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Mathematical Model for Liquid Holdup in Multi Nozzle Jet Ejector

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Abstract:- The dispersion of gases in liquids in many areas like chemical engineering, biochemical engineering and waste treatment systems is of prime importance. Hence, there have been many significant contributions in recent years in the development of more efficient gas- liquid ejector. In this paper we have made an attempt to develop a mathematical model for liquid hold up.

I. INTRODUCTION

Because of high energy efficiency in gas dispersion, many researchers used jet ejector and considerable amount of work has been done: (Jackson, 1964; Volmuller and Walburg, 1973; Nagel et al., 1970; Hirner and Blenke, 1977; Zehner, 1975; Pal et al., 1980; Ziegler et al., 1977).
It is important to note that the kinetic energy of a high velocity liquid jet is used for getting fine dispersion and mixing between the phases in the given gas liquid ejector. The studies in this area are listed below:

- (Zlokamik, 1980) has reported that oxygen absorption efficiency is as high as 3.8 kg O_2/kwh in ejectors as compared to 0.8 kg O_2/kwh in a propeller mixer. The higher gas dispersion efficiency of the ejector type can be understood from the well known fact : "gas dispersion is possible only if the fraction of micro turbulence is high" (Schugerl, 1982).
- Radhakrishnan et al. (1984) have used a vertical column fitted with a multi jet ejector for gas-dispersion for studying the pressure drop, holdup and interfacial area.

1.1.1 Hold up

Yamashita and Inoue (1975), Koetsier et al. (1976) and Mandal et al. (2003 and 2004) reported the holdup characteristics with respect to gas flow rate in the jet ejector. At lower range of gas flow rate, gas hold up increases with increase in gas flow rate but at higher range of gas flow rates the increase in gas flow rate decreases the gas hold up or it remain constant depending on the height of liquid in the follow up column is high or low respectively. At lower gas flow rates small bubbles produced are in large number and at higher gas flow rate due to coalescence the bubbles of larger size are produced which lead to decrease in number of bubbles.
Hills (1976) has reported that the holdup is not affected by liquid flow rate. Mandal et al. (2004) observed that for the same gas flow rate the increase in liquid flow rate decreases the gas hold up. The variables A_R, n, Re_{ls} and Re_{gs} affect the liquid holdup in a jet ejector.

Radhakrishnan et al. (1984) obtained following correlation by applying multi linear regressions analysis on their experimental data:

$$\chi_1 = 1 - \exp\left[-38.176\, {A_R}^{-0.06} n^{-0.06} {Re_{ls}}^{0.0002} {Re_{gs}}^{-0.55}\right] \qquad (1.1.1)$$

A new mathematical model has been attempted to predict the gas hold up as follows:
It is assumed that the model is of the form:

$$\alpha_1 = 1 - \exp[a_1 A_R^b n^c Re_{ls}^d Re_{gs}^e]$$

Therefore $\log[-\log(1-\alpha_1)] = \log a_1 + b\log A_R + c\log n + d\log Re_{ls} + e\log Re_{gs}$.

Using experimental data and multi linear regression analysis the values of a_1, b, c, d and e were obtained. The values obtained are $a_1 = -51.467,\ b = -0.03,\ c = 0.03,\ d = 0.0002$ and $e = -0.41$.

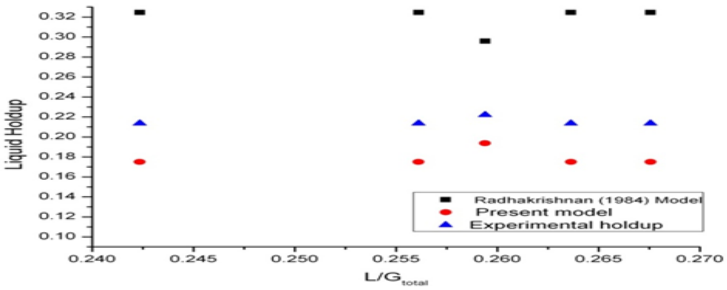

Figure 1.1.0 : Comparison of liquid holdup predicted by Radhakrishnan (1984), present model and experimental value at different L/G_{total} ratio.

Thus mathematical model for gas hold up is as follows.

$$\alpha_1 = 1 - \exp\left[-51.467\, {A_R}^{-0.03} n^{-0.03} {Re_{ls}}^{0.0002} {Re_{gs}}^{-0.41}\right] \qquad (1.1.2)$$

Liquid holdup may be determined by following equation.

$$\chi_1 = 1 - \alpha_1 = \exp\left[-51.467\, {A_R}^{-0.03} n^{-0.03} {Re_{ls}}^{0.0002} {Re_{gs}}^{-0.41}\right] \qquad (1.1.3)$$

The results predicted from Radhakrishnan (1984) model and present model (equation – 1.1.3) is compared with actual experimental value at different L/G in figure (1.1.0).

Some Terminology

χ_1	liquid holdup	[-]
A_R	area ratio (ratio of cross section area of throat to nozzle)	[m^2]
n	number of nozzles	[-]
R_{ls}, R_{gs}	Reynold number based on superficial gas and liquid velocity	[-]
α_1	gas hold up	[-]
a_1,b,c,d,e	constants	[-]

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REFERENCES

[1]. Hills, J. H., (1976), The operation of a bubble column at high throughputs in gas holdup measurements, *Chem. Eng.,* 12, 89-99.
[2]. Hirner, W., and Blenke, H., (1969), *Gas gehalt und phascngren zflache in schlaufen und strahl reaktoren*, Verfahrenstechnik 11, York.
[3]. Jackson, M. L., (1964), Gas Absorption in Venturies, A.I.Ch.E.J., 10**.**
[4]. Koetsier, W. T., Van Swaiij, W. P. M., and Van der Most. M., (1976), Maximum gas holdup in bubble columns, *J. Chem. Eng. (Japan),* 9. 332-333.
[5]. Mandal Ajay, Kundu Gautam and Mukherjee Dibyendu, (2004), Gas-holdup distribution and energy dissipation in an ejector-induced down flow bubble column: the case of non-Newtonian liquid, *Chemical Engineering Science,* 59, 2705 – 2713.
[6]. Mandal, A., Kundu, G. and Mukherjee, D., (2003), Gas holdup and entrainment characteristics in a modified downflow bubble column with Newtonian and non-Newtonian liquid, *Chemical Engineering and Processing,* 42, 777-787.
[7]. Nagel, O., Kurten, H., and Sinn, R., (1970), Strahldiisenreaktoren -Teil I, *Chem. Eng. Tech.,* 42, 474-479.
[8]. Pal, S. S., Mitra, A. K. and Roy, A. N., (1980), Pressure drop and holdup in a vertical two-phase counter current flow with improved gas mixing liquid, *Ind. Eng. Chem. Process Des. Dev.,* 19(1), 67-75.
[9]. Radhakrishnan, V. R., and Mitra, A. K., (1984), Pressure drop, holdup and interfacial area in vertical two-phase flow of multi-jet ejector induced dispersions, *The Canadian Journal of Chemical Engineering*, 62, 2, 170–178.
[10]. Schugerl, K., (1982), New Bioreactors for Aerobic Processes, *Int. Chem. Eng.,* 22, 591–610.
[11]. Volmuller, H., and Walburg, R., (1973), Blasengrope bei der Begasung mit Venturidiisen, *Chern. Ing. Tech.,* 45, 913-920.
[12]. Yamashita, F. and Inoue, H., (1975), Gas Holdup in Bubble Columns, *J. Chern. Eng. (Japan),* 8, 334-340.
[13]. Zehner, P., (1975), Stoffaustausflache und Gasverteilung in einer neu entwickelten Ejektor Strahldue, *Chem. Ing. Tech.,* 47, 209-214.
[14]. Ziegler, H., Meister, D., Dunn, I . J ., Blanch, H. W., and Russel, W. F., (1977) Schlaufen reaktoren, *Biotech. Bioeng.,* 19, 507-511.
[15]. Zlokarnik, M., (1980), Eigung und Leistungsfahigkeit von Beluftingungs Vorrichtungen fur die biologische Abwasserreinigung, *Chem. Ing. Tech.*, 52, 330-331.