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Wear Progress and -Mechanisms in Torpedo Ladles in Steel Industry

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Abstract : Torpedo ladles are necessary transport carriages in steel production to move the molten crude iron from the blast furnace to the steel refining plant. This requires the ladles to be high temperature resistant and insulate well to preserve the temperature and hold the risk of solidification at bay. Therefore, the involved refractories lining the inside of the torpedo ladles are chosen mostly according to their thermal properties, although wear of the materials by the liquid iron is also of major importance. In this work, we combined investigations of the thermal behaviour with wear studies of the lining over the whole lifetime of a torpedo ladle. Additional numerical simulations enabled a detailed model of the mechanical loads and temperature propagation at the various stations (heating, filling, emptying, cooling). The core of the investigation were detailed 3D measurements of the ladle's cavity and thereby quantitative information of the wear progress at different time intervals during the lifetime of the ladles. The measurements allowed for a separation of different wear zones according to severity, namely the "splash zone" where the melt directly hits the ladle, the "melt zone" where during transport always liquid melt is present, and the "slag zone", where the slag floats on the melt causing the most severe wear loss. Numerical simulations of the filling process were taken to calculate stress levels and temperature gradients, which led to the different onset of wear on those zones. Thermal imaging and punctual temperature measurements allowed for a study of the thermal consequences entailed by the wear onset. Additional "classical" damage analysis of the worn refractories complete the investigation. Thereby the wear mechanisms leading to the substantial wear loss were disclosed.

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