ABSTRACT

With the increase in demand for quality steels having very stringent compositional control, the secondary steelmaking has become one of the significant developments in the steel making technology during the past few decades. Predominantly, submerged injection of gas and powder in ladle is commonly practiced in the industry to decrease the level of impurity in steel in a more economical way. However, the efficacy of powder injection remains limited by the fact that only 30 to 40% of the injected powder particles can penetrate into the melt and the remaining ascend as "particle inside the bubble". Gas film layer around those particles offer resistance both to heat and mass transfer. As a result these particles move up in a semi solid state, with very little participation to the mass transfer process. Therefore, liquid slag injection instead of powder injection could be considered as a potential technique to improve the rate of mass transfer in refining of steel.

In the present investigation, cold model experiments have been conducted to elucidate the influence of various design and operating parameters on the kinetics of submerged liquid slag injection process, using water as the liquid metal, paraffin oil as the liquid slag, and benzoic acid as the transferable impurity in the steel melt. These have been chosen on the basis of similarity in their physical properties. All necessary similarity criteria have been considered while designing the cold model setup in the laboratory. The obtained results have been analyzed in terms of mass transfer rate constant.

The effect of parameters like, gas flow rate, oil injection rate, lance depth, and aspect ratio on the mass transfer rate have been clarified. Subsequently the

relative contributions of the transitory and permanent contact reactions have been estimated from the experimental data utilizing the mathematical model as suggested by Ohguchi and Robertson.

Furthermore, efforts have been made to compare the mass transfer efficacy of the powder injection process with the present study on the basis of data reported in literature and those obtained in the present investigation. It has been observed that the fraction of impurity transferred in liquid slag injection process is enhanced by 33% to 55% as the gas flow rate is increased from 16.34×10^{-5} Nm^3/s to 24.18×10^{-5} Nm^3/s.

Dimensional analysis has revealed that the modified Froude number may be considered as a scale up criterion for submerged liquid slag injection process. A regression analysis has also been carried out to correlate the dimensionless mass transfer rate constant with the relevant dimensionless numbers.

Further some experiments have been carried out with zero oil injection, where the total amount of oil was poured at the top of the aqueous bath, to compare this mass transfer efficacy of the process with that of the full oil injection experiments. The results indicate that at lower gas flow rates, the values of mass transfer rate constant for full oil injection are higher than that for zero oil injection.

Moreover, some partial injection experiments have also been conducted in which a certain percentage of oil was injected through the submerged lance and the balance was poured on the top of the aqueous phase at the onset of each experiment. Interestingly it is revealed that for partial oil injection up to 50%, there is no significant change in the mass transfer rates from the zero injection point. The experimental results have demonstrated that partial

injection with higher volume fraction (0.2) of oil is not at all effective in improving the mass transfer efficacy of the process, while partial injection with lower volume fraction of oil (0.1) has been found to provide a maximum rate of mass transfer at 80% oil injection.