General Introduction

Inoculation with Ferro Silicon Inoculants is the final stage in the preparation of graphic irons and involves the introduction of small quantities of highly oxidisable elements such as Aluminium (Al), Barium (Ba), Bismuth (Bi), Calcium (Ca), Strontium (Sr), Zirconium (Zr) or the rare earths Cerium (Ce) and Lanthanum (La).

Pure Ferro Silicon (FeSi) is a very weak inoculant, but is the usual alloy carrier for the active elements, allowing good dispersion throughout the melt. Combinations of elements are generally used for specific nucleating properties and contained in a FeSi base alloy with Si level of 50 to 80%.

Why is Inoculation Important?

Graphite is the important element in cast irons, influencing the strength and hardness of the final cast product. Inoculation acts by reducing undercooling and extending the precipitation of graphite. Maximising the potential precipitation of graphite reduces the risk for shrinkage (gross and micro) and carbide defects (edge and inverse), and helps achieve consistent cast and mechanical properties. Therefore, all graphic grades of cast iron should be inoculated, through ladle addition, in-stream via a ladle or in moluids and in wire form.

Although the nucleation mechanism for flake and nodular grades require nuclei with dissimilar crystal structures, most inoculants can be used for both flake and nodular grades.

Inoculation of Flake / Grey Iron

Manganese Sulphide (MnS) particles are present at the heart of all flake graphite nuclei. The active elements present in inoculants interact with the MnS particles allowing the formation of desirable crystals for the nucleation of flake graphite. Therefore, it is important that the base iron contains suitable levels of Mn and S to help the nucleation process.

The usual ratio quoted to allow the correct balance of MnS is: %Mn = (%S x 1.7) + 0.3. However, the temperature at which MnS precipitates is also important. To help achieve maximum nucleation potential, MnS needs to precipitate between the liquidus temperature (TL) and the low eutectic temperature (TElow). Therefore, Mn and S levels should be chosen to ensure optimum precipitation of MnS.

A degree of undercooling is required during eutectic freezing to give energy for the precipitation of graphite. Low levels of undercooling promote the formation of ‘A’ type graphite. If undercooling falls too low, the risk for B, D and E type graphite increases. If excessive, there is a risk for carbide, and recalcenece (R) tends to increase due to the uncontrolled precipitation of graphite, increasing the risk of shrinkage due to mould dilution.

Inoculation of Nodular / Ductile / S.G. Iron

Sulphur (S) is found at the heart of nodular graphite nuclei, in conjunction with complex silicates. The silicates are modified by the active elements in inoculants to provide a suitable crystal structure for the precipitation and formation of nodular graphite. Therefore, an adequate level of Sulphur is required in the base iron to help achieve maximum graphitisation. Excess Sulphur will reduce the level of active Magnesium (Mg), requiring increased Mg additions; too little S will reduce nucleation potential. For optimum nucleation and Mg efficiency, S should be controlled between 0.05 and 0.015%.

Common to flake and nodular iron nucleation, Oxygen is the other important element required for consistent and adequate graphite precipitation. Base iron high oxygen content for a prolonged time will be depleted in Oxygen due to the oxidation of carbon to CO and released from the melt. Poor choice of charge materials, including heavily shot blast returns and clean scrap will tend to produce a problem of low oxide content. Excess Oxygen will promote slag, inclusions and associated gas related defects. Melts depleted in Oxygen require preconditioning with oxide enriching materials. Base iron Oxygen can be optimised using preconditioners such as Asmet’s Alcast®, Barcast 90™ or Reo™ and universal products like Silicon Carbid, Rare Earth Silicide and Cerium Mischmetal.

Inoculation Fade

Although a suitable crystal lattice structure is necessary, nuclei also require a high surface energy to attract carbon atoms. Small particles have a high surface energy and after initial inoculation the melt is flooded with suitable sized particles. Over time, these particles coalesce and grow, reducing their surface energy and nucleation potential. This is called inoculation fade

The use of late or in stream inoculant (typically in sizes of 0.2:0.7 mm, and often called GSK or MSI size), in-mould techniques and in wire form.

Technical Introduction

Inoculation of Graphitic Irons with Ferro Silicon Inoculants

Your Choice of Ferro Silicon Inoculant

Alcast®
A high Aluminium (Al) / Calcium (Ca) inoculant promoting excellent nodule count and nodularity and the first choice material for production of nodular / ductile / S.G. iron grades. Also used as a base metal preconditioning agent due to the stabilising properties of Al.

Barcast®
The Barcast range of Barium inoculants contain between 1 and 10% Ba and have excellent fade properties, ideal for long casting procedures. Also beneficial in the preconditioning of heavy section castings. Barcast MnTM is a highly soluble low temperature inoculant, due to the effect of Manganese. Barcast 90TM is also used as a highly effective furnace preconditioner.

Biscast® 10TM
A Bismuth (Bi) inoculant for nodular iron production. Bismuth suppresses chill in thin section castings by promoting a very high nodule count and suppresses chunk graphite by helping to neutralise excess rare earth.

Castaal LC™
A Strontium (Sr) inoculant and first choice for the production of flake iron. Provides excellent chill suppression in thin or fast cooling sections with reduced risk for mould dilution and associated shrinkage defects. Also used for nodular production with zero rare earth processes and CGI production.

Castaal Zr™
Similar properties to Castaal LC Ferro Silicon Inoculant added Zincium (Zr), which helps to suppress nitrogen defects and further refines graphite.

Ferrocast™
A Zincium (Zr) inoculant for the effective nucleation of flake and nodular iron. The action of Zr also helps suppress nitrogen defects. Also recommended for CGI and Ni-Resis grades.

Inomet 35™
Inomet 35 inoculant contains Aluminium (Al), Calcium (Ca), Zincium (Zr) and Manganese (Mn) to give excellent nucleation properties for flake and nodular production. Also has excellent solubility in low temperature applications.

LN 50™
A Lanthanum inoculant used for the production of nodular irons. Lanthanum extends eutectic graphitisation which helps suppress micro shrinkage defects. Best used as a late stream addition inoculant.

Supano™
Supano is a general Aluminium (Al) and Calcium (Ca) Ferro Silicon inoculant for the production of flake and nodular irons.

Greycast™ and Nodular™
For inoculation of grey and nodular / ductile / S.G. iron, solid cast mould inoculation inserts are inserted in the running system for a highly effective, efficient and controlled method of late inoculation.

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