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(214) Entrainment of Overlying Second Phase Liquids and Their Dispersion Behaviour in Gas Stirred Ladles

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I. INTRODUCTION

The work described here consists of experimental measurement and theoretical prediction of slag droplets entrainment and dispersion during gas injection operation in water model ladles.

II. EXPERIMENTAL WORK

1. DETECTION OF SECOND PHASE PARTICLES

The slag droplet (or solid tracer) population was measured in situ using the E.S.Z. (Electric Sensing Zone) method.[1] The E.S.Z. system is schematically shown in Fig. 1. It consisted of a glass probe for sampling, an electrical circuit, a pre-amplifier, a logarithmic amplifier (a peak detector), a pulse height analyzer (P.H.A.) and a recording system.

2. EXPERIMENTAL PROCEDURES

The same oil-water system as described in the previous report[2] was used to simulate a slag-metal system. On-line detection of oil droplets was carried out at various locations during submerged gas bubbling through the ladle bottom. From these measurements and knowing the relationship between the channel number of the P.H.A. and particle diameter, one can obtain the required information on particle population for any particular diameter.

III. THEORETICAL CONSIDERATION

The mathematical model of slag droplet population distribution employed a standard two dimensional convection-diffusion equation describing distribution of volume fraction of droplets within a fluid control volume. Thus, in the presence of a steady dimensional flow field, u and v, the volume fraction of slag droplets of a specific size, i, can be expressed as :

$$\frac{\partial \phi_i}{\partial t} + \frac{\partial}{\partial z}(u\phi_i) + \frac{1}{r}\frac{\partial}{\partial r}(rv\phi_i) = \frac{\partial}{\partial z}\left(D_e\frac{\partial \phi_i}{\partial z}\right) + \frac{1}{r}\frac{\partial}{\partial r}\left(rD_e\frac{\partial \phi_i}{\partial r}\right) + S_{\phi,i} \quad \cdots(1)$$

where the eddy diffusivity D_e is expressed as :

$$D_e = \frac{\Gamma_{eff}}{\rho} \quad \cdots\cdots (2)$$

and Γ_{eff} is the effecive exchange coefficient.
In the present analysis, in the absence of any droplet agglomeration and disintegration, $S_{\phi,i}$, the net source term has been assumed to be comprised of two different components and can be represented according to :

$$S_{\phi,i} = E_{\phi,i} - u_{s,i}\frac{\partial \phi_i}{\partial z} \quad \cdots\cdots (3)$$

where $E_{\phi,i}$ represents an increase in the number of droplets of size, i, in a control-volume due to entrainment action, and $u_{s,i}\frac{\partial \phi_i}{\partial z}$ represents the efflux of droplets of size, i, from any control volume because of Stokes rising velocity.

IV. RESULTS AND DISCUSSION

Steady-state oil droplet population distributions for $u_{s,i}$=0.5mm/s thus calculated are shown in Fig. 2, together with those experimentally measured using the E.S.Z. technique. Since an empirical estimation of $E_{\phi,i}$ may introduce some error in the predicted results, it is useful to compare slag (oil) droplet density distributions using populations normalized against that of a particular grid point value, rather than comparing the absolute numbers. Fairly good agreement was obtained between the observation and the numerical prediction.

V. CONCLUSION

A mathematical model of slag droplet dispersion behaviour for an axisymmetric gas injection system has been presented. The experimental data derived from the oil-water system have been compared with such numerical predictions, and reasonable agreement achieved.

REFERENCES

1) W.H. Coulter : U.S. Patent No. 112819, Oct.20, 1953.
2) H. Nakajima et al. : to be presented at the 114th ISIJ meeting.

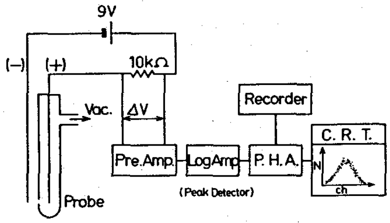

Fig.1 Schematic diagram of the E.S.Z. system for water model study

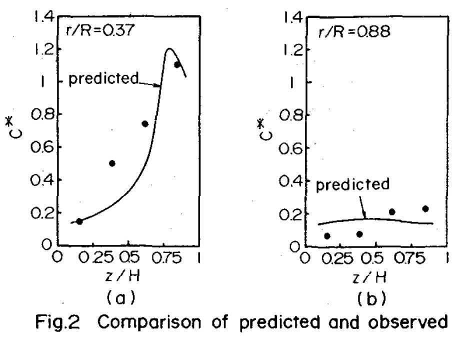

Fig.2 Comparison of predicted and observed slag droplet population distributions normalized with respect to the location r/R=0.42 and z/H=0.92 with Us=0.5mm/s , Qg=2.5x10^{-5} m^3/s