Phosphorous Removal

Question

How do we go about lowering phosphorous in liquid steel? We have a shop that produces liquid steel using hot metal in both BOF and EAF furnaces. G.M. Peru

Answer

Phosphorous can come from both the hot metal and scrap. Perhaps, first check the scrap addition for heavy castings or other items, which may contain a high phosphorous content. If found, make several heats without the heavy castings. If changing the scrap mix does not solve the problem, then other methods must be used to lower the phosphorous levels.

Various schemes exist for lowering the phosphorous in pig iron. The most obvious solution is to go to a low phosphorous ore. This may take some time. Next, steel plants try to remove the phosphorous from the hot metal. This method requires the installation of injection equipment, silicon levels < 0.15 % and is capital intensive.

Removal of phosphorous in liquid steel requires the use of a basic oxidizing slag. Normally this is performed in the melting vessel, be it an EAF, BOF or open hearth. Oxygen in the steel combines with phosphorous to form P_2O_5. Furthermore the P_2O_5 combines with the CaO in the lime which forms $4CaO.P_2O_5$. The slag binds the phosphorous in place. With rising liquid steel temperatures, the P_2O_5 becomes unstable so the phosphorous may return to the steel bath.

Blowing oxygen to get the carbon level in the liquid steel down to 0.10 % is one method of increasing the oxygen content in the steel to promote the formation of P_2O_5. Another method is adding mill scale or iron ore to the bath. Adding oxygen rich iron bearing materials produces an endothermic reaction so it has the double effect of lowering the steel temperature and increasing the oxygen content.

Sufficient weight of CaO in the slag must be available to bind the P_2O_5 as it comes out of the liquid steel. Phosphorous removal efficiency by an oxidizing slag is characterized by a partition ratio, that is the weight of phosphorous in the slag divided by the weight of phosphorous in the liquid steel. A slag FeO content of 20 % or greater and a basicity ratio ($\%CaO/\%SiO_2$) of

2.5 produces a partition ratio of 200 at 1600°C. A partition ratio between 100 to 200 is normally sufficient for most phosphorous removal duties. Indiscriminate additions of lime to the melting furnace will not solve the problem. The slag in the furnace must be fluid in order to absorb the phosphorous.

Care must be taken during tapping not to allow furnace slag to flow into the ladle. When the steel is deoxidized, phosphorous and manganese will revert from the slag to the steel. Sometimes a heat will go out of specification at the ladle furnace due to phosphorous reversion.

Work has been performed on removing phosphorous at the ladle furnace using mill scale to increase the FeO level in the slag. Unkilled steel is vigorously stirred while quick lime and mill scale are added to the slag. The slag absorbs the phosphorous. Then the phosphorous rich slag is decanted from the ladle and a second slag is made for desulfurization or inclusion removal. Removal of phosphorous at a ladle furnace is time consuming and energy inefficient.

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