EAF Cooling Boil Reactions

Question

Due to the current economic conditions our melt shop has been forced to curtail the operations of the EAF for about 6 hours per day. During the first and second heat made after the delay, the EAF has started having violent reactions just after the start of the refining phase. Liquid slag and steel come shooting out of the slag door, travelling more than 30 feet across the floor. We do not have scrap burners. Normally we inject about 25 Nm^3 oxygen per ton of liquid steel. Could you please describe the cause and possible steps to prevent the reaction? T.C. USA

Answer

A cooling boil is causing the condition described. Due to the production delay scrap, is sticking to the walls. During normal melting operations a molten pool of liquid steel and slag forms across the bottom of the furnace. As long as the molten pool temperature is around liquidus temperature the oxygen solubility of the pool is relatively low. Typically, operators switch to a shorter arc once the molten pool is formed. Superheating and refining take place. Oxygen injection into the molten pool combined with the short arc causes a temperature rise and increase in oxygen solubility. A rapid increase in the total oxygen content results.

At this point everything looks normal but soon the radiant heat from the molten pool and electric arc causes the solid scrap sticking to the EAF sidewall to fall down into the bath. The scrap causes a rapid localized cooling of the molten pool. As the temperature decreases so does the oxygen solubility. The oxygen reacts with the carbon in the melt and forms CO gas. The gas explodes out of the molten pool thus causing the boil. Liquid steel and slag take the path of least resistance and shoot out the slag door.

About 3 to 10 seconds before the cooling boil occurs, your operator will observe a bright yellow flame coming out of the slag door, electrode port(s) and the joint between the roof and bezel ring. Carbon monoxide gas is coming out of the bath and burning in the air. This is a sure sign that a boil is imminent. Immediately shut off the power and if possible, remove the oxygen lance and close the slag door. No one should be in front of the slag door at this time. Within one to two minutes slag

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and steel flow out the door will cease. Heat energy will be lost with the slag and steel flowing out of the EAF. Temperature in the molten pool will once again be around liquidus and normal superheating can resume.

When melting direct reduced iron this same type of phenomena can occur if a pile of unmelted material collapses into the bath. However, the reaction can be even more violent than that which occurs with scrap due to the fact that direct reduced iron contains additional intrinsic sources of carbon and oxygen.

In order to avoid the cooling boil, the scrap should be completely melted prior to the start of the refining stage. During the first and second heat after the delay, take a quick look in the EAF for scrap sticking to the sidewalls. This will indicate if your operator needs to run with a long arc for some more time. If possible, use the oxygen lance to impinge on and directly melt the scrap.

Another solution is to lower the oxygen content of the molten pool. Additions of silicon-manganese or ferrosilicon directly to the molten pool will lower the dissolved oxygen content and prevent the boil but cost money and waste time and energy if roof must be opened to input the alloys.

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