Controlling Green Sand Carbons

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The use of carbon additives, generally bituminous coal, in an iron foundry's green sand mixture is common practice to reduce adhering sand grains and improve casting surface finish. Although the carbon's primary function is to eliminate penetration defects, it also reduces expansion-type defects caused by the nonlinear growth of silica aggregates.

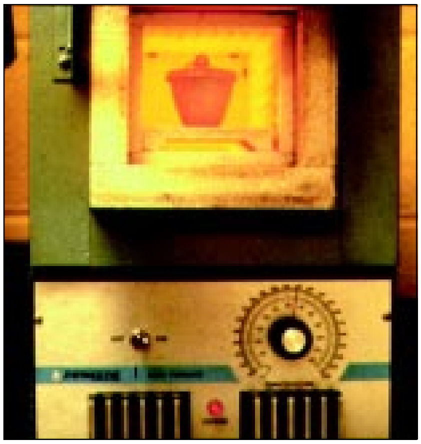
Generally, iron casting penetration defects are caused in two ways. The first, mechanical penetration, is defined as penetration of the alloy beyond the first layer of sand grains at the mold metal interface. High pouring temperatures, variations in metal composition, poorly rammed molds, low grain fineness numbers, poor sand distribution and high metallostatic head pressure all contribute to this form.

The second form, chemical penetration, is caused by the reaction between iron oxide (FeO) and silicon dioxide (SiO_2). Known as burn-on and burn-in, FeO and SiO_2 combine to form a fluid slag that easily penetrates the molding media, resulting in an iron oxide iron silicate phase on the casting surface. If the casting surface cools slowly, a layer of crystalline fayalite forms, known as burn-on.

On the other hand, burn-in is caused by a rapid cooling rate at the casting surface that results in a noncrystalline iron silicate glass. Burn-in defects are generally more difficult to remove from the casting surface.

Burn-in and burn-on should not be confused with metal penetration, which is the result of liquid iron that has penetrated into the voids between sand grains at the mold metal interface. In many cases, the solution for a mechanical type penetration differs from that of a chemical reaction type penetration.

However, adding carbons can reduce the formation of mechanical and chemical type penetrations by creating a reducing (oxygen-free) atmosphere within the mold cavity. Free of oxygen, this environment lowers the odds of iron combining with oxygen to form the iron oxide—which eventually results in chemical reaction defects upon contact with silica. The hydrocarbon gases released by the coal also coat the mold cavity with a thin layer of lustrous carbon. At lower temperatures, liquid iron will not wet the surface of this carbon layer, which helps eliminate both forms of penetration.



A volatiles test is conducted to determine the amount of live carbons in a sand system.

Coal Transformation

To accurately and successfully control carbons to reduce penetration, it is necessary to understand the influence of heat energy. At about 400–1100F, coal evolves—or volatilizes—into gases, most of which are hydrocarbons. At 1000–1100F in a reducing atmosphere, the coal swells and volatilizes its hydrocarbon gases to form an extremely porous mass called coke.

Coal is considered a live carbon if it has not evolved its hydrocarbon gases. If heated to these temperatures in the presence of oxygen, the carbon fully combusts, resulting in a fine particle of ash instead of coke. The hydrocarbon gases released from the coal during the early stages of pouring help eliminate penetration defects.

Cokes and ashes, which have already released their gases, are considered dead forms of carbon. Both coke and ash contents in a molding sand must be controlled within specified limits. Because coke is porous and ash is extremely fine, the surface area requirements for the entire sand system increase, resulting in a higher water percentage to reach constant compactibilities. This increase in moisture causes casting scrap.

Controlling Carbon Additives

Although the nature of green sand and carbons tolerates misuse and poor control, close control must be achieved to produce high-quality castings at the lowest possible cost. An increase of spent carbons within a sand system can be extremely detrimental, since they absorb water. Therefore, it is important to focus on testing both live and dead forms of carbon.

Generally, a loss on ignition (LOI) test is used to control carbon percentages within a sand system. The LOI test uses a representative sample of dried molding sand placed within an open crucible and positioned in a muffle furnace set at 1800F until the sample achieves a constant weight. Coke will combust and form ash within the oxygen reach atmosphere of the muffle furnace used for LOI testing. Therefore, the LOI test is not only sensitive to live carbons, but also to dead forms of carbon within the sand. It doesn't, however, differentiate between the two.

Many foundries also incorporate the volatiles test into control programs. The volatiles test differs from the LOI in that a lid is placed on the crucible and the muffle furnace is set at 1200F. The lid quickly creates a reducing atmosphere in the crucible, in which only live carbons and additives that can volatilize gases will be detected. The loss of live carbon is accompanied by a decrease in the volatile content of the sand system.

The volatiles test is one of the most difficult tests to perform in a sand lab because it depends on time, temperature and sample weight. However, LOI and volatiles tests combined can be effective when controlling carbon additives in green sand. ▼

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