Process Control for CGI

The most important consideration during the production of Compacted Graphite Iron (CGI) is to avoid the formation of flake graphite caused by magnesium fading. During the 10 to 15 minute period from the end of base treatment until the end of pouring, up to 0.003% Mg can be lost due to fading. If the initial starting point of the base treated iron is too close to the abrupt CGI/grey iron transition, the castings produced at the end of the ladle may contain flake graphite. It is not enough to know the solidification behaviour of the iron at the start of casting. The reliable high-volume production of CGI requires a measurement technique that can predict the graphite shape at the end of casting.

Magnesium Fading

Flake graphite first appears in CGI microstructures as discrete flake patches. In the absence of sufficient magnesium, the graphite begins to grow with a flake morphology. As the solidification front advances radially outward, the active magnesium segregates ahead of the solid/liquid interface. Depending on the initial magnesium content and the solidification rate, the Mg-segregation may result in stable compacted graphite growth around the perimeter of the cell. If the local solidification conditions allow flake patch formation, several such patches will grow and the mechanical properties of the CGI will be dramatically reduced.

CGI Properties

The presence of flake graphite changes the fatigue and fracture behaviour of CGI. The sharp flake edges allow crack initiation while the smooth surfaces promote crack propagation by delamination along the flake/metal interface. The presence of even a small amount of flake graphite results in an abrupt 20-30% reduction in tensile strength and elastic modulus. Fatigue strength and impact toughness are also significantly reduced with the onset of flake patch formation. The higher carbon content (3.5-3.8% C) typical of complex CGI castings further reduces the strength in flake-containing regions. A fully A-Type flake structure produced with CGI composition would have a room-temperature tensile strength of less than 200 MPa.
The SinterCast Sampling Cup >

The SinterCast thermal analysis is obtained by immersing the patented Sampling Cup into the magnesium and inoculant treated iron. During the three-second immersion time, the walls of the Sampling Cup are heated to thermal equilibrium with the molten iron sample. This preheating prevents the formation of a solidified chill layer and ensures that the probe walls remain in direct contact with molten iron until true solidification begins.

Uniquely, the inner walls of the SinterCast probe are treated with a reactive coating which consumes active magnesium and thus simulates fading. Because the cup geometry is predominantly spheroidal, thermal convection currents develop within the sampled iron promoting the chemical reaction between active magnesium in the iron and the reactive coating. These currents also cause the reacted metal to collect in a flow-separated region at the base of the Sampling Cup. The reactive wall coating is designed such that the magnesium content in the flow-separated region will be 0.003% less than that in the centre of the sample. If the initial magnesium content of the iron is too close to the grey iron border, the flow-separated region will solidify as grey iron while the central region solidifies as Compacted Graphite Iron (CGI).

Magnesium Fade Simulation >

The SinterCast Sampling Cup contains two re-usable thermocouples in a protective steel tube. The first thermocouple is located in the thermal centre of the sample while the second is located at the base of the protective tube. As a result of the fluid flow and ultimate solidification pattern, the centre thermocouple remains surrounded by unreacted iron while the bottom thermocouple is surrounded by reacted iron. Thus, the centre thermocouple indicates the solidification behaviour at the start of casting while the bottom thermocouple simulates the solidification behaviour at the end of casting.

This patented simulation of the natural Mg-fade allows foundries to accurately foresee the formation of flake graphite. Automatically programmed additions of magnesium cored wire before the start of casting ensure that the flake patches do not occur during series production.