Energy-Efficiency Refractory Bricks for Steel Ladle Linings

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Steel ladle lining plays an important role in energy consumption during production, and refractory lining design contributes to minimizing thermal bath loss and shell temperature. A new generation of unfired zero-carbon refractories was developed with two specific approaches: (i) replacement of firing bricks reducing CO_2 footprint and (ii) replacement of carbon-containing refractories while increasing performance. Bricks can be used in working and safety linings with a unique microstructure with better heat scattering and similar thermomechanical properties. This work presents customers' performance compared to traditional products, highlighting energy savings.

The iron and steel industry is one of the most energy-intensive industries worldwide and accounts for around 21% of global industrial energy use and about 24% of industrial CO_2 emissions. Global steel production has more than doubled between 2000 and 2018. The energy use and greenhouse gas (GHG) emissions of the steel industry are likely to continue to increase because of the higher demand for steel, particularly in developing countries, due to infrastructure constructions and the higher output for cleaner steels.[1]

Clean steel encompasses a multitude of concepts that are based on fulfilling customer requirements. Clean steel can be produced in many ways depending on the existing equipment and specific customer demands. A common feature of all clean steel production is tight process control along with continuous monitoring. The major remaining issues to be addressed are disturbances that occur in industrial reality. This requires continuous improvements in processes and equipment on the one hand, and further development of quality assurance systems for full size control of any possible detrimental effects on the other hand.[2]

To meet an increasing demand for cold-rolled (CR) steel sheets of improved mechanical properties, and to cope with the change of the annealing process from a batch-type to a continuous process, it is necessary to establish a technique for making ultralow-carbon (ULC) steel. Particularly for an economical manufacture of extra deep drawing or high-tensile-strength CR steel sheet with superior deep drawing properties, it is essential to obtain ULC molten steel with a C concentration lower than 20 ppm for the steelmaking process. ULC steel is widely used for the automotive industry.[2,3]

The composition, quantity and size distribution of non-metallic inclusions (NMI) in steel determine the quality and performance in application. Over the past decade, ULC steel, also referred to as interstitial-free (IF) steel, has been used in automobile parts because of the excellent formability. However, the high quantity of inclusions, especially larger ones, can cause a deterioration of surface properties. In addition to the low C (< 30 ppm) and the low N (< 30 ppm) requirements for obtaining an extraordinary formability and providing a non-aging property, a constraint over the maximum inclusion size (< 100 µm) is also required for ULC steels.[4]

The ULC molten steel is produced by two decarburization steps: (1) in the BOF for reducing the C concentration to approximately