Degenerated graphite seams often occur in SG iron castings. They can project below the surface of the casting by up to 1 mm and are therefore normally removed when machining the metal. However, the flake graphite seam remains in unmachined sections and has the effect of a notch on castings which are subjected to fatigue stresses.

This degeneration is generally ignored on large castings with a greater wall thickness. The defect has been investigated by numerous researchers and foundries. The causes are now clearly explained. The sulphur in the moulding material is of particular significance here. It migrates into the molten metal and consumes the dissolved magnesium as well as the cerium mischmetal through the formation of magnesium sulphide, MgS. The amount of Mg (< 0.015 %) remaining on the surface of the moulding material is insufficient for the formation of nodular graphite and, when solidifying, flake graphite crystallizes out in the form of an approx. 0.2 – 1 mm thick layer. This is referred to as a degenerated-graphite surface.

Large amounts of oxygen present in the air can also lead to the formation of MgO, and the metallic Mg is thus no longer available for the production of nodular graphite. The sulphur content in the moulding material comes principally from sulphur-rich lustrous carbon producers or, in the case of cold-setting resin moulding, from p-toluene sulphonic acid.

**Characteristics**

Degenerated graphite layer deposited on the surface of the spheroidal graphite (SG) cast iron as a flake graphite seam.

**Incidence of the defect**

Depending on the casting wall thickness and rate of cooling, a 0.2 to 1 mm thick degenerated seam of flake graphite can occur on SG iron castings. This seam then blends smoothly into the structure of the spheroidal graphite.

The defect can occur with any moulding technique and is principally dependent on the sulphur content in the mould and the supply of oxygen at the mould surface. The mould regions which are most at risk are those furthest away from the gate.

The flakes which have formed on the casting surface can undermine its fatigue strength when it is subjected to alternating stresses.

**Causes**

Where a degenerated graphite layer of this type forms on the surface of the casting, oxygen from the mould cavity or sulphur from the moulding material reacts with magnesium so that the residual magnesium content is no longer available for the formation of graphite spheroids, and therefore only flakes form.

Magnesium consumption at the surface of the mould can be due to an excessive supply of oxygen (V-process, shell-moulding method) or to sulphur from the carbon carrier (e.g. bitumen) or p-toluene sulphonic acid as the hardener used in cold-resin moulding.

It appears that the sulphur can dissipate before solidification begins in the molten metal, without there being sufficient time for new spheroidizing elements to reach the surface by diffusion from adjacent metal layers.
Bauer \(^1\) carried out investigations into the breakdown of nodular graphite formation in the surface layer of SG iron when casting in a furan resin-bonded mould hardened with p-toluene sulfonic acid. He suggests keeping the quantity of p-toluene sulfonic acid as low as possible and even blending this with phosphoric acid. He draws attention to the accumulating sulphur content in regeneraged circulating sands.

The limits depend on the wall thickness:

- Up to 25 mm thick: < 0.15 % sulphur in the sand
- Up to 75 mm thick: approx. 0.07 % sulphur in the sand

Dressing has a positive effect; however, the dressing must be of a particularly high density. Dressings with a CaO/MgO/talc composition are regarded as particularly effective.

Martin and Karsay \(^2\) have studied the local precipitation of flake graphite due to a reaction between SG cast iron and a number of harmful components in the moulding material. They also arrive at the conclusion that certain dressings can prevent the degeneration. Barton \(^3\) attributes the quality and depth of the non-nodular graphite to the residual magnesium content in the iron, the flow characteristics of the metal in the mould, the cross-section of the casting and conditioning of the moulding sand. Magnesium may then be lost due to reaction with the air within the mould and with the sulphur contained in the moulding sand. He suggests that the proportion of sulphur in the lustrous carbon producer be limited to 1 %.

For cold-setting resin and regeneraged used sand, a sulphur content of 0.15 % should not be exceeded. Increasing the magnesium content alone would be insufficient to compensate for high sulphur contents.

Barnabe \(^4\) also states a limit of 0.15 % for the sulphur content. In addition, he cites the proportion of MgS as the influencing parameter.

Voroncov and colleagues \(^5\) have examined the influence of the pouring temperature. According to their findings, it should be possible to greatly reduce degeneration at low pouring temperatures \((1330 – 1360°C)\). Here, suitable dressings based on FeSi or Al for deoxidation are suggested.

Dunks \(^6\) reports on the influence of the moulding materials and mould dressings on graphite structure in the production of SG cast iron. Sodium silicate-bonded sands and bismuth dressings are said to promote degeneration.

Golovan \(^7\) provides evidence that, for a fatigue-stressed crankshaft cast in a shell mould, the depth of the degenerated layer has an effect on the fatigue limit. The cooling rate, casting temperature and residual magnesium content are further influencing factors.

Here it is discussed for the first time that the degenerated zone can arise not only through oxidizing gases but also through the reduction of silica sand in accordance with the reaction:

\[
\text{SiO}_2 + 2 \text{Mg} \rightarrow \text{Si} + 2 \text{MgO}
\]

**Testing**

Y2 wedge test bars as used by Bauer \(^1\) and Berndt \(^6\) in experiments are particularly useful for testing for degenerated graphite zones.

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