SYNOPSIS

The mechanism of jet action has largely been utilized in ejectors or jet-pumps in which momentum and kinetic energy of high velocity motive fluid is used to entrain and pump secondary fluids. In recent years, the concept of ejector has been enriched and amplified and its practical applications have proliferated enormously. The wide applications of steam and air ejectors are well known; but during the last few years, there has been growing realization to utilize liquid-jet ejector in chemical engineering operations to entrain and pump corrosive liquids, slurries, fumes and dust-laden gases which are otherwise difficult to handle. Further, in liquid-jet ejectors large interphase between primary and secondary fluid is generated because of high turbulence, so it may possibly be used to obtain large mass transfer rate even though residence time is small. This opens up a bright prospect of new fields of study combining functions of a pump and reactor or similar mass transfer equipments.

Extensive literature published in this field broadly deals with processes occurring in free jets, mixing of free jets and induced fluid stream, and in the performance of jet-pumps. The liquid-jet ejector where liquid is the driving fluid and air or liquid the entrained fluid, has not received much attention. In view of this, the present investigation has been aimed to study the momentum transfer

in horizontal and vertical liquid-gas ejectors, and in vertical liquid-liquid ejector systems. Theoretical analyses of the systems on the basis of macroscopic momentum and mechanical energy balance enable evaluation of the friction factor which varies over a wide range. Correlations are proposed to predict entrainment rate as a function of physical and dynamic variables of the system.

The thesis has been presented in four chapters. In chapter I an attempt has been made to present a comprehensive literature survey on the design and analyses of performance of ejectors. The scope of the present work is also discussed.

Chapter II deals with studies on the performance of horizontal ejector in liquid-air system. A detailed discussion on the experimental set-up designed and technique employed are presented. Motive liquids used in the experiments are water, kerosene, and three solutions of different concentrations of glycerine covering a wide range of physical properties.

First, studies have been made for co-axial flow of liquid-jet and air in the extended diffuser. Next, to enhance the performance of ejector, i.e., to give better mixing between primary and secondary fluids, mixing shock is produced by increasing separator pressure, whereby jet-flow is converted into froth-flow. Studies have been made to find the effect of various parameters, viz., motive pressure, area ratio, separator pressure etc., on the entrainment of secondary fluid.

A mathematical analysis of the system based on the momentum and energy relations for homogeneous bubble flow in the diffuser leads to the following equation :

$$M_r^2 \rho_r \left[-\gamma_2^2 + \frac{2\gamma_1 A_r}{A_r - 1} + 2(\gamma_1 - 1)\frac{\gamma_3}{(\gamma_3 - 1)}\left(\gamma_3 - \frac{A_r}{A_r - 1}\right) - \gamma_1^2 \right]$$

$$- M_r \gamma_1^2 (\rho_r + 1) - (K' + \beta) A_r^2 + 2\gamma_1 A_r - \gamma_1^2 = 0 \qquad ..(1)$$

From the above equation, the value of K' has been calculated using experimental data and has been found to vary over a wide range. A relationship of the following form has been proposed which relates K' with β and A_r

$$K' = -\beta - 0.0123\, A_r + 0.116 \qquad ..(2)$$

Dimensional analysis approach has been employed for predicting mass ratio as a function of the physical and dynamic variables of the system and the geometry of ejector. The final correlation is expressed by the following equation :

$$M_r = 8.5 \times 10^{-2} \left(\frac{g_c \, \Delta p}{\rho_e \, U_e^2} \right)^{-0.305} (A_r)^{0.466} \left(\frac{g \mu_m^4}{\rho_m \sigma_m^3} \right)^{-0.02} \qquad ..(3)$$

Chapter III presents the investigations on the performance of vertical ejector for liquid-air system. It also presents a discussion of the experimental set-up and technique. Motive liquids used are the same as those used in the case of horizontal ejector.

In this case there is no co-axial flow of liquid-jet and air. However, as air enters the ejector it gets dispersed in vertical column of liquid and mixing occurs. Theoretical analysis of the system on the basis of momentum and energy relations leads to following equation :

$$M_r^2 \rho_r \left[\gamma_3^2 + \frac{A_r(A_r-2)}{(A_r-1)^2} - 1 \right] - M_r(\rho_r + 1) - (K'' + \beta) A_r^2 + 2 A_r - 1 = 0 \qquad ..(4)$$

The value of K" has been evaluated and is found to vary over a wide range. Dimensional analysis technique has been applied to correlate the data and is represented by

$$M_r = 5.2 \times 10^{-4} \left(\frac{g_c \Delta p}{\rho_e U_e^2} \right)^{-0.305} (A_r)^{0.680} \left(\frac{g \mu_m^4}{\rho_m \sigma_m^3} \right)^{-0.035} \qquad ..(5)$$

Following the investigation in liquid-air systems, studies have been extended to liquid-liquid systems. Chapter IV presents the investigation on the performance of vertical ejector for the water-liquid system. A detailed description of the experimental set-up and procedure are discussed. The vertical ejector used is the same as that used in the liquid-air system. Motive fluid used in the experiments is water whereas secondary liquids used are water and different solutions of brine and molasses. Data on entrainment are obtained at various motive pressures for different nozzles and secondary liquids. Theoretical analysis of the system has been attempted similar to the previous cases and the values of friction factor, K''' calculated varies over a wide range. Expressions have been proposed to predict friction losses in the case of vertical liquid-jet ejector systems also, and it has been found that friction loss in the case of liquid-air vertical system is more than liquid-liquid miscible system for the same values of β and A_r. Since prediction of entrainment theoretically becomes difficult dimensional analysis has been applied to correlate the data and is given by the following equation:

$$M_r = 1.6 \times 10^{-1} \left(\frac{\rho_m U_m d_n}{\mu_m}\right)^{0.155} (A_r)^{0.625} \qquad ..(6)$$