(213) Effect of Overlying Second Phase Liquids on the Hydrodynamics in Gas Stirred Ladles

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I. INTRODUCTION

Several investigations[1], over the last decade or so, have been aimed to understand the hydrodynamic characteristics of submerged gas injection refining in transfer vessels. However, it is still not known how, and to what degree, the presence of an upper slag phase affects the various flow variables (i.e. bulk motion, turbulence level etc.) in the bath.

In the present study, the effect of an upper slag layer on the fluid dynamics within a gas stirred model ladle is investigated.

II. EXPERIMENTAL WORK

Water model investigations were carried out in a cylindrical vessel of Plexiglas. This corresponded to a 0.1 scale model of a 100ton steel processing ladle. Gas was injected through a central orifice located at the bottom of the vessel. A 15mm thick layer of olive oil (ρ_{oil}= 900kg/m^3, μ_{oil}=0.05kg/ms) was poured on top of the water so as to simulate the slag layer of an industrial system.

Extensive Laser Doppler Velocimetry (L.D.V.) was carried out so as to determine mean velocity vectors and associated fluctuating components of the flow ($\bar{u}$, $\bar{v}$, u' and v') at eight different axial stations and at six different radial positions.

III. THEORETICAL CONSIDERATIONS

Flow fields in a model ladle were calculated combining continuity and turbulent Navier-Stokes equations. For the case of turbulence, the k-$\hat{\epsilon}$ two equation model of turbulence, proposed by Launder and Spalding[2], was used.

The prediction of flow and turbulence parameters in a slag-metal/oil-water multi-phase system would be of an extremely complex task. Based on the L.D.V. measurement, one can however attempt to model such systems hydrodynamically by applying known velocity boundary conditions near the oil-water interface and at the immediate vicinity of the plume zone.

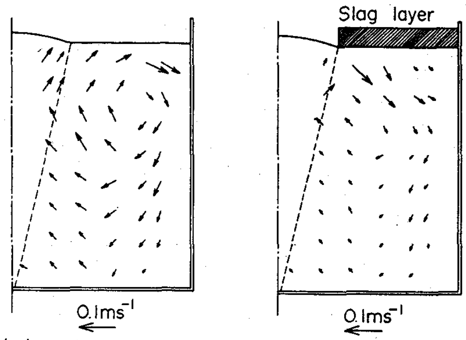
IV. RESULTS AND DISCUSSION

Figs. 1 show the observed flow fields for the case with and without an upper oil layer. The flow field in the system drastically changes owing to the presence of an overlying oil layer. The results on mean speed of bath recirculation, $\bar{U}$, and mean fluctuation velocity in the bath are plotted against gas flow rates, in Figs. 2 and 3 respectively. These clearly show that, at any gas flow rate, the kinetic energy of mean and fluctuating motion (i.e. the total kinetic energy of motion in the system) are considerably reduced in the presence of an overlying oil layer.

The predicted flow field for the case without an upper oil layer is shown in Fig. 4. Comparing Figs. 1 (b) and 4, the flow pattern and the mean speed of liquid recirculation thus predicted were in very reasonable agreement with those observed.

REFERENCES

1) e.g., Y. Sahai and R.I.L. Guthrie : Metall. Trans. B, Vol. 13B, 1982, pp. 203-211.
2) B.E. Launder and D.B. Spalding : Comp. Meth. Appl. Mech., Vol. 3, 1974, pp. 269-289.



(a) without slag (b) with slag

Fig.1 Comparison of flow fields for a 0.1 scale water model of a 100ton steel ladle. Gas flow rate : 2.5x10⁻⁵m³/s

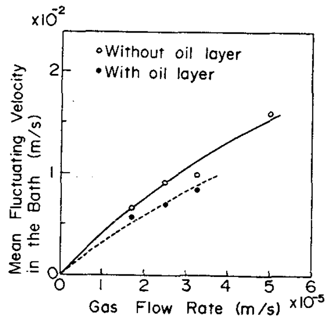


Fig.2 Effect of an upper oil layer on mean speed of bath recirculation

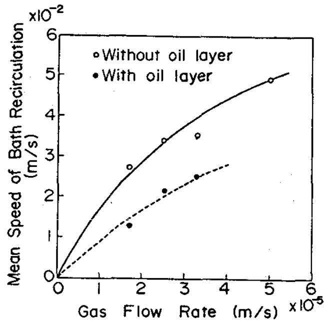


Fig.3 Effect of an upper oil layer on the mean fluctuating velocity in the bath

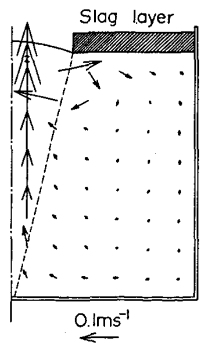


Fig.4 Predicted flow field for the case with an upper slag layer