

Abstract

This is an experimental study of the surface entrainment of buoyant surface plume at varying Densimetric Froude number.

The average surface entrainment velocity in this investigation in the lateral direction was 26.7 inches/minute, and in the longitudinal direction 25.7 inches/minute, and the entrainment coefficient obtained in this study for the non-buoyant jet was 0.126. The surface entrainment velocities did not have any correlation with Densimetric Froude number, based on average and peak velocities. Longitudinal and lateral location have a greater direct impact on peak velocity than Densimetric Froude number. Coefficients of curve fits to the individual data sets did show inverse correlation with Densimetric Froude number.

Isolating the longitudinal or lateral axis as an independent variable to entrainment was only applicable for the velocity acting in the same direction. Data analyzed with parameters of opposing directions, yielded inconclusive data. Analysis off individual curve slopes and acceleration with respect to distance, also yielded inconclusive results.

Higher temperature runs grow increasingly difficult to execute and obtain useful data. As Densimetric Froude number increase, the jet entrainment region decreases and plume effects become increasingly prominent. The effects and error incurred by large gyres present after tank filling have been isolated.

The governing relation for longitudinal entrainment velocity is as follows:

$$V_y = -(1.3062 \cdot \ln(\text{Fr})) + 0.6876y + (-5.1743 \cdot \ln(\text{Fr})) + 6.1276$$

The governing relation for lateral entrainment velocity is as follows:

$$V_{y \text{ zone } 1} = ((0.3345 \cdot \ln(\text{Fr}) - 0.9133) \cdot x) + (1.7812 \cdot \text{Fr}^2) - (16.465 \cdot \text{Fr}) + 63.118$$
$$V_{y \text{ zone } 2} = ((0.3261 \cdot \ln(\text{Fr}) - 0.8197) \cdot x) + (2.3367 \cdot \text{Fr}^2) - (23.208 \cdot \text{Fr}) + 79.205$$

Where:

- V_y = Longitudinal Entrainment Velocity
- V_e = Lateral Entrainment Velocity
- y = Longitudinal Distance from Discharge
- x = Lateral Distance from Discharge
- Fr = Densimetric Froude Number

The maximum entrainment velocities for the Densimetric Froude numbers of 2.3, 2.6, 2.9, 3.3, 4.2, 5.4, and 12.7, were 28.4 in/min, 20.8 in/min, 24 in/min, 18.8 in/min, 29.2 in/min, 41.8 in/min, and 23.8 in/min in the lateral direction; and 26.6 in/min, 21.4 in/min, 22 in/min, 20.4 in/min, 19.4 in/min, 53.6 in/min, and 10.8 in/min in the longitudinal direction, respectively. Location imposes a greater influence to the data than Densimetric Froude number.