High Carbon Billet Startup Breakouts

Question

We are producing 100 mm square billets with metering nozzles and unshrouded streams. When we cast low or medium carbon grades, carbon < 0.20 % C, normally there are no breakouts on the first heat of a sequence. But whenever we cast high carbon steels, > 0.45 % C, a breakout frequently occurs during the first heat of a sequence. The breakout occurs either in the mold or after one-half meter of casting. Casting of a high carbon grade during the middle of a sequence is of no problem. Can we safely cast high carbon steel in the first heat of a sequence? What extra precautions need to be taken as compared to low or medium carbon grades? PCD, India

Answer

Breakouts on start up are always a major problem. The first place to look is for the usual suspects such as debris in the tundish, wet chill material, loose silica refractory washing into the mold or metering nozzle alignment. Once these are eliminated start looking for other causes.

One area to examine is the Mn/Si ratio. According to an operator in the field, he has found that it is necessary to start with a Mn/Si ratio of 3.5/1 on high carbon start up heats. High carbon heats inherently contain less oxygen than low carbon heats. Removal of dissolved oxygen is one of the prime functions of the Mn and Si added to the steel. This ratio of oxides can be affected by the amount of oxygen removed by the Mn or Si. In turn the liquidity of the slag is affected by the ratio of MnO to SiO_2.

The operator mentioned to this writer that on high carbon heats a 3.5 Mn/Si ratio helps to produces a liquid slag in the mold as opposed to a gummy slag which must be dipped out of the mold. A gummy slag will stick to the side of the mold at start up and cause a tear in skin of the newly formed billet shell. Additionally, operators typically will find slag embedded in a breakout shell thus causing a point for the shell to pull apart or bleed out. The use of Cal Sil, aluminum shot or FeSi in the tundish at start up will enhance the formation of a gummy slag and thus increase the chances for a start up breakout on heats with > 0.45 % C.

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A quick check of the Fe - C phase diagram shows that steel with 0.20 % C has a liquidus to solidus temperature range of 38°C while steel with 0.45 % C has a liquidus to solidus temperature range of 62°C. The difference in liquidus to solidus temperature ranges shows that the mushy zone is spread across a greater temperature range indicating that more time will be needed for complete solidification of high carbon grades at startup.

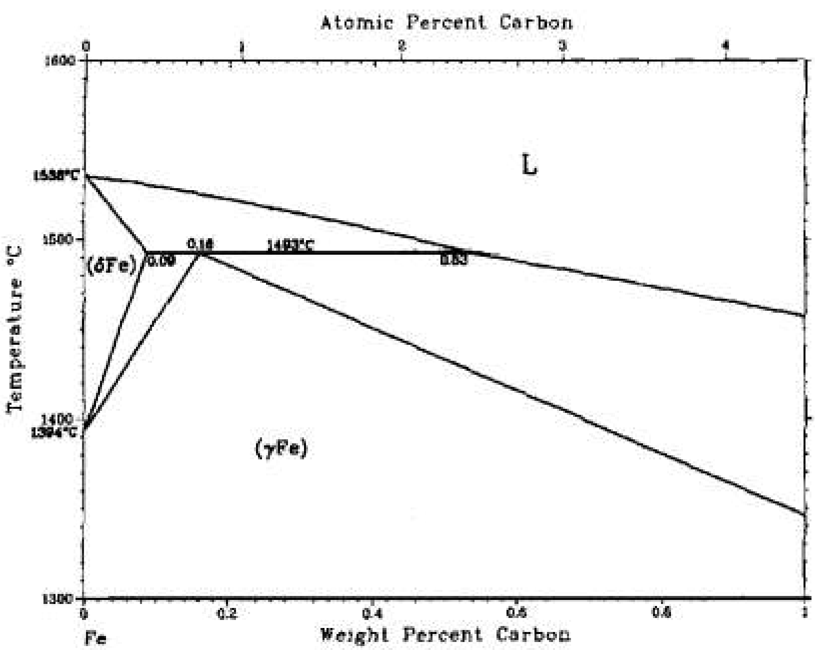

Figure 1. Fe – C Phase Diagram. Hugh Baker et al. eds., ASM Handbook, Volume 3 Alloy Phase Diagrams (Materials Park, ASM International, 1992), Section 2, p. 110.

Many operators tend to compensate for start up freeze off by increasing the tundish temperature 15 to 25 °C higher than on subsequent heats. Since high carbon grades have a greater liquidus to solidus temperature range as opposed to low and medium carbon heats, keeping the tundish temperature only 10 to 15 °C higher on the first heat as compared to subsequent heats is always the first solution to startup breakouts. If subsequent heats in the sequence are kept at 15 to 25 °C above liquidus temperature in the tundish then the startup heat should be no hotter than 40 °C over liquidus.

Dissolved oxygen content in liquid steel is raised with increasing temperatures. Even though high carbon steel may be dead killed in the tundish, a chance for reoxidation occurs when the steel flows from the tundish into the mold. This is self-evident by the number of sparks observed during any startup.

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When the liquid steel encounters the chill material in the mold, CO gas is quickly evolved. If blowholes are seen in the breakout shell they very well could be due to higher than normal tundish temperatures causing excessive oxygen absorption and subsequent CO evolution.

Another source of the breakouts may be starting the strand very quickly after filling the mold. One technique observed by this writer for preventing startup breakouts is to open the nozzle and allow steel to flow into the mold. After getting about 150 to 200 mm (6 to 8”) of steel in the mold, interrupt the flow with the launder for about 5 to 8 seconds. After the interruption start filling the mold once again. When the metal level in the mold gets to the normal operating level start the strand. This method gives the steel in bottom of the mold additional time for solidification prior to exiting the mold. Interrupting the initial flow works for casters with and without automatic strand start. Additional chill material may be required in the bottom of the mold to accelerate the initial solidification of high carbon grades.

Many steel plants around the world successfully start sequences with high carbon grades. Your company will be able to eliminate high carbon start up breakouts by systematically studying and eliminating all of the potential problems.

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