Desulphurization of molten cast iron

Why desulphurize iron?

In the production of nodular iron, it is necessary to reduce the sulphur content to very low levels before treatment with magnesium or nodularizing alloys, to minimize costs and avoid gross defects in castings.

In grey iron production, high sulphur contents coupled with low pouring temperature promote the formation of subsurface blowholes (see BCIRA Broadsheet 69). High sulphur contents also increase the risk of chill if not adequately neutralized by manganese. Where these casting defects are difficult to prevent by other measures, desulphurization may be justified.

Desulphurizing agents

Calcium carbide, soda ash, burnt lime and magnesium metal can be used as desulphurizing agents. Desulphurization can also be effectively carried out using lime/flourspar mixtures which offer storage and reaction product disposal advantages. Use of lime/flourspar is covered in BCIRA Broadsheet 185. Important factors to be considered when selecting a desulphurizing agent are shown in the table. The quantity of desulphurizing agent required varies according to the particular application but is normally between 0.5 and 2 per cent of the metal weight, depending on the initial sulphur level, the required sulphur level, metal temperature and the desulphurizing process used.

Methods of ladle desulphurization

Sulphur may be removed from molten iron by thoroughly mixing a desulphurizing agent with the iron in a suitably designed treatment vessel. There are six principal methods in use:

Shaking ladle - The ladle and its contents are supported in a framework and subjected to a horizontal gyratory motion that causes efficient mixing of the molten iron and desulphurizing agent - usually calcium carbide and sometimes lime. The shaking ladle can desulphurize from 2 to 60 tons of iron in a single treatment and is useful for preparing base metal in ductile iron production, and desulphurizing or carburizing metal in pig iron, refined iron and ingot mould iron production.

Methods of ladle desulphurization

Porous plug ladle - Nitrogen or compressed air is blown through a porous refractory plug in the ladle bottom, creating turbulence to ensure intimate mixing of the molten metal and the desulphurizing agent - usually calcium carbide. This method is particularly suitable for small foundries, mainly for ductile iron production. Up to 10 tons of iron can be treated at low cost.

Stirring - The Rheinстал Quirl and Ostberg Stirrer are electrically driven stirring devices, comprising a rotary refractory paddle which is lowered into the ladle to mix the molten iron with a desulphurizing agent. Up to 50 tons of iron can be desulphurized in a single treatment.

Injection - The desulphurizing agent is metered into a gas flow by a powder dispenser and injected through a refractory

Characteristics of various desulphurizing agents

<table>
<thead>
<tr>
<th>Factor</th>
<th>Calcium carbide</th>
<th>Burnt lime</th>
<th>Soda ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slag produced</td>
<td>Granular - easy to remove</td>
<td>Granular - easy to remove</td>
<td>Very fluid - complete removal difficult</td>
</tr>
<tr>
<td>Fume</td>
<td>Very little</td>
<td>Very little</td>
<td>Applicable - extraction essential</td>
</tr>
<tr>
<td>Temperature loss</td>
<td>Small - exothermic reaction</td>
<td>Large</td>
<td>Large</td>
</tr>
<tr>
<td>Silicon loss</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Up to 0.3 per cent</td>
</tr>
<tr>
<td>Storage requirements</td>
<td>To comply with statutory regulations</td>
<td>Keep dry</td>
<td>Keep dry</td>
</tr>
<tr>
<td>Refractories</td>
<td>Not Important</td>
<td>Preferably basic</td>
<td></td>
</tr>
</tbody>
</table>

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lance immersed in the molten iron. This method is used in the USA for ductile iron production and for reducing the sulphur content of grey iron, but other processes are generally preferred because the lances require frequent maintenance and injection blockage problems can arise.

**Magnesium injection** - Magnesium cored wire processes have been successfully employed for simultaneous desulphurization and nodularizing of ductile iron. These processes employ pure magnesium or a mixed composition of magnesium and calcium carbide in a sheath. It is claimed that the magnesium vapour bubbles provide the necessary agitation.

**Tapping iron onto the desulphurizing agent** - The desulphurizing agent is placed in the ladle bottom and molten iron tapped on to the agent. Up to 50 per cent of the sulphur can be removed by this method, although results are not always reproducible. Only the use of soda ash will produce a very significant decrease in sulphur content. Soda ash does, however, produce a very fluid slag which must be coagulated and removed. Unless great care is taken, soda ash slug defects can arise in the castings.

**Continuous desulphurization**

Cupola melted iron can be continuously desulphurized by fixing a porous plug in the bottom of a specially designed treatment vessel. The desulphurization agent - calcium carbide or lime/fluorspar mixes - is added to the metal stream as it flows into the vessel, producing a granular slag which is pushed over a slag notch by the turbulence, leaving desulphurized metal to flow from the vessel through a teapot spout.

**Refractories for desulphurization vessels**

Sulphur contents below 0.010 per cent can be obtained using a calcium carbide or burnt lime desulphurizing agent in a vessel lined with acid, neutral or basic refractories. Ladles are normally lined with good quality firebrick, but porous plug treatment vessels used for continuous desulphurization are usually lined with an alumina refractory. Basic refractories are preferable when soda ash is used to reduce slag attack on refractories and promote efficient sulphur removal.

**Damage to electric furnace refractories**

When desulphurized metal is transferred to an electric furnace, great care must be taken to remove the desulphurizing slag otherwise severe erosion of the furnace lining can result.

**Achieving efficient desulphurization**

The molten iron should be as free as possible from acid slag carried over from the melting furnace if maximum desulphurization is to take place. Metal temperatures should be as high as possible. On completion of the treatment, slag should be removed from the iron as soon as possible to prevent sulphur reversion, i.e. sulphur passing back into the metal from the slag.

**Waste disposal**

The slag residues are likely to require special handling and disposal arrangements, especially when calcium carbide has been used as the desulphurization agent.

**Recommended further reading**


THOMAS, C H. The metallurgy and production of ductile iron. BCIRA one day seminar, 22 November 1998. section 3.
