Interactions Between Dry Vibratable Tundish Linings and Steel Melts

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ABSTRACT

Interactions between two tundish working linings and molten steel were investigated using industrial samples and laboratory testing. Periclase-based dry vibe linings from two production facilities were sampled and examined after casting: one containing 30 wt.% olivine and one without olivine. Cathodoluminescence imaging, secondary electron microscopy, energy-dispersive spectroscopy and x-ray diffraction analysis were performed to characterize the interactions. An experiment was developed to replicate the conditions found in a production tundish on the laboratory scale. Results comparing interactions observed in laboratory lining tests and commercial lining samples for the two lining materials are presented and discussed.

Keywords: Tundish lining, Spinel, Refractory corrosion, Tundish flux, Post-mortem, Cathodoluminescence, Magnesia, Olivine

INTRODUCTION

In a continuous casting steel mill, the refractories used for transferring steel from the ladle to the mold are among the last surfaces molten steel contacts before solidifying. As such, a thorough understanding of the interactions that occur between the molten steel and these refractories is vital to maintaining an optimal level of steel cleanliness and quality. A tundish is typically lined with three layers. The outermost layer is composed of an insulating material that protects the steel shell from heat that transfers from the molten steel through the refractory lining during a sequence. The second layer is typically a high-alumina (Al₂O₃) castable refractory. The innermost layer is the working lining, a disposable lining that is dumped from the tundish shell between continuously cast sequences.

Most tundish linings are composed primarily of MgO in the form of periclase. The periclase aggregates consist of smaller crystals of MgO bonded by a secondary phase, often a calcium magnesium silicate phase similar to monticellite in composition (CaMgSiO₄). MgO is widely used for its chemical compatibility with most basic steelmaking practices. While many available tundish linings consist almost entirely of periclase with some minor constituents (phenolic resin binder, free silica, etc.) other linings have been developed that substitute a portion of the periclase with other oxides. Kalantar et al., for example, experimented with compositions containing olivine ((Mg, Fe)₂SiO₄, particularly on the Mg-rich side) and chromite ((Mg, Fe)Cr₂O₄). The use of these materials in conjunction with periclase results in a lining closer in composition to a typical tundish flux and may enhance corrosion resistance where flux/slag is present. This may be especially helpful when the flux is less basic (i.e. higher in SiO₂).

In the past, preformed bricks or boards have been used, though many practices now use either a gunnable/sprayable or a dry vibratable system. The latter technology consists of a refractory mix that is poured, in a dry state, into the tundish shell around a mandrel. This mandrel is then vibrated to promote consolidation. Dry vibratable material contains a small amount of binder (often ~5 wt% phenolic resin) that can be cured at low temperatures (~400 °C) to impart some green strength. During the casting sequence, the lining is held together almost entirely by sintering driven by heat from the melt. Further from the hot face (the surface of the lining in contact with molten steel), the lining is weakly bonded to the backup alumina lining, allowing for easy removal.

The aim of this paper is to characterize the interactions between a commercially available periclase/olivine tundish lining and molten steel and flux. Comparisons will be made through post-mortem analysis of industrial linings and the development of a new experimental system designed to simulate industrial tundish conditions in the lab.