Exothermic Sleeve Technology for Ductile Iron Castings

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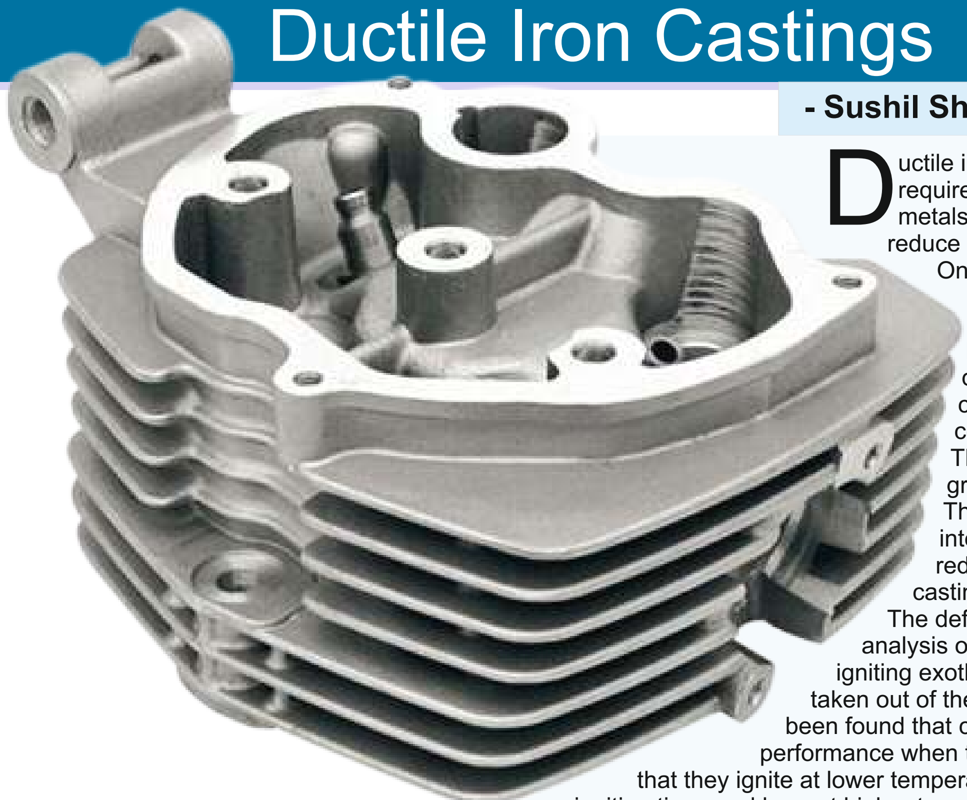


Ductile iron castings have unique riser requirements compared to the feeding of other metals. Foundries are trying to find ways to reduce their overall cost to produce a casting. One way to reduce costs is to incorporate the use of exothermic sleeves around the risers. But the use of conventional Exothermic Sleeves results in certain defects that appears on the surface of the casting as a round depression with a raised center. The other defect is a degradation of the graphite nodule from spherical to flake form. This flake structure can potentially extend into the casting, resulting in severe reductions in the physical properties of the casting and its subsequent performance. The defect is noted during the microstructure analysis of the surface. To solve this, a special, fast-igniting exothermic sleeve is needed so that the energy taken out of the metal in the cold riser is minimized. It has been found that cold ductile iron risers exhibit improved performance when their formulation has been optimized so that they ignite at lower temperature and energy levels, have a faster ignition time, and burn at higher temperatures with more energy. The result is a flatter feed pattern in the riser removing surface defects in ductile iron castings.

Introduction

To produce a metal casting, metal is poured into the pouring cup of the casting assembly and passes through the gating system to the mold and/or core assembly where it cools and solidifies. The metal part is then removed by separating it from the core and/or mold assembly.

Risers or feeders are reservoirs that contain excess molten metal. The excess molten metal is needed to compensate for contractions or voids of metal that occur during the casting process.

In order to serve their function, sleeves have exothermic and/or insulating properties. Exothermic sleeves function by liberating heat. This liberated heat satisfies some or all of the specific heat requirements of the riser and limits the temperature loss of the molten metal in the riser, thereby keeping the metal hotter and liquid longer. Insulating sleeves, on the other hand, maintain the heat of the molten metal in the riser by insulating it from the surrounding mold assembly.

The exothermic sleeve compositions normally comprises of an oxidizable metal which is now-a-days normally aluminum dross, and an oxidizing agent like iron oxides, nitrates, cryolites etc. capable of generating an exothermic reaction. This study relates to sleeve mixes prepared with the sleeve compositions, the use of the sleeve composition to prepare sleeves, the sleeves prepared with the sleeve compositions and the use of the sleeves to prepare metal castings.

Basics Of Exothermic Feeder Sleeves

The basic of exothermic feeder sleeves is to generate sufficient heat to keep the riser metal in liquid condition and feed the casting during the solidification process.

The heat generating source happens to be Aluminium powder which on oxidation generates heat, which in turn is retained by the sleeve. The exothermic sleeves are so designed that the heat generated during the burning process is retained and not lost and mostly utilized to keep riser metal in liquid state.

It is known to use sodium silico fluoride alone or in conjunction with alkali chlorides or cryolite as purifying and degassing media in aluminum melts. The elimination of gases and impurities, mainly aluminum oxide, proceeds according to the following Equation 1 & 2

$$AlF3 + 2Al = 3\ AlF \qquad \text{Equation 1}$$

$$3AlF + 3O = Al2\ O3 + AlF3 \qquad \text{Equation 2}$$

It is also known to produce a double fluoride of sodium and aluminum, which is cryolite mixed with aluminum fluoride, by reacting aluminum with sodium silico fluoride. This reaction is based upon the following chemical equation:

$$Na2Sif6 + 2Al = 2\ Na + Si + 2AlF3 \qquad \text{Equation 3}$$

All exothermic feeders contain fluorides which destroy the aluminium oxide layer on the aluminium powder. Depending on the binder, the aluminium used and the oxidant, it is possible to work with different amounts of fluoride. The user should know the fluoride content of the feeder.

There is also the option of using sodium silicate-bonded feeder sleeves which adhere to the metal feeder and are removed with it. However, it should be noted that the fluoride content in sodium silicate-bonded feeder sleeves is normally higher. It is often possible to use insulating sleeves that are free of flouride.

The most common fuel material is aluminum. When mixed with an oxidizer and an initiator/fluxing material and exposed to extreme heat, the aluminum is oxidized, giving off heat as the reaction proceeds as per Equation 4.

2Al + Fe203 = Al203 + 2Fe + Heat Equation 4
(Fluoride initiator / Flux + Heat)

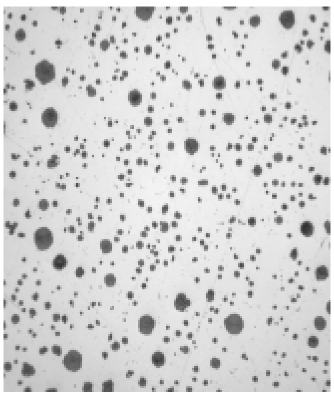
The heat generated in case of feeder mix with fluorides normally generates more heat as compared to oxidizers as in case of fluorides it is like a chain reaction in which AlF3 is formed which again reacts with Al to produce AlF & in turn to produce AlF3.

Graphite Degradation in Case of Ductile Iron Castings

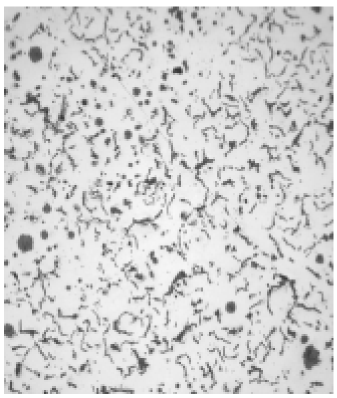
It has been observed in case of ductile iron castings that there is complete degradation of graphite nodules into flakes graphite below the riser, while the nodularity on the rest of the casting surface is above 90%.

It was also observed that the degeneration pattern was observed in the metal in the riser also as shown in Figure-1.

Fig 1 : Graphite Degradation in Case of Ductile Iron Castings



90% Nodularity

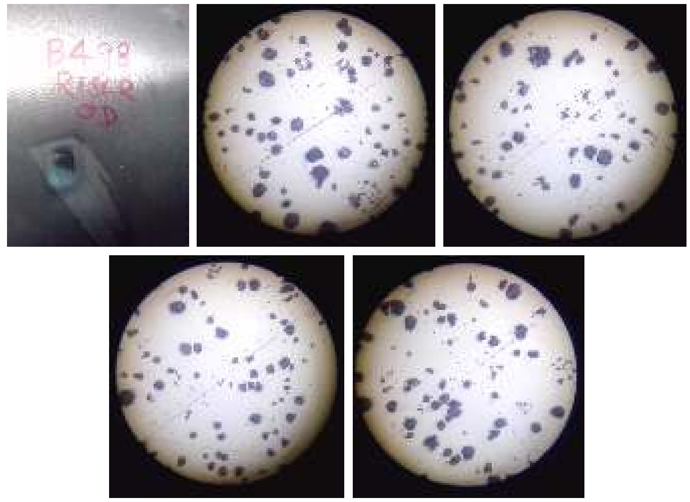


60% Nodularity

Flake Graphite

In Fig.2 Test result shows the following specification requirement 90% Form VI nodularity according to ISO945.

Fig 2 : 90% Nodularity below Sleeve Riser as per ISO945



Different test were conducted with various levels of Exothermic property of the Exothermic Riser Sleeves and changing the oxidizers as per Figure-3 and following results as shown in Table-1 were obtained

Table : 1 Variation in Nodularity with Different Oxidizers in the Exothermic Sleeve.

Type of Exothermic Sleeves	Type of Oxidizer	Nodularity %
Highly Exothermic	Cryolite	67%
Mild Exothermic	Cryolite	75%
Highly Exothermic	No Cryolite	85%
Mild Exothermic	No Cryolite	>90%

Fig 3 : Cryolite Based Sleeve & Non-Cryolite Based Sleeve

Analysis

Flourine is the major constituent of Cryolite and is in fact responsible for the degradation of graphite flakes. In most of the cases Aluminium dross is also used to manufacture Exothermic Feeder sleeves. Aluminium dross is normally generated during either primary melting of aluminium or secondary melting of aluminium. During this melting drossing fluxes are generally used which normally contains Flourine as one of the major components .

The Aluminium dross generated has fluoride as one of the major impurity and hence is one of the major source of fluoride contamination in the exothermic riser sleeves.

Conclusion

It is concluded that the Exothermic Feeder sleeves should be free from Fluoride content which can be a source of contamination either by way of cryolite addition in the exothermic sleeve mix.

Another source of fluoride contamination can be due to the fluorine impurity in the Aluminium dross and hence the Exothermic sleeves based on aluminium dross should be Fluorine free.

The aluminium used in the exothermic sleeve formulations should have fluorine free oxidizers as the best oxidizing agents for generating heat.

The exothermic property of the Riser sleeves should be mildly exothermic instead of highly exothermic as in the case of steel castings in view of avoiding un-burnt aluminium in the sleeve residue which can also affect the nodularity.

By controlling the above factors during the manufacture of exothermic riser sleeves the foundry can be sure that there won't be any graphite degradation below the riser and the chances of achieving nodularity of 90% and above will be very high provided all other factors during the ductile iron production are taken care off.

References

1. Larsen & Toubro (Coimbatore)
2. Lakshmi Machine Works Ltd. (Coimbatore)