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2022

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Analysis of Torpedo Ladle Refractories Experiencing Premature Failure at the Spout

Abstract

In recent years, it was found that torpedo ladle refractories, specifically at the spout area, experience premature failure. This has an adverse effect on the cost and efficiency of the process as torpedoes are removed from service at more frequent intervals. The objective of this research was to determine the factors that contribute to decreased torpedo life. Thus, refractory design, installation method and effect of operations were examined. Subsequent investigations were conducted for deviations noticed in procedures. This included evaluation of torpedoes that were removed from service with unsatisfactory campaign tonnages, in terms of molten metal mass, shell temperature, and tap to tap and residence. Furthermore, bricks from a failed torpedo were examined to determine the failure mechanisms experienced. It was found that the thermal and chemical properties of the brick are suitable for the temperature and chemistry it is exposed to as heat losses are minimal and corrosion is controlled. One of the major problems identified was spalling, which is caused by overfilling of torpedoes and long tap to tap times, resulting in rapid brick removal. The next problem was stress cracking as a result of incorrect mortar application, which occurs when the expansion due to thermal cycling cannot be accommodated. Incorrect mortar application also resulted in metal and slag penetration through the joint. When metal penetration occurs, the metal remains in the area it penetrated. The metal expands and contracts during operation, causing further cracking in the brick. The final problem experienced was skull formation, which is attributed to high tap to tap and residence times, as well as low molten metal temperatures. The brick was also subjected to XRF, XRD and SEM/EDS analysis. XRF analysis shows a decrease in the Al_2O_3 content and an increase in the CaO content at the hot face. The MgO and SiO2 content remain relatively unchanged. There is a 1.4% decrease in the alumina content and 0.6% increase in CaO content, which indicates that there is a small degree of dissolution that takes place, indicating that the refractory has good slag resistance. From the cold to hot face, XRD showed phases changes consistent with dissolution of alumina and iron infiltration. At the hot face, SEM/EDS analysis showed an increase in iron and other trace elements, and a decrease in aluminium and oxygen, indicating slag and iron infiltration, and a small degree of corrosion of the refractory.