if tariffs or quotas were placed on Chinese DIWFs because other countries' imports would quickly fill the void. President Bush added that import relief would cost U.S. consumers more than the increased income that could be realized by domestic producers.

"The circumstances of this case make it clear that the U.S. national economic interest would not be served by the imposition of import relief under Section 421," President Bush said. "I remain fully committed to exercising the important authority granted to me under Section 421 when the circumstances of a particular case warrant it."

For more information contact Dwight Barnhard, AFS executive vice president, at dbarnhard@afsinc.org or 800/537-2437. Headquartered in Des Plaines, Ill., AFS is a not-for-profit technical and management society that has existed since 1896 to provide and promote knowledge and services that strengthen the metalcasting industry for the ultimate benefit of its customers and society.

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Control of Slag and Insoluble Buildup in Ladles, Melting and Pressure Pour Furnaces

By
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Dave Williams, Allied Mineral Products, Inc., Columbus, Ohio
Pete Satre, Allied Mineral Products, Inc., Columbus, Ohio

Introduction: During the past 30 years, the melting methods and associated molten metal-handling systems used by the U.S. foundry industry have changed significantly. During the same period, while ductile iron production has experienced continued growth, the quality of metallic scrap and other iron-unit feed stocks has steadily deteriorated. The result: slag related melting problems have become widespread issues in recent years. Yet, a search of the foundry technical literature from the past 30 years about slag control and buildup will result in only a handful of articles.

A new flux, Redux EF40L, has been developed that controls and minimizes buildup in pouring ladles, melting furnaces, pressure pour furnaces and magnesium treatment vessels with minimal to no adverse effects on refractory linings.

Slag Formation: The formation of slag in the melting of ferrous metals in the foundry is inevitable. The composition of slag varies with the type of melting process used and the type of iron or steel being melted. The cleanliness of the metallic charge, often consisting of sand-encrusted gates and risers from the casting process or rust- and dirt-encrusted scrap, significantly affects the type of slag formed during the melting operation. Additional oxides or nonmetallic compounds are formed when liquid metal is treated with materials to remove impurities or to change the chemistry of the system (inoculation and nodulizing). Because these oxides and nonmetallics are not soluble in iron, they float in the liquid metal as an emulsion. This emulsion of slag particles remains stable if the molten iron is continuously agitated, such as in the case of the magnetic stirring inherent in induction melting. Until the particle size of the nonmetallic increases to the point where buoyancy effects countervail the stirring action, the particle will remain suspended. When flotation effects become great enough, nonmetallics rise to the surface of the molten metal and agglomerate as a slag. Once the nonmetallics coalesce into a floating mass on the liquid metal they can be removed. The use of fluxes accelerates these processes.

In some instances, oxides may have a lower melting point than the prevailing metal temperature and a liquid slag is formed. In other cases, where the oxides have a higher melting point than the metal temperature, a dry, insoluble, solid slag is formed.

When slag makes contact with the refractory lining of a furnace wall (or other areas of the holding vessel) that is colder than the melting point of the slag, the slag is cooled below its freezing point and adheres to the refractory lining. This adhering material is called buildup. High-melting point slags are especially prone to promoting buildup. If not prevented from forming or not removed as it forms, buildup will reduce the overall efficiency of the metal handling system.

Three important physical characteristics of slags are the melting point, the viscosity and the “wetting” ability. Generally, a slag should remain liquid at temperatures likely to be encountered during melting, molten metal treatment, or molten metal handling. The viscosity of the slag needs to be such that removal from the metal surface is easy. At the same time, a fluid slag of low melting point promotes good slagging reactions and prevents buildup in channel furnace throats and loops as well as coreless furnace sidewalls. Slags must have a high interfacial surface tension to prevent refractory attack (wetting) and to facilitate their removal from the surface of the molten metal.

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Slag Composition: The composition of furnace and ladle slag is often very complex. The slags that form in electric furnace melting result from complex reactions between silica (adhering sand and dirt from casting returns), oxides from scrap, other oxidation by-products from melting and reactions with refractory linings. The resulting slag will thus consist of a complex liquid phase of oxides of iron, manganese, magnesium and silicon, silicates and sulfides plus a host of other complex compounds, which may include alumina, calcium oxides and sulfides, rare earth oxides and sulfides. Examples of these complex compounds include spinels, anorthites, hibonites, oldhamites and fosterites that are predominate in slags of base ductile and treated ductile irons. These components tend to be present in channel furnace melting and holding applications. Table 1 illustrates the chemical analysis of a sample of buildup taken from the inductor throat of a 30-ton vertical channel furnace used to melt base ductile iron.

Table 1: Chemical composition of the slag buildup from a 30-ton vertical channel furnace*

Compound	Percent Present
MgO	45.2
SiO_2	31.0
Al_2O_3	17.4
Fe_2O_3	3.5
CaO	1.6
MnO	0.29

***Ref: DC Williams, Modern Castings, August, 1990**

Melting Methods

Coreless Induction Furnaces: The coreless induction furnace is a refractory-lined vessel with electrical current carrying coils that surround the refractory crucible. A metallic charge consisting of scrap, pig iron and ferroalloys are typically melted in such a vessel. Electrical current in the coil forms a magnetic field, which in turn creates thermal energy, melting the charge. The magnetic currents in the molten metal cause an intense stirring action, thus ensuring a homogenous liquid.

During the melting process, slag is generated from oxidation, dirt, sand and other impurities. Slag can also be generated from the scrap, erosion and wear of the refractory lining, oxidized ferroalloys and other sources. In a coreless induction furnace, slags normally deposit along the upper portion of the lining or crucible walls and above the heating coils. Figure 1 shows typical slag buildup in a coreless induction-melting furnace.

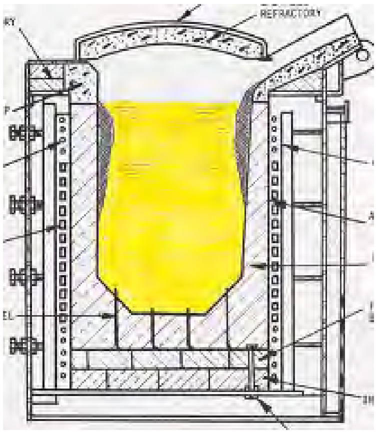

Figure 1: Typical slag buildup in a coreless induction furnace (gray shaded areas)

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The hottest area of medium and high frequency coreless furnaces is at the mid-point of the power coil. All areas of slag deposit will be at a much lower temperature than those occurring at the center of the coil. Slag can also be deposited in areas midway down the crucible lining, where insufficient metal turbulence from magnetic stirring occurs.

Channel Furnaces: Another type of induction melting furnace is the channel furnace. The configurations can be either vertical or drum type furnaces. In a coreless furnace, the power coil completely surrounds the crucible. In a channel furnace, a separate loop inductor is attached to the upper-body, which contains the major portion of the molten metal bath. In a coreless furnace, solid charge materials are melted using the induction field, whereas in a channel inductor, the induction field is used to superheat colder molten metal within the channel loop. A vertical channel furnace may be considered a large bull ladle or crucible with an inductor attached to the bottom. Figure 2 illustrates how insoluble components, such as slag, accumulate over time in the inductor loop or throat area. Buildup on the sidewalls of channel furnaces is also a common occurrence.

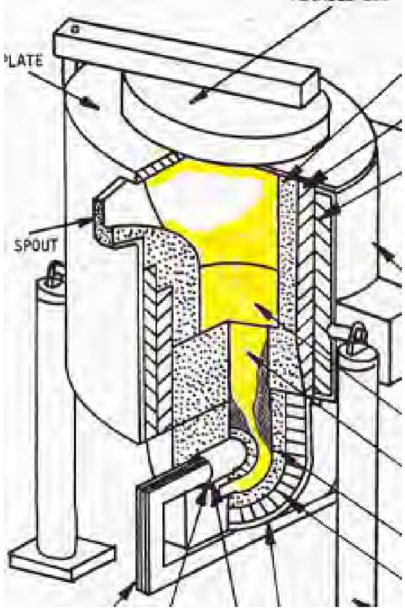
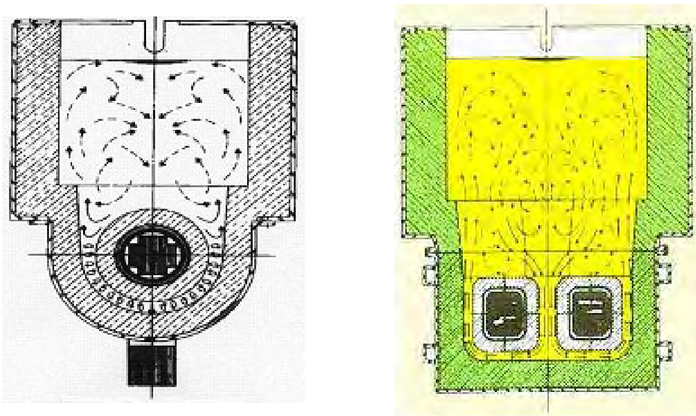


Figure 2: Slag buildup in the inductor and throat of a vertical channel furnace (gray shaded area)



(a) (b)

Figure 3: Circulation and metal flow (shown by the arrows) in a (3a) single loop inductor and (3b) double loop inductor.

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Figure 3 illustrates circulation and metal flow through both single and double loop inductors. Not only can buildup occur in the inductor loop and throat areas, but it also occurs in the stagnate or low metal flow areas immediately above the inductor loops. When this build occurs, insufficient metal flow between the inductor and uppercase limits heat transfer and interferes with the melting operation. It is difficult to remove buildup from the inductor loop or throat area. Often a furnace operator will attempt to insert a steel rod or green wooden pole into the throat area even though accessibility is often severely limited. When significant accumulations of buildup cannot be removed, the furnace is taken out of operation, the throat(s) are scraped clean and a newly lined inductor(s) is (are) installed. Normal inductor life may be as long as 18 months, however, if buildup occurs, the useful life may be reduced to only a few months and in some cases, a few weeks.

Pressure Pour Furnaces: Pressure pour furnaces are sealed holding/pouring furnaces blanketed with either an inert or air atmosphere and have an inductor attached to the bottom or side. Pressure pour furnaces are designed to hold liquid metal at a constant temperature for extended periods of time. When the furnace is pressurized, a stream of molten metal exits the vessel for mold filling. These furnaces are not designed to melt metal. Circulation of liquid metal through the inductor loop provides the continuous superheating of liquid metal to keep a constant temperature of the remaining liquid metal in the furnace. Pressure pours are widely used in the processing of magnesium-treated ductile irons; they are usually pressurized with an inert atmosphere. As in a vertical channel furnace, slag often builds up in the inductor loop and throat areas (Figure 4). Slag buildup also occurs along the sidewalls, effectively reducing the capacity of the vessel. Additional buildup in the “fill (receiver) siphon” and “pour (exit) siphon” areas restricts metal flow rates into and out of the vessel. The “choking” or “formation of restrictions” in the siphons often is an ongoing battle that must be maintained throughout each heat or shift. Careful refractory selection and proper back-up insulation can help to lessen the degree of build-up that forms.

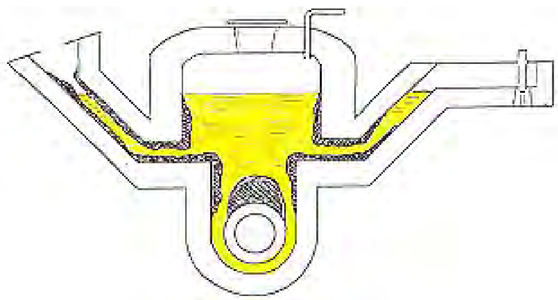

Figure 4: Traditional throated pressure pour vessel showing slag buildup in (gray shaded areas)

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When sufficient buildup forms that prevents adequate heating of the metal, the inductor will have to be replaced because it can be extremely difficult to remove the buildup. Attempts to modify the furnace design with a throatless inductor (Figure 5) have been partially successful in eliminating buildup, but a periodic rigorous cleaning procedure is still necessary.

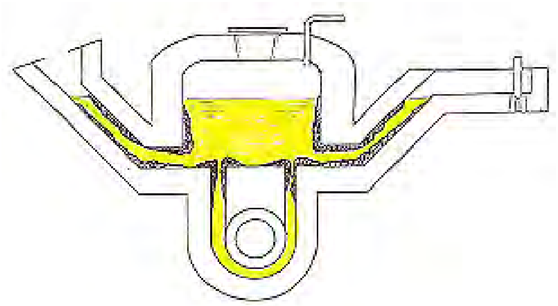

Figure 5: Throatless pressure pour vessel showing slag buildup in (gray shaded areas)

Depressurizing a ductile iron pressure pour vessel and removing the top hatch for cleaning allows outside air to enter the vessel. This increases metal oxidation and can aggravate buildup problems since oxygen is introduced into the vessel. The buildup must be scraped from the sidewalls, inductor channel and throat. If the buildup is hard, it is very difficult to remove. If the buildup is soft, then it is possible that routine maintenance (scraping the sidewalls and rodding the inductor throat area with a metal tool or green wooden pole) can minimize accumulations. When the buildup becomes severe, power factor readings of the inductor drop and the efficiency of the pressure pour is dramatically reduced.

Ladles: Slag from the melting methods detailed above, if not totally removed at the melting furnace, will be transferred to the metal pouring ladles, along with new slag generated during the metal transfer process. Because the walls of the pouring ladle are much thinner with little insulation, more heat loss occurs in ladles when compared to the furnace refractory lining and thus slag buildup is inevitable. The task of continually keeping the pouring ladles clean requires a significant amount of labor and maintenance materials. Failure to maintain pouring ladles may result in costly casting scrap from slag inclusions.

Slag and insoluble buildup formation are usually very troublesome problems in the production of ductile irons. Buildup occurs initially in treatment ladles and then may continue in downstream holding vessels.

Buildup is also a major problem in ductile iron treatment vessels utilizing pure magnesium and in the Flotret® process treatment chamber.

The pressurized magnesium converter process is very susceptible to buildup constituents of magnesium oxide and sulfides. These are residual by-products of the treatment process. Similarly, rare earth metallic oxides and sulfides can also form. In large converter vessels, significant buildup on inner surfaces can accumulate in just a few days, necessitating converter replacement and re-lining. Premature chamber plate failure due to slag buildup can also result.

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The Flotret® process utilizes a refractory-lined reaction chamber for nodulizing. The reaction chamber is filled with a nodulizing alloy such as magnesium ferrosilicon. Slag buildup occurs rapidly in the reaction flow-through chamber and it tends to clog both the opening of the chamber and exit hole.

Slag Additives and Fluxes: Additives to the melting process that ensure that slags have a melting point below the coldest temperature in the system are called fluxes. Fluxes can help prevent slags and other insolubles from freezing on the cooler refractory surfaces. The use of a flux allows floatation of the emulsified oxides; it also reduces the melting point of the slag to below the lowest temperature encountered in the melting furnace and associated liquid metal handling system.

Fluxes are widely used throughout the basic steel industry and their extensive use is considered a science. In the foundry industry, however, there has historically been a reluctance to use fluxes. Refractory suppliers, often without knowledge about the chemistry or potency of fluxes, have convinced foundry men that the use of any flux will greatly shorten refractory life. Improper use of fluxes can rapidly erode refractory furnace linings, especially if potent fluxes are used. However, if a flux is carefully engineered for specific applications and used properly, reduced refractory life isn't an issue. Redux EF40L flux meets these criteria. In fact, some users of Redux EF40L have reported increased refractory life that directly results from reduced slag buildup. Improved refractory life associated with using Redux EF40L flux results from reductions in lining damage due to mechanical chipping required to remove tenacious slag deposits.

Fluxes undergo complex reactions with slags at elevated temperatures. They will dissociate into alkaline metal oxides that disrupt the silica space lattice structure of almost all slags. By disrupting the bonds of the three-dimensional slag space lattice, fluxes reduce slag viscosity. Fluxes also affect the surface tension of slags. Lastly, fluxes allow for the coalescence of low melting point slag droplets that otherwise may become emulsified in the liquid metal bath of high frequency induction furnaces.

Flux additions produce a nonmetallic liquid to absorb extraneous impurities. Fluxes assist in producing a liquid slag of absorbed nonmetallics, providing the slag is sufficiently low in viscosity at existing furnace operating temperatures. Fluxes also modify slags so they will separate readily from iron and facilitate nonmetallic removal. In ductile iron processing, fluxes assist in the removal of silica and metal oxides, such as magnesium oxides and rare earth oxides, all of which have a relatively high melting point. The high melting point of these nonmetallic materials fosters the formation of a viscous or a pasty constituent in electric melting furnaces.

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The formation of viscous nonmetallics can negatively affect the operational efficiencies of any coreless, channel or pressure pour furnace. For instance, they can cause slag buildup on the furnace and/or inductor walls. The adhesion of buildup interferes with melting, thereby decreasing furnace efficiency. Many of the materials in the slag are acidic. The acidity interferes with the absorption of sulfur. Iron and steel fluxes normally contain alkali elements that assist in the reduction and removal of sulfur. Fluorspar, a calcium fluoride mineral ($CaF2$), is a powerful supplemental fluxing agent that is commonly used in small proportions with limestone and lime to improve slag fluidity. Fluorspar is a very aggressive flux and works extremely well in integrated steel mills as well as cupola operations. Fluorspar, though effective, has serious disadvantages. The overuse of fluorspar or fluorspar containing fluxes in electric-melting furnaces can result in severe lining attack and erosion. In addition, as fluorspar decomposes in the furnace, it releases highly reactive gaseous fluorides. In electric melting operations with emission control systems that use fiberglass bags as a filtration device, the gaseous fluorides attack the glass fibers.

Other supplemental fluxes may include sodium carbonate, calcium carbide, borates, olivines, sodium chloride (rock salt), calcium aluminates and ilmenite. Again, overuse of any of these supplemental fluxing compounds can cause refractory attack. Within the past year, a new flux based on proprietary chemistry (Redux EF40L) been developed specifically for use in electric melting furnaces, pressure pour furnaces, ladles and for certain ductile iron treatment methods. Redux EF40L provides excellent fluxing action comparable with that of fluorspar, however, it is not aggressive toward furnace linings and is environmentally friendly. This new flux is available in a 50-gram size for ease of use in ladles and pressure pour furnaces. A larger size weighing 5.5 pounds is available for large furnaces during metal charging. The addition of 1 to 2 pounds of flux per ton of molten metal is sufficient to cleanse the metal, remove slag, prevent buildup of slag and other insolubles on furnace walls, and in channel furnace throats and inductors. Figure 6 illustrates the shape and size of the new flux.

Figure 6: Illustration of Redux EF40L electric furnace, pressure pour and ladle flux.

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Production Results: To date, many gray and ductile iron foundries in the United States, Japan, China, the United Kingdom, and Spain are using Redux EF40L flux to solve buildup problems in coreless induction furnaces, channel furnaces, pressure pour furnaces, Fisher converters and ductile iron treatment ladles. The production experience of seven foundries, each of which has different needs, is discussed in detail in this section.

Foundry A is a medium sized foundry that manufactures gray iron and ductile iron valves. Daily production capacity is 150 tons. The foundry has historically experienced extensive slag buildup on the upper sidewalls of its three 3 – 15 ton coreless induction furnaces. Each coreless furnace is lined with a silica refractory. During operation, the buildup reduced furnace capacity and contributed to slag-related casting blowholes. In addition, considerable refractory repair on weekends was required from buildup removal.

Initially, 12 pounds (approximately 1 pound per ton) of Redux EF40L flux was added to each 23,000-pound charge. The EF40L was placed in the furnace before back charging. After about a week, buildup along the sidewalls and weekend maintenance on pouring ladles were virtually eliminated. In addition, slag-related casting defects were significantly reduced. No evidence of refractory wear or attack was present. However, melting personnel objected to the reduced viscosity of the slag. They had greater difficulty removing the lower viscosity slag – because of its fluidity – from the furnace. The addition rate was reduced to 0.5 pounds of Redux EF40L flux per charge; which allowed easier removal of furnace slag. Refractory lining life has been extended mainly because of reduced mechanical damage from slag buildup. The foundry has been using EF40L fluxes for more than a year and is extremely satisfied with the results.

Foundry B is a high-production ductile iron foundry that produces automotive castings. Melting is accomplished in two 10-ton coreless induction furnaces. The induction furnaces each have silica linings. A 65-ton vertical channel furnace, lined with a high alumina castable, is used as a holder. Iron from the holder is nodulized with a low calcium, low aluminum containing magnesium ferrosilicon, post-inoculated with a 1.5 percent magnesium containing ferrosilicon alloy and then transferred into a 9-ton pressure pour furnace. The uppercase of the pressure pour furnace is also lined with a high alumina castable refractory. The inductor is lined with an alumina-magnesia spinel forming dry vibratory mixture.

Buildup in the pressure pour furnace has long been a serious problem. The buildup is extremely tenacious and high in magnesium oxide (MgO). Table 2 lists the composition of the buildup removed from the inductor loop.

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Table 2: Composition of buildup from 9-ton pressure pour furnace

Compound	Percent Present
MgO	85.6
Fe_2O_3	9.4
Al_2O_3	1.4
CaO	1.5
SiO_2	0.2
TRE oxides	0.3

Because of the high levels of magnesium oxide in the slag, inductor life averaged only two and a half months, rather than a hopeful life of 8 to 10 months.

In an attempt to increase inductor life, Foundry B investigated the use of sodium chloride (rock salt); however, the rock salt additions failed to reduce buildup. In addition, the generation of chlorine gas from sodium chloride (NaCl) dissociation created an extremely unpleasant working environment.

The foundry then tried Redux EF40L flux briquettes. Foundry B added 18 pounds of EF40L to its pressure pour furnace at the end of each week. The life of the inductor after treatment with EF40 flux has tripled – inductors now last more than seven months. Foundry B has been using the flux for more than a year; no erosion or refractory attack has been observed during this period. It has been suggested that more frequent flux additions, made at the end of each shift, would be more effective and further increase inductor life. Foundry B is considering making this change in the future.

Foundry C is a producer of specialty high chrome wear-resistant mining parts. It melts a total of 250 to 300 tons per day in three 5-ton, magnesite-lined arc furnaces. The high-chrome irons from the arc furnaces are transferred to a 7.5-ton pressure pour furnaces via a mullite-lined transfer ladle. The pressure pour furnace has a high alumina, spinel-forming castable uppercase lining and a high alumina, spinel-forming dry-vibratable lining in the inductor. Slag buildup and premature inductor clogging has been a continuing problem for Foundry C. Inductor failure in a month or less was common. The composition of the buildup taken from two locations in the pressure pour furnace is shown in Table 3.

Table 3: Composition of samples removed from a 7.5- ton pressure pour furnace

Compound	Slag from PP	Build-up from PP
Al_2O_3	60.9%	76.5%
Fe_2O_3	9.5	4.6
MgO	7.2	4.8
Cr_2O_3	11.1	5.9
SiO_2	5.2	5.1
MnO	4.8	2.6

After consulting with its refractory supplier, Foundry C purchased 2,000 pounds of Redux EF40L flux for a trial. After using the initial sample, Foundry C found that the slag buildup was considerably softer and could be more easily removed with periodic "rodding" of the inductor channel. Without the flux addition, the buildup was "rock" hard and almost impossible to scrape loose from the walls and inductor throat. The foundry stated that before they switched to the Redux EF40L flux, rodding the inductor produced marginal and inconsistent results. Before the change to Redux EF40L flux, inductor current often dropped to as little as 360 amps, from the normal level of 480 amps.

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Foundry C has been using the Redux EF40L flux for close to one year. One pound of Redux EF40L is added per ton of metal melted. The flux briquettes are added into the transfer ladle, the ladle is slagged off and then the molten metal is transferred into the 7.5-ton pressure pour furnace. Flux additions are made to every ladle; as many as 60 taps of 5 tons each per day are treated with flux additions. Foundry C has found that although some buildup remains in the inductor loop, it is soft and easily removed. Current readings now consistently run between 460 to 480 amps. Foundry C's inductor replacement target is now six to eight months. The foundry also plans to modestly increase flux additions to the transfer ladle in hopes of reducing the amount of soft slag that still forms in the pressure pour furnace.

Foundry D is a large high production foundry that produces both gray and ductile automotive and truck castings. Melting is accomplished in two 121-inch cupolas with a melt capacity of 3,000 tons per day. The metal handling system is composed of three 150-ton capacity rotary drum channel furnaces, four 15-ton transfer ladles and four 25-ton tilt pour furnaces on the molding lines. Because of the high volume, slag buildup in the treatment and holding vessels has been a continuous battle. Buildup also occurred in the inductors of all three rotary drum-holding furnaces and, to a lesser extent, in transfer ladles. However, the major problem area was significant buildup in the 12-ton Fisher converters and downstream tilt pour furnaces.

Buildup in the Fisher converter was severe and converter life before lining maintenance was two days of operation, or roughly 2,600 tons of processing. Buildup between 12 to 18 inches thick in the converter body was normal, and was of sufficient magnitude to reduce the working volume of the converter by almost 4,000 lbs per treatment. Chamber plate buildup was also a problem, necessitating weekly replacement. Emulsified slag carryover from the converters also reduced the efficiency of the tilt pour furnaces and inductor clogging became troublesome.

To solve these problems, Foundry D adds 11 pounds of Redux EF40L flux directly to the body of the Fisher converters prior to each magnesium treatment. Buildup in the converters has been drastically reduced. Converter life is now approaching five days before routine refractory maintenance is needed. Buildup is now only about an inch in thickness. Foundry D reports that the silicon carbide refractory chamber plate looks almost brand new after 6,500 tons of ductile processing. Further, buildup in the tilt pour furnaces from magnesium oxide carryover has been greatly reduced.

Foundry E is a medium size ductile iron foundry producing automotive castings. Foundry E melts with three 9-ton, medium frequency induction furnaces lined with a silica refractory. Daily production is 250 tons. Ductile iron is produced using the sandwich technique; treatments are 6,000 pounds. Significant buildup in the treatment ladle occurred along with slag carryover in the two 8.5-ton pressure pour furnaces. A ladle flux based on a blend of calcium fluoride and ferrosilicon fines was initially used as a ladle flux with marginal results. Ladle life was limited to a maximum of three shifts before buildup in the ladle and ladle pocket prevented its continued use. Further, slag carryover and buildup in the pressure pour furnaces significantly reduced inductor life. In fact, buildup became so bad that a hot spot in one of the pressure pour furnace’s inductor caused a serious run-out.

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To eliminate these problems, Redux EF40L was incorporated into the magnesium treatment process. The Redux EF40L flux is added with the magnesium ferrosilicon at the rate of 0.66 pounds per ton of metal. Incoming ductile treatment temperature is 2,700^{o}F.

Starting with a new ladle lined with a 70 percent alumina castable refractory, Foundry E quickly discovered that their sandwich ladles now last three full days of production or nine shifts before refractory maintenance is required.

Redux EF40L flux also has a carryover effect on the pressure pour furnaces. The pressure pour uppercase is lined with a 90 percent alumina castable refractory and the inductor is lined with a high alumina, spinel-forming dry-vibratable refractory. Slag buildup in the inductor loop of the pressure pour furnace has been significantly reduced.

Foundry F is a captive foundry pouring gray, ductile and high alloy irons for the mining, transportation and oil well industries. Foundry F operates two 55-ton vertical channel furnaces for melting Class 30 grey iron. Pouring temperature is 2700oF. Each furnace has one 1,750-kilowatt double loop inductor attached to the bottom. Both uppercases are lined with a zoned lining of dry-vibratable refractories that include an alumina-based mix in the sidewalls and a chrome-alumina in the floor and throat. Each inductor contains a dry vibratable magnesia-based, spinel-forming mix. Average lining life is approximately 12 to 14 months. Typical conductance readings from the inductor will be between 72 to 85 percent during normal operation after several months of operating.

Recently, Foundry F developed a severe buildup problem in the throats of both furnaces in a matter of 48 to 72 hours. One of the furnaces, which was only 3 months into a service campaign, had the conductance ratio drop from 80 percent to below 60 percent in a 24-hour period. Continued operation of this furnace caused the conductance ratio to drop below 55 percent. The foundry was ready to take the furnace out of service. The second furnace was showing a similar drop in conductance ratio but not as severe; conductance ratios declined to 65 percent. Foundry F took many slag samples before and after the occurrence and found that the silica and calcium oxide content of the slag had increased. Many different methods of buildup removal were tried including green-poling, periodic superheating of the inductor and oxidized steel additions on a low molten metal level. Nothing reduced the buildup and the conductance ratio continued to drop.

Foundry F contacted their refractory supplier who recommended the use of Redux EF40L flux. The foundry decided to try the Redux EF40L as a last resort before removing both furnaces from operation. By this time, the conductance ratio had dropped to less than 50 percent on one furnace. Twenty pounds of Redux EF40L flux was added to 20 tons of molten metal left in the furnace. During this period, furnace operators superheated the molten metal to 2825^{o}F for 2 hours. Furnace charges were reduced by 50 percent to 1,500 pounds and 1.75 pounds of Redux EF40L flux was added with each charge. Within the first 24 hours, the conductance ratio had improved to 65 percent. After 72 hours, the conductance ratio improved to 73 percent, which was considered acceptable. Recently, the molten metal level within both furnaces was dropped in order to inspect the refractory sidewalls for any sign of erosion from the flux and none was observed. This furnace continues to operate satisfactorily.

Foundry G is a gray and ductile iron producer of continuous-cast bar stock. They currently pour between 250 and 300 tons of iron per day. One particular alloy produced at Foundry G generates a tremendous amount of ladle slag. The metal pourers know that when this alloy is scheduled for production that it’s going to be a difficult day. Typically, the 1,800-pound ladles will completely bridge with slag at the top of the ladle. This occurs every few hours and requires constant chipping by the operators as they try to maintain ladle functionality. The chipping of the slag off the sidewalls and spout is hot, dirty and tedious work and an ongoing battle during the melting campaign.

Starting with a new 1,800 pound castable alumina-lined ladle, one half pound of Redux EF40L flux was added to the pouring ladle. Within the first hour of operation, it was apparent that slag buildup on the sidewalls and spout was virtually eliminated. After 3 hours of operation, the ladles showed only a slight slag buildup at the metal line and no chipping was required. Foundry G ran an entire shift adding Redux EF40L to their ladles. At the end of the eight hour-shift, the iron pourers needed to chip the ladles just once. Foundry G now uses Redux EF40L on a regular basis.

Other U.S. foundries with coreless induction furnaces have reported similar operating benefits after using Redux EF40L flux. The foundries have stated that using Redux EF40L flux on a daily basis consistently results in cleaner pouring ladles and reduced maintenance. One ductile iron producer reported that adding 1 pound of EF40L flux to his treatment pocket during the course of a week resulted in negligible slag and dross buildup.

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Redux EF40L flux may also help to remove the harmful tramp element boron from ductile base iron. Boron levels as low as 20 parts per million (ppm) have been reported to significantly reduce Brinnel Hardness values of pearlitic ductile irons. Theoretical thermodynamic reactions studied by Martin Gagne from Rio Tinto Iron and Titanium indicate boron removal with sodium oxide based fluxes during melting is possible. (see Ductile Iron News, 2003, issue no. 3).

Recent trials by a pearlitic ductile iron producer have produced some encouraging results. The addition of two pounds of Redux EF40L flux per ton of molten metal reduced boron levels by 47%. Additional tests using larger quantities of Redux EF40L flux are planned at this foundry. In addition, research is underway at Case Western Reserve University, sponsored by the Ductile Iron Society, to further define the effectiveness of fluxing boron from pearlitic ductile irons using Redux EF40L flux.

Conclusions: The incorporation of 0.5 to 2.0 pounds of Redux EF40L flux per ton of metal has significantly improved the inductor life of pressure pour furnaces, coreless induction and vertical channel furnaces. Redux EF40L has been successfully used in the production of gray and ductile irons as well as high alloy irons and steels to minimize slag buildup on furnace sidewalls and ladles. Using recommended addition rates, Redux EF40L flux effectively combats slag buildup without the adverse effects of aggressive refractory attack or emissions of fluorine or chlorine gases. Flux additions can significantly improve furnace performance and prolong useful ladle life.

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Improved Ductile Iron Casting Quality Through Optimized Coating Technology

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Introduction
Although it is possible to produce castings without the use of a refractory mold or core coating, the optimum application of a suitable coating can dramatically improve casting surface finish and overall component quality. Aside from enhancing casting surface appearance, the utilization of refractory mold and core coatings can often result in a reduction or elimination of a number of casting defects, such as :

- metal penetration
- sand burn-in
- mold or core erosion
- gas defects
- metal – mold reactions
- sand expansion defects, e.g. veining
- metallurgical defects

With the growing need for higher quality casting finish, more complex iron casting designs, lower overall process costs, and increased productivity, the requirement for higher performance coating technology is becoming increasingly important.

This paper outlines certain coating technology fundamentals and illustrates through example how advanced coating technology can help improve ductile iron casting quality.

Coating Application
A fundamental objective when using a refractory coating is to apply a uniform coating layer free from surface imperfections - such as runs or drips - which could later replicate on the final cast surface. The dry refractory layer needs to be of sufficient thickness to prevent any detrimental interaction between the molten metal and the mold or core substrate during pouring.

Obtaining an even, consistent coating layer application is dependant upon the application method utilized and the coating chemistry - it is important that coating properties are designed to suit the application method selected. Though brushing or spraying methods can obtain good coating application, both these techniques are operator dependent and consequently prone to inconsistency. It is widely acknowledged that either dipping or flowcoating techniques should be used for reproducible coated cores and molds.

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- Dipping – the core is submerged into the coating and removed within a set period of time, the properties of the coating ensuring an even layer application. By a combination of manipulation of the core after dipping and the properties of the coating, a surface free from drips and runs can be achieved.

- Flow Coating – the mold or core is angled to between 20 and 40° to the vertical and coating applied through a hose, starting at the top and in lateral movements progressively working down to the bottom. The properties of the coating should ensure an even layer build-up with excess coating flowing into a collection tray.

Different application techniques demand quite different flow behavior for optimum application results and it is important for coating rheology to be adjusted by manipulation of the coating gel components.

For example, pseudo plastic rheology is highly desirable when dipping complex cores. This type of flow behavior ensures that coating viscosity decreases rapidly as the core is immersed in the coating, thereby ensuring complete coverage of the core surface. As the core is removed from the coating, the coating viscosity regains it's original level quickly to ensure the coating does not flow to form runs and drips, i.e. the deposited coating effectively "gels" on the core surface.

Conversely when a large mold is flowcoated, the coating needs to be flowable for a longer period to enable the coating to flow easily over the entire mold face, producing an even layer of coating, and allowing time for coating excess to run freely from the mold surface.

In addition to flow behavior, the speed at which the carrier liquid penetrates into the core or mold surface during application is also critical to controlling layer thickness and uniformity. This effect - known as "matt time" among other terms - is adjusted primarily through the chemistry and addition level of the surfactants incorporated in the coating.

Refractory Coating Layer
Casting surface finish and quality imparted by a coating is directly related to the dry coating layer deposited onto the core or mold substrate and the layer chemistry.

The refractory blend must be thermally stable at the temperature of the alloy being cast but by careful selection of type and grading, other characteristics can be imparted to the coating. Some examples are :-

- High Insulation – a highly insulating coating layer can delay the thermal expansion of a silica sand substrate long enough to prevent sand expansion defects such as veining.
- Lustrous Carbon – inclusion of lustrous carbon forming agents improve the surface finish of most iron castings.
- Metallurgical Modifiers – the inclusion of active components in the coating can initiate beneficial reactions at the casting surface e.g. localized grain refinement or the elimination of flake reversion (see later case-study).

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Coating Process Control
The main goal in production is to achieve a consistently applied dry layer thickness on each and every coated core or mold. This thickness will have been pre-determined through controlled trials to give optimum casting quality. Coating application control is ideally achieved in two steps - firstly control of the dilute, ready-to-use coating prior to application and secondly, subsequent measurement of the applied layer thickness on the core or mold surface.

In practice, dry coating layer thickness is often difficult to measure accurately in a production situation. However for any given coating, dry layer thickness can be correlated to wet layer thickness, which can be measured easily with a wet thickness gauge. (Figure 1).

Figure 1 - Measuring the wet thickness layer of a coating

Figure 2 - Measurement of viscosity with a Flow Cup

Figure 3 - Measurement of viscosity with a Baume Stick

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In turn, for a given coating, wet film thickness can be accurately correlated to both flow cup viscosity (Fig 2) and baume (Fig 3) measurements - both these tests can be performed easily and quickly on line and have been found to be adequate in-process control tools.

Case Study: Influence of Coating Chemistry on the Rim-Zone Structure of a Ductile Iron Casting[1]

Background
The occurrence of structural anomalies in the casting rim-zone in the production of ductile iron castings with larger metal cross-sections is not uncommon. Degeneration of the desired spheroidal graphite structure can occur due to reactions at the metal-mold interface, which can result in an adverse effect on the resulting component mechanical properties. Under cyclic or dynamic loading, as in the machine or automotive industry, such structural imperfections can lead to catastrophic failure.

The factors influencing the graphite structure are many2, however the appearance of irregular graphite development has been observed notably when using silica sand molds that contain sulfur.

Studies3,4,5 have established that molding sands containing sulfur (i.e. reclaimed sand bonded with furan or phenol binders catalysed by sulfur bearing catalysts), can be prone to sulfur pick-up in the cast rim-zone, resulting in the presence or promotion of flake graphite.

Experimental Procedure
For the tests, a U-shaped test casting was used with dimensions 7" x 8" x 5" approx. and weighing 55 lbs. Wall thickness in the area of the core was around 2 inches. The casting was simulated to determine solidification times and in-mold temperatures during the casting process.

Molds were produced in reclaimed sand with known sulfur content (0.1%), and a furan binder catalysed with PTSA was used.

Coatings with four different combinations of refractory filler materials were tested, with an applied dry layer thickness of 0.2mm. The properties of the coating refractory filler materials can be seen in Table 1.

Table 1 : Properties of Coating Refractories Investigated.

	Base Material	**Density g/cm^3**	**Raw Density g/cm^3**	**Porosity**	**S content**	**C content**
A	Aluminum Silicate	2.70	1.05	0.611	0.027	1.50
B	Zirconium Silicate	4.36	2.33	0.465	0.013	0.83
C	Coke Flour	2.21	1.16	0.475	0.082	25.70
D	Zirconium & Magnesium Silicate	4.15	2.11	0.491	0.010	2.34

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Casting Results
Metallurgical structure was checked using micrographs of samples

taken from an identified “hot spot” location of the casting. The molds that were coated with Coating A (Figure 4a.) and Coating B (Figure 4b.), showed defective development of the graphite structure in the casting rim zone, mainly in the form of flake graphite.

With Coating C (Figure 4c.) no flake graphite was observed but the nodule structure is significantly disturbed. In the rim-zone many relatively small nodules can be seen compared to the other coatings. This effect can be classified as inoculation by the coating.

Best nodule structure results were obtained with Coating D (Figure 4d.).

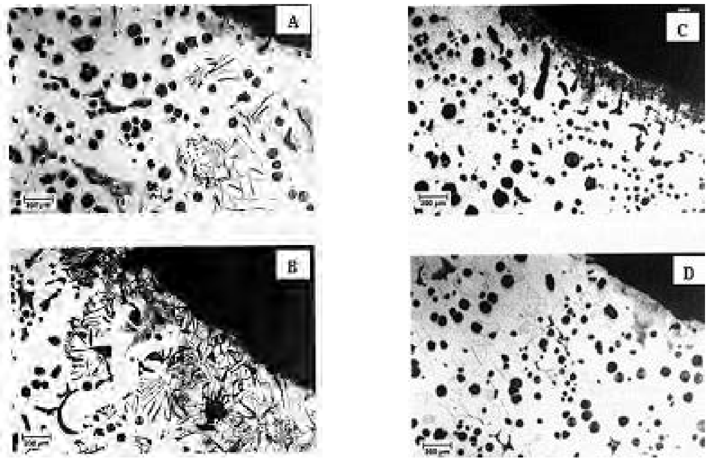

Figure 4 - Casting structures using Coatings A,B,C & D

Further Investigation
To further assess the effect of coating chemistry, samples of residual coating were taken from the surface of the casting at the hot spot area location, and the casting was also machined to 0.5mm and 1.0mm respectively. Coating and metal samples were then tested for sulfur level (see Figures 5 and 6)

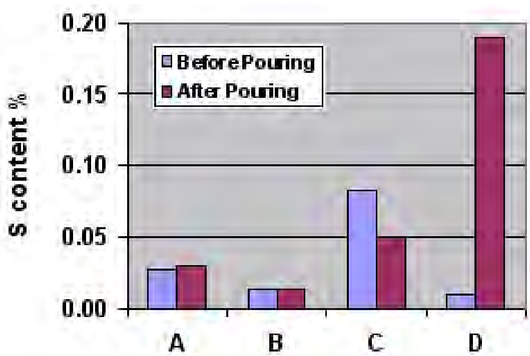

Figure 5 - Sulfur % content of Coating samples before and after pouring

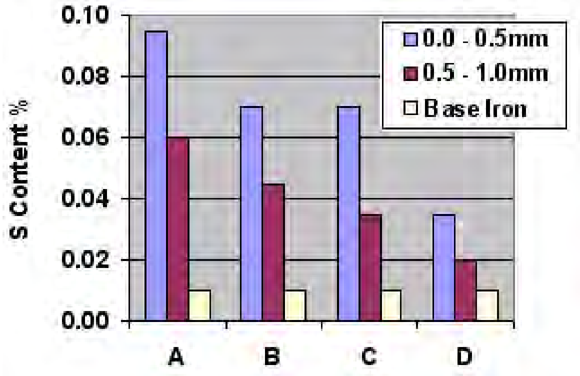

Figure 6 - Sulfur % content of casting at different sections

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In contrast to Coatings A, B,&C, the sulfur content of Coating D showed a dramatic increase of approximately twenty times its initial value after pouring (Figure 5), while the rim-zone metal section from the casting produced using Coating D showed a greatly reduced sulfur level compared to the effect of other coatings (Figure 6).

These results provide strong evidence that the superior graphite structure observed at the rim-zone when using Coating D is a direct result of the coatings inherent ability to effectively block sulfur migration from the mold sand through to the metal skin.

To further assess the effectiveness of Coating D, sulfur level within the molding sand was manipulated to higher levels by varying the PTSA catalyst and reclaim sand processing parameters. Samples of mold sand, coating and metal were then assessed for sulfur content from the hot spot location of the casting (Figures 7, 8 and 9.).

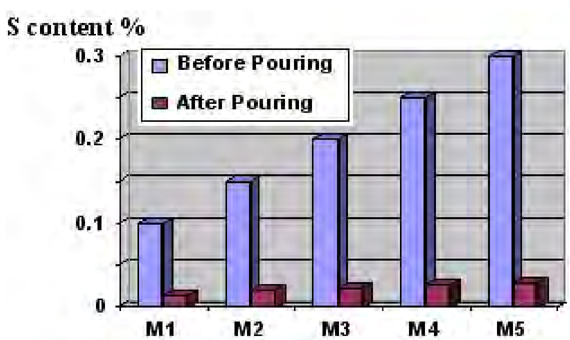

Figure 7 - Sulfur % content of furan bonded sand.

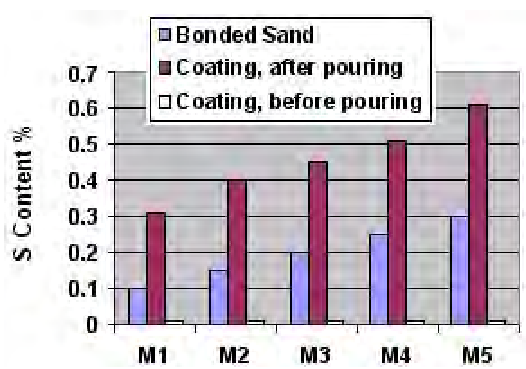

Figure 8 - Sulfur % content of Coating D

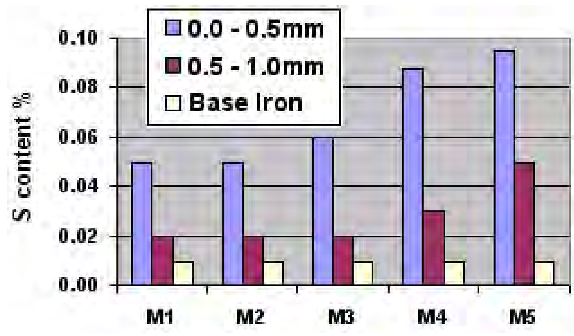

Figure 9 - Sulfur % level of Casting

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Final Results
After casting, the sulfur content of the molding sand was recorded at between 0.014 and 0.030% (Figure 7), indicating that in all cases the sulfur in this area of the mold was almost completely burnt out.

The sulfur content in Coating D after casting was approximately three times the initial values in the molding sand for the trial M1 (S=0.1%) and M2 (S=0.15%). However, when the sulfur content of the molding sand was increased to 0.20% (M3) and above, only about twice the sulfur level was measured in the coating (Figure 8).

Sulfur analysis of metal sections taken at a depth of 0.5mm and 1.0mm from the cast surface (Figure 9) showed that sulfur level in these areas was kept below 0.05% when sulfur content was 0.15% or less within the molding sand. The sulfur level at the casting rim-zone increased steadily as the molding sand sulfur level increased above 0.20%.

No significant graphite flake reversion was observed with a molding sand sulfur content of up to 0.20%, when using Coating D at the nominal 0.2mm dry layer thickness. At higher sulfur levels in the mold or core sand the ability of the coating to absorb sulfur in the coating layer is progressively less effective and rim-zone graphite structure degeneration more likely.

It is anticipated that, at molding sand sulfur levels above 0.20%, greater resistance to graphite flake reversion would be achieved through the application of a slightly heavier layer of Coating D.

Summary
Aside from enhancing casting surface finish quality, refractory mold and core coatings can be used to prevent many different casting defects. In all situations a carefully selected refractory combination and uniform, consistent coating application behavior is vital for quality casting finish and integrity.

Through close attention to the process requirements of the modern foundry, refractory coatings have been developed which suppress or eliminate totally costly defects such as veining and localised metal penetration.

As the case study outlines, inherent casting metallurgical properties can also be enhanced. The application of a suitable refractory coating at a nominal 0.20mm thickness can help prevent graphite reversion at the rim-zone of the casting when the molding sand contains up to 0.2% sulfur content.

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T.Birch, Foseco Europe.

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Ductile Iron News

Ductile Iron Society

To Promote the production and application of ductile iron castings Issue 1, 2004

News Briefs

MEETINGS - BUSINESS - PEOPLE

MEETINGS

Ductile Iron Society 2004 Annual Meeting. June 23-25, 2004 at the Delta Montreal Hotel in Montreal Quebec Canada. Events include a tour of the QIT Sorel Plant of Rio Tinto.

BUSINESS

Ashland Casting Solutions enters into marketing agreement with Dakota International, Inc.

Dublin, Ohio (USA) – Ashland Casting Solutions, a business group of Ashland Specialty Chemical Company, announced today that it has entered into a global marketing agreement with Dakota International Inc. The agreement will allow Ashland Casting Solutions to market and distribute Dakota International's complete line of Dakota scrubber systems to its worldwide metal casting customer base.

Dakota International, Inc., a leader in cold box scrubber technology in the North American metal casting industry, offers turnkey scrubber systems that trap and remove amine catalyst gases from the cold box core-making process. Dakota's scrubber systems are compliant with the emissions, data logging and compliance confirmation aspects of the MACT standard for iron and steel foundries.

By adding Ashland's patented ISOCYCLE® recycling program, which is designed specifically to handle spent scrubber solution containing amine catalysts, Casting Solutions can offer its customers a complete package for effectively managing the amine catalyst waste stream, and maintaining compliance with the industry's environmental requirements.

Ashland's HOODSTACK® emissions analysis program is also available for customers who require assistance in determining emission control and permit requirements.

"Our agreement with Dakota International is a strategic addition to our metal casting product offering that is designed to create value and provide integrated solutions to the casting industry," states Mike Swartzlander, vice president, Ashland Specialty Chemical Company, and general manager, Ashland Casting Solutions. "The Dakota scrubbers line combined with our existing environmental services further strengthens our commitment to health, safety and environmental protections at our customers' facilities as well as our own."

About Ashland

Ashland Casting Solutions, a business group of Ashland Specialty Chemical Company, is a leader in supplying products, processes and technologies to the global metal casting marketplace. The group has operations (including licensees and joint ventures) in 21 countries.

Ashland Specialty Chemical Company, a division of Ashland Inc., is a leading, worldwide supplier of specialty chemicals serving industries including adhesives, automotive, composites, metal casting, merchant marine, paint, paper, plastics, watercraft and water treatment. Visit www.ashspec.com to learn more about these operations.

Ashland Inc. (NYSE:ASH) is a Fortune 500 transportation construction, chemicals and petroleum company providing products, services and customer solutions throughout the world. Find us at www.ashland.com.

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Ashland Purchases Metal Casting Technology from Blackhawk

DUBLIN, Ohio (USA) — Ashland Specialty Chemical Company, a division of Ashland Inc., has announced it has signed an agreement with Blackhawk Specialty Products in Rock Island, Ill., to purchase its metal casting technology over the next three years.

The purchase includes formulations and technology for core and mold release agents, green sand release agents and metal cleaners, which will be incorporated into the Casting Solutions business group. Blackhawk has been producing these mold release agents and metal cleaners under contract for Ashland since 1992.

"This acquisition strengthens our global position for offering world-class, high-performance release agents and metal cleaners to the marketplace, providing improved productivity for metal casters," said Michael W. Swartzlander, vice president of Ashland Specialty Chemical, and general manager of Casting Solutions. "This is part of the total solution package offered by Casting Solutions, which includes binders, coatings, sleeves, sand additives, core and mold simulation software, and technical support and design services. Ashland continues to broaden the scope of products offered to the metal casting industry with investment and continuing R&D for metal casting consumables."

Casting Solutions is pursuing globalization of the technology, with planned manufacturing start-up projects at its facilities worldwide.

Dear Friends,
I am closing **Foundry Information Systems** in order to reorganize our services on a less burdensome business model. With the amount of business these last few years it doesn't make sense to be burdened with the legal requirements of Incorporation or the required bookkeeping. Most of the services offered by FIS will still be available, and paid for service contracts will be honored.

It will take a few weeks to get everything back up to speed. Please bear with us.

Sincerely,
David Sparkman

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PEOPLE

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