Explanations
Molten cast iron containing a high proportion of scrap steel has a high nitrogen content, which may be in excess of 100 ppm. The likelihood of fissure defects has grown with the increased use of scrap steel. The risk of gas defects has also increased through the use of nitrogen-containing binders (mould and core binders) and carburizing compounds.

Possible causes
Metallurgical
• Nitrogen content in the melt too high.
• Titanium content low relative to comparatively high nitrogen content.
• Carbon equivalent low relative to comparatively high nitrogen content.

Resin-bonded sand
• High nitrogen content in the core binder or too much binder
• High formation of gas and poor core venting.

Clay-bonded sand
• High moisture content in the sand and consequently high water absorption by the melt.
• High nitrogen content in the sand resulting from incoming core sand or lustrous carbon producer.

Characteristic features
Mostly narrow crack-like cavities which often run perpendicular to the casting surface. The interior of the cavity is predominantly dendritic. The surface of the cracks is not as shiny as that found with hydrogen pinholes. The defect can be several millimetres wide.

Where there is an extremely high nitrogen content, the cavities become round and the surface of the blowhole smooth. There are no inclusions found in the nitrogen defects.

Incidence of the defect
The up to 2 cm deep crack-like cavities, mostly perpendicular to the surface, frequently have dendritic structures in the surface of the cavity. The defect can occur at mould surfaces and edges as well as at core surfaces. The fissures arise through the precipitation of nitrogen during solidification, simultaneous precipitation of hydrogen intensifying the defect even further.

Nitrogen defects can be distributed over a larger area of the casting than blowholes. A casting with a thicker wall is more likely to show this defect than a casting with a thinner wall.

Fissure defects

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Fig. 16: Micrograph of a crack in a grey iron housing caused by the formation of nitrogen molecules. The dendritic structure of the iron is a characteristic feature. Scale: 10 mm = 16 mm
Background information

Fissure defects are principally attributed to the nitrogen content in the iron melt being too high. Reference works state that the limit for grey iron and SG cast iron is 100 ppm.\(^1\),\(^2\) Below this value, gas precipitation can be excluded.

A high proportion of scrap steel in the charge make-up will increase the nitrogen content of the melt. In a test foundry, the following values were determined\(^3\) in a cupola iron:

<table>
<thead>
<tr>
<th>Proportion of steel [%]</th>
<th>Nitrogen content [ppm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>100</td>
<td>170</td>
</tr>
</tbody>
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The solubility of nitrogen in iron can be influenced by various alloying elements. Vanadium and chromium increase solubility, silicon and carbon reduce it.

Nitrogen-containing carburizing compounds can also lead to fissure defects. Reports on such defects have already been presented.\(^4\) It is possible to combat these defects by adding titanium or aluminium to the iron melt. However, the risk of increased water absorption through the use of these substances should be considered.

Remedies

Metallurgical
- Reduce proportion of steel in the charge makeup. Reduce nitrogen content to 100 ppm.
- Bind nitrogen content in the melt through the addition of titanium.
- Increase the carbon equivalent.

Resin-bonded sand
- Use binder with lower nitrogen content.
- Use binder with slower release of gas; if possible, use binders with less gas.
- Add iron oxides.

Clay-bonded sand
- Reduce moisture content through better sand development, reduced addition of bentonite and smaller amounts of inert dust.
- Reduce nitrogen content in the sand. If necessary, reduce lustrous carbon carrier content or use low-nitrogen carbon carrier.
- If necessary, reduce nitrogen content in the inflowing core sand.

Gating and pouring practice
- Shorten the pouring channels in order to reduce gas pick-up.
- Increase pouring temperature and, if necessary, also the pouring rate.

Description of defects:

Fissure defects

Fig. 17: Cracks in a grey iron ring due to formation of nitrogen molecules.
Scale: 10 mm = 4 mm
Absorption of nitrogen by the iron melt from the air is unlikely, due to the high bonding energy of the nitrogen molecule. The absorption of nitrogen from mould binders is far more significant. Cold-setting and hot-setting resin binders frequently contain proportions of urea resin with a high nitrogen content. The Coating technique (shell process) uses hexamethylene tetramine as the hardener. The isocyanate components of the cold-box hardener also contain nitrogen. The occurrence of defects can be suppressed by the addition of iron oxide.

Nitrogen is readily absorbed from many nitrogen compounds. In an experiment, increasing quantities of Na$_3$(Fe(Cn)$_6$)$_3$ were added to cast iron with a low carbon equivalent, and the nitrogen content and formation of defects then determined. With a gas content of 140 ppm, fissure defects arose; with a gas content of over 300 ppm round gas blowholes formed. Technically, these high gas contents are meaningless.

In addition to the organic binders, bentonite-bonded sands can also have an influence on these defects. The proportion of inflowing nitrogen-bearing core sand can have an influence, as well as the nitrogen content of the carbon carrier. To avoid defects, it is recommendable to keep the bentonite and water content as low as possible. There is no standard reference available for the effectiveness of carbon carriers, but the use of highly active carbon carriers with a low nitrogen content appears practical where these defects are experienced.

The addition of barium sulphate, which is recommended in the literature, is also effective. However, problems arise due to the reduction of the sulphate to sulphide and the subsequent formation of barium hydroxide and hydrogen sulphide, so limiting the extent to which this technique may be applied.

References

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