Metal penetration

What is 'metal penetration'? Metal penetration is the result of metal passing into the voids of the sand mass in a mould or core, to produce an agglomeration of sand grains and metal adhering to the casting surface. It can occur as a thin layer (Fig. 1), or it may be several centimetres thick (Fig. 2). Metal can sometimes penetrate the complete section of a core causing an internal obstruction which it is then often impracticable to clear, so that the casting has to be scrapped.

Fig. 1 Metal penetration at the surface of a casting.

Fig. 2 A mass of sand, penetrated by metal, removed from the surface of a casting—metal penetration caused by cracks in the coating.

Causes of metal penetration

Metal penetration occurs when sufficient pressure is built up to force molten metal between the sand grains (Fig. 3). The necessary pressure can be developed in the mould cavity by:

- High hydrostatic head—metal penetration will occur if the hydrostatic pressure (that is, pressure created by the height and the running-system of the casting) exceeds the resistance forces set up at the pore boundaries. The grain size of most sands in use in foundries is too coarse to prevent metal penetration when the head exceeds about 50 cm, unless the sand surface is covered.
- Dynamic pressure developed by the flow of metal within the mould cavity.
- Explosions caused within the mould cavity—caused when flammable gases, evolved from the sand mould or core, during casting, mix with air and are ignited by hot metal.

Once started, penetration will continue even if the metal pressure is reduced, if there is sufficient heat to keep the mould-metal interface temperature above the solidus temperature of the iron. The iron will continue to penetrate until its leading edge solidifies.

A sand which has a grading of Average Grain Size 350 µm (45 AFS Grain Fineness Number) compared with sand of grading 250 µm (60 AFS Grain Fineness Number) will have correspondingly larger voids between the sand grains, enabling metal penetration to take place more readily in the coarser sand.

- Revised Jan 85.
**Recommended action**

To prevent metal penetration of the mould and core surface it is necessary to:

**Avoid high ferrostatic pressures.** Keep riser height to the minimum consistent with adequate feeding. Avoid pouring from a high ladle position directly into the sprue—if necessary use an offset pouring-bush to break the metal stream and provide a constant head of metal.

**Use as fine a sand as possible.**

**Compact the sand well.** Greensand moulds and moulding machines must not be overloaded, and the air to each machine should be maintained at the correct pressure. Avoid the use of very tough greensand mixtures, which are difficult to compact. Use mixtures well within their shelf life to ensure compaction. Corebox vents should not be allowed to become blocked. Do not rely exclusively on the good flowability of resin-bonded sands; ensure that the sand is fully compacted, using vibration if necessary.

**Avoid mould-cavity explosions.** Do not add excessive amounts of carbonaceous materials and water to greensand mixtures. Vent the mould and cores as well as possible.

**Relieve dynamic pressure developed in the mould.** Incorporate suitable risers or flow-ells on castings. Strip vents on the mould joint should be used on highly compacted greensand moulds.

**Apply an effective refractory coating to the mould or core.** If coatings are used, they need to be applied in such a way as to fill the voids between sand grains at the immediate mould or core surface. If the coating is applied too thickly the coated layer can crack, allowing metal to penetrate into the sand (see Fig. 2). The first coating to be applied needs to be of low viscosity (corresponding to the relative density of water, \(1 \leq 1.5 \leq 1.7\)) and at least two applications of thin film coating are recommended when severe penetration is possible. The thin coatings can then be followed by a normal, thicker coating with a viscosity corresponding to relative density in the range \(1.5\) to \(1.7\) (500-600 Bc).

**RECOMMENDED FURTHER READING**