S.E.N. Clogging With 0.02 % Al and 0.02 % S and Erratic S.E.N. Clogging in Bearing Steels

Question

Could you please tell us what should be the calcium PPM in medium carbon steel grades containing 0.02 % aluminium and 0.02 % sulphur to cast smoothly without clogging? At present, with the above levels of sulphur and aluminium we face the problem of submerged entry nozzle clogging. Process route followed is electric arc furnace-ladle furnace-vacuum degassing. The casting machine is of 9-meter radius and equipped with electromagnetic stirring.

Occasionally, clogging occurs in some bearing steel heats. Oxygen level in bearing grades is around 10 to 12 PPM while the sulphur is around 0.01 %. What could be the reasons for this type of clogging? S.K.K., India

Dear S.S.K.,

Based on the limited information presented. it is difficult if not impossible to specify a given PPM of calcium in order to eliminate submerged entry nozzle clogging. The issue of calcium treatment and its effects on castability has been studied and discussed for many years, and although the thermodynamics are relatively simple there is no easy solution on an industrial basis. For a good general overview on the subject however, I would recommend the article written by L.A. Frank and published in the
April 1999 issue of Iron and Steelmaker.

In order to determine an answer for any specific location, it is necessary to first identify the problem. Nozzle clogging can be a result of a number of different causes and the solution to each is substantially different. These include, but are not limited to temperature, deoxidation, reoxidation, refractory interactions and sulfide formation. Further complicating the picture is the fact that these factors are frequently interrelated, which adds another layer of confusion to the issue. A good starting point would be to perform metallographic analysis of the inclusions in blocked nozzles to determine what are the main constituents of the blocked nozzles. If samples of the steel earlier in the process are available they also can be examined in order to evaluate inclusion morphologies and changes during the steelmaking and casting process.

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Without this type of analysis it is impossible to formulate a solution. Within the limitations listed above, however I would offer the following steps:

1. Has the steel been protected from reoxidation? Calcium has a very limited solubility in steel and is mainly found in the inclusions present. If reoxidation occurs, whether from air entrainment, stirring, slag, etc. the calcium content of the inclusions will be effectively lowered due to the formation of additional Al_2O_3.

2. The grades discussed are particularly susceptible to clogging due to the formation of CaS as well as Al_2O_3. Depending on steel temperature and the relative concentrations of C, Ca, Al, S, and O thermodynamics may favor the formation of calcium sulfides as opposed to low melting temperature calcium aluminates. If this is the case, an entirely different approach must be taken.

3. It is an oversimplification, but in general if clogging is related to alumina buildup the calcium analysis should be higher, while if clogging is sulfide related the calcium analysis should be reduced. If the cause is reoxidation it is doubtful that any steel analysis would be successful.

4. The influence of MgO spinels must also be considered. Calcium content has minimal effect on castability if it is MgO related and steps must be taken to reduce Mg content of the steel if this is the cause.

Due to the multiple effects possible a thorough analysis of the entire steelmaking process is called for rather than a cookbook answer. Answer provided courtesy of Richard S. Baum of MINTEQ International Inc., 640 North 13th Street, Easton, PA 18042 who can be contacted directly at Richard.Baum@Mineralstech.com or via phone at +1 (610) 250-3114 or fax at +1 (610) 250-3217.

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