Penetration due to chemical reaction

Characteristic features
Firmly adhering conglomerates of sand/metal at hot or poorly compacted positions.

Incidence of the defect
One refers to penetration due to chemical reaction when, as opposed to simple penetration by the molten metal, there is a strong chemical reaction between the metal and the sand grain (fritting, sintering).

A solid conglomerate of metal and sand adheres firmly to the casting. The spots where this defect is likely to occur are edges in the mould or the core where, owing to the geometry of the casting, the metal remains molten for a long time, resulting in extreme heating. Apart from edges, overheated areas of the mould and the core which are poorly compacted are also at risk. The defect occurs more frequently with copper alloys than with iron alloys, on account of the reaction between sand and melt.

Possible causes

Clay-bonded sand
- Compactability of the sand too high
- Moulding sand too coarse
- Sand has a low thermal resistance
- Too little lustrous carbon producer

Moulding plant
- Uneven or poor compaction

Resin-bonded sand
- Sand grains too coarse
- Poor compaction

Gating and pouring practice
- Pouring temperature too high
- Excessive local overheating of mould and core sections
- Metallostatic pressure too high

Fig. 52: Iron/sand conglomerate firmly adhering to a grey iron casting.
Scale: 10 mm = 16 mm

Fig. 53: Micrograph of a layer formed by penetration with chemical reaction in a grey iron casting. The melt/sand reaction products are clearly recognizable. Scale: 10 mm = 0.08 mm
Remedies

Clay-bonded sand
- Reduce compactability of the sand; this will lead to more uniform and improved compaction
- Make moulding sand finer; if necessary, use finer core sand; use inert fines (coke, etc.)
- Increase temperature resistance of the moulding sand; if necessary, add new sand to reduce oxidation; do not use silica sands containing impurities
- Increase carbon carrier content in moulding sand to increase coke residue and lustrous carbon production; if necessary, use lustrous carbon carriers with higher coke production

Moulding plant
- Improve compaction of moulds; if necessary, increase compacting pressure
- Improve sand filling process to attain more evenly compacted moulds

Resin-bonded sand
- Use finer core sand; compact cores more evenly and effectively
- Dress cores all over or at positions at risk; if necessary, apply dressing of greater thickness; use dressing with low susceptibility to cracking.

Gating and pouring practice
- Reduce pouring temperature and pouring rate
- Improve gating systems in order to avoid local overheating of mould and core sections
- Reduce metallostatic pressure

Background information

The defects “penetration” (physical) and penetration due to chemical reaction cannot be clearly differentiated from each other. The latter is always preceded by physical penetration. In the case of physical penetration, the main effect is the ingress of molten metal owing to metallostatic pressure. Reactions between the melt and moulding sand hardly ever occur. However, with this type of metal penetration, thicker silicate layers form on the sand grains. Due to the reaction between silica sand and melt, the surface tension is markedly reduced; the molten metal permeates deeply into the mould. Small pores are also filled with melt. Hard, firmly adhering conglomerates of sand, slag and metal are formed.

With copper-tin and copper-zinc alloys, penetration due to chemical reaction is triggered by low-melting-point lead components and lead compounds. When casting such alloys using bentonite-bonded sands, enrichment of the lead compounds further promotes reaction of the metal with the sand. Apart from copper alloys, metal penetration frequently occurs during steel casting, principally manganese steels.

Metal may also more rapidly penetrate into poorly compacted sand sections, with severe heating leading to reactions with the moulding material and allowing the melt to permeate even deeper.

It is also important to achieve good compaction of cores. Where there is a risk of metal penetration, it is necessary to select a fine sand grain size. Careful dressing is imperative, as metal penetration can occur through small cracks in the dressing.

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