Sulfur Control at the Mold/Metal Interface of Cast Ductile Iron

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A s any foundryman knows, the number of variables that affect any given characteristic of a casting is enormous. Often, troubleshooting a problem with the finished product involves a careful examination of all constituent materials and relevant practices.

**Ductile Surface Defects**

Taylor & Fenn, a 160-year-old foundry that pours ductile and cast iron and various steel grades, recently began to experience a surface finish problem with its ductile iron cast pump housing. The pattern was molded in reclaimed sand with the furan nobake system catalyzed with toluolsulphonic acid (TSA). A core wash of graphite with methanol as the carrier was also used. The parts exhibited good surface finish in the as-cast condition.

When the parts had been annealed, however, their surface finish had significantly deteriorated. The annealing temperature of 1650°F (899°C) released gas trapped beneath the surface, leaving pockmarks. While many of the castings could be salvaged by time-consuming grinding and shotblasting, some were so badly pockmarked that they had to be scrapped.

Upon further inspection, technicians noticed that, in terms of the amount and severity of the pocking, the defects were not evenly distributed over the whole casting surface. Because they are subjected to radiant heat and metal turbulence during pouring, the cope surfaces of the parts were more badly pockmarked than the drag.

**Eliminating Variables**

In searching for an answer to the problem, technicians considered a long list of variables. Among these were:
- percent of magnesium in the ductile iron;
- pouring temperature;
- carbon equivalent for a given section of the casting;
- loss on ignition (LOI) in the nobake sand;
- the core wash;
- venting;
- water in the furan binder.

Several control experiments were conducted with those variables in mind, only to find that the plant’s metallurgical and foundry practices were well under control. Still, the pockmarks continued.

Close inspection of the gating system revealed leekie pockmarks on the runner bar of the castings after heat treating. This led technicians to consider the mold/metal interface as the source of the defects.

A second battery of tests showed that the reclaimed furan sand had as high as 0.09% sulfur, largely due to the use of TSA as a catalyst. Ductile foundries generally keep sulfur levels to 0.03% or lower to avoid magnesium/sulfur interaction. A well-known problem for ductile iron producers, this interaction draws away the magnesium that should be forming nodules and leaves magnesium sulfide inclusions at the surface of the casting.

The higher the sulfur level, the worse the reaction. And in this case, the high surface area of the pump housing offered more opportunity for the molding sand to react with the ductile and cause the pockmarks.

**The Solution**

Thus, it was concluded the foundry must either use a different catalyst or try to provide an effective barrier at the mold/metal interface. An alternative catalyst was quickly ruled out because all of the reclaimed sand had been catalyzed with the TSA. In addition, the molds could not be made from all new sand using a phosphoric acid catalyst.

So the solution must lie in protecting the mold face from the metal. To that end, a magnesium-graphite mold wash was applied to the mold faces, and then ferritic ductile castings were poured in controlled experiments. The surface finish improvement was dramatic, resulting in the virtual elimination of the pockmarks and a 50% reduction in grinding time in the cleaning room.

Later, the foundry began applying two coats of the wash with a brush, further improving the finish by providing a highly effective barrier between the magnesium of the ductile iron and the sulfur of the TSA catalyzed furan sand.

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