LIST OF FIGURES

Figure 1.1	Typical gas-liquid jet ejector	03
Figure 2.1	Flow of a submerged circular jet (Rushton and Oldshue, 1953)	08
Figure 2.2	Break up time and/or jet breakup length as a function of jet exit velocity [Adopted from (1) Atay (1986), (2) Lin and Reitz (1998)]	11
Figure 2.3	Images of cavitation in a 2D nozzle and liquid jet (water) (Suo et al., 2006)	15
Figure 2.4	Different schemes of secondary atomization (Meyers, 2006)	18
Figure 2.5	Flow pattern in vertical column [(a) homogeneous bubbly flow (b) heterogeneous churn flow, (c) slug flow and (d) annular flow] (Mandal et al., 2004)	21
Figure 2.6	Gas holdup and $k_L a$ as function of the superficial gas velocity (Zahradnik and Fialova, 1996)	23
Figure 2.7	(A) The dependence of drag coefficient on Reynolds number for the deformable particles. (B) Dependence of the drag coefficient on Bond numbers (Bo) for the deformable particle (Ceylan et al., 2001)	29
Figure 2.8	Bubble size distributions at different reaction mixer configurations (Bailer, 2001).	30
Figure 2.9	Characteristic bubble size distributions in water and in the 0.25 M Na_2SO_4 −solution (Bailer, 2001)	31
Figure 2.10	Bubble size distributions with nitrogen at different pressures (Bailer, 2001)	32
Figure 2.11	d_{32} versus the gas density (Bailer, 2001)	32
Figure 2.12	Comparison of axial pressure drop predicted by different models with experimental data (Vishwanathan et al., 2005)	37
Figure 2.13	Variation of the total pressure drop in the venturi with liquid to gas ratio and throat velocity. Liquid injected as a spray (Silva et al., 2009)	37

Figure 2.14	Comparison of overall pressure drop predicted with and without correction factor α, experimental data of Silva et al. (2009) (Rahimi et al., 2011)	38
Figure 2.15	Dependence of the overall collection efficiency of liquid gas ratio (Vishwanath et al., 1997)	39
Figure 2.16	The effect of throat gas velocity on the collection efficiency in venturi scrubber (GA–ANN no. 1). (Taheri et al., 2008)	39
Figure 2.17	Effect of variation in venturi number and aspect ratio on collection efficiency for a constant venturi number. (Ananthanarayanan and Vishwanathan, 1998)	40
Figure 2.18	Efficiency as a function of (A) particle diameter (B) liquid to gas ratio with liquid surface tension as a variable. (Ott el al., 1987)	40
Figure 2.19	Schematic diagram showing geometry of an ejector	43
Figure 2.20	Effect of area ratio on mass ratio for water-water system (Singh et al., 1974)	46
Figure 2.21	Variation of entrainment of air with projection ratio of water-air system (Acharjee et al. 1975)	46
Figure 2.22	Effect of projection ratio (L_{TN}/D_T) on energy efficiency (Yadav and Patwardhan, 2008)	47
Figure 2.23	Effect of area ratio $(D_S^2 - D_N^2)/(D_N^2)$ on efficiency of ejectors for different values of projection ratio (Yadav and Patwardhan, 2008)	48
Figure 2.24	Effect of angle of converging section (θ) on rate of entrainment (Yadav and Patwardhan, 2008)	4 9
Figure 2.25	Influence of the swirl device on the total gas holdup (ε_{tot}) (Bailer, 2001)	62
Figure 2.26	Influence of the mixing tube length on $k_L a$ (Bailer, 2001)	63
Figure. 2.27	Influence of gas density on $k_L a$ without swirl device (Bailer, 2001)	63

Figure 2.28	Influence of the liquid viscosity on $k_L a$ (Bailer, 2001)	64
Figure 2.29	Concentration profiles for absorption of Cl_2 into aqueous $NaOH$ solution. (Hikita et al., 1973)	68
Figure 3.1	Detail of the jet ejector used in experimental setup 1	75
Figure 3.2	Schematic diagram of experimental setup 1	75
Figure 3.3	Details of the jet ejector used in experimental setup 2	78
Figure 3.4	Schematic diagram of experimental setup 2	79
Figure 3.5	Detail of the jet ejector used in experimental setup 3	80
Figure 3.6	Schamatic diagram of experimental setup 3	81
Figure 4.1.1	Comparison of k obtained by Ashour et al. (1996), proposed mathematical model and present experimental result over the temperature range of 293-312 K	94
Figure 4.1.1a	Detailed view of Figure 4.1.1 at a temperature T^{-1} =3.3x10^{-3}	94
Figure 4.1.2	Error estimates for k_2 and Ashour et al. (1996)	95
Figure 4.1.3	Comparison between the values for rate of absorption obtained experimentally and predicted by proposed model with respect to $C_{Ag,in}$ at different C_{B0}	96
Figure 4.2.1	Concentration profiles for absorption of Cl_2 into aqueous $NaOH$ solution	103
Figure 4.2.2	Variation in enhancement factor with respect to C_{B0}/C_{Ai}^* at different $D_B/D_A = 2.43, 1, 0.1$ and constant $D_E/D_A = 10$ and $D_C/D_A = 0.1$ for absorption of Cl_2 into aqueous $NaOH$ solution	109
Figure 4.2.3	Error estimates between experimental data and proposed mathematical model at different $D_B/D_A = 2.43, 1, 0.1$ and constant $D_E/D_A = 10$ and $D_C/D_A = 0.1$.	110

Figure 4.2.4	Comparison of value of β determined experimentally and by proposed mathematical model for different C_{B0} at $C_{Ag,in} = 0.602\ x\ 10^{-3}\ kmol/m^3$	112
Figure 4.3.1	Variation of gas phase concentration C_{Ag} along the axis of ejector for different values of initial gas concentration $C_{Ag,in}$ at $C_{B0} = 0.95\ kmol/m^3$ (comparison between proposed model and experimental value)	118
Figure 4.3.2	Variation of gas phase concentration C_{Ag} along the axis of ejector for different nozzles N5 (no. orifice 1), N6 (no. of orifice 3) and N7 (no. of orifice 5) for setup 3 at $C_{B0} = 0.578\ kmol/m^3$ and initial gas concentration $C_{Ag,in} = 1.967 \times 10^{-3}\ kmol/m^3$ (comparison between proposed model and experimental value)	118
Figure 4.3.3	Velocity profiles (m/sec.) of gas and droplet along axial direction (m)	119
Figure 4.4.0	Comparison of liquid holdup predicted by Radhakrishnan (1984), present model and experimental value at different L/G_{total} ratio.	121
Figure 4.4.1	Effects of $C_{Ag,in}$ on $R_A a$ for different C_{B0} for setup – 1 with nozzle N1 (no. of orifice 1)	126
Figure 4.4.2	Effects of $C_{Ag,in}$ on $k_g a$ for different C_{B0} for setup – 1 with nozzle N1 (no. of orifice 1) (comparison of experimental result and present model)	127
Figure 4.4.3	Effects of $C_{Ag,in}$ on ejector interfacial area for different C_{B0} for setup – 1 with nozzle N 1 (no. of orifice 1) (comparison of experimental result and present model)	127
Figure 4.4.4	Effects of $C_{Ag,in}$ on k_g for different C_{B0} for setup – 1 with nozzle N1 (no. of orifice 1) (comparison of experimental result and present model)	128
Figure 4.4.5	Effects of $C_{Ag,in}$ on $R_A a$ for $C_{B0} = 0.525$ for set up 2 (a) with nozzle N2 (no. of orifice 1), (b) with nozzle N3 (no. of orifice 3)	128

Figure 4.4.6	Effects of $C_{Ag,in}$ on $k_g a$ for $C_{B0} = 0.525$ for set up 2 (a) with nozzle N2 (no. of orifice 1), (b) with nozzle N3 (no. of orifice 3)	129
Figure 4.4.7	Effects of $C_{Ag,in}$ on interfacial area for $C_{B0} = 0.525$ for set up 2 (a) with nozzle N2 (no. of orifice 1), (b) with nozzle N3 (no. of orifice 3)	129
Figure 4.4.8	Effects of $C_{Ag,in}$ on k_g for $C_{B0} = 0.525$ for set up 2(a) with nozzle N2 (no. of orifice 1), (b) with nozzle N3 (no. of orifice 3)	130
Figure 4.4.9	Effects of $C_{Ag,in}$ on $R_A a$ for different C_{B0} for set up 3 (a) with nozzle N5 (no. of orifice 1), (b) with nozzle N6, (no. of orifice 3), (c) with nozzle N7 (no. of orifice 5)	130
Figure 4.4.10	Effects of $C_{Ag,in}$ on $k_g a$ for different C_{B0} for set up 3 (a) with nozzle N5 (no. of orifice 1), (b) with nozzle N6, (no. of orifice 3), (c) with nozzle N7 (no. of orifice 5)	131
Figure 4.4.11	Effects of $C_{Ag,in}$ on interfacial area for different C_{B0} for set up 3 (a) with nozzle N5 (no. of orifice 1), (b) with nozzle N6, (no. of orifice 3), (c) with nozzle N7 (no. of orifice 5)	131
Figure 4.4.12	Effects of $C_{Ag,in}$ on k_g for different C_{B0} for set up 3 (a) with nozzle N5 (no. of orifice 1), (b) with nozzle N6, (no. of orifice 3), (c) with nozzle N7 (no. of orifice 5)	132
Figure 4.4.13	Effects of $C_{Ag,in}$ on $R_A a$ for different nozzle for set up 3 (a) with $C_{B0} = 0.79$ (b) with $C_{B0} = 0.57$ (c) with $C_{B0} = 0.11$	132
Figure 4.4.14	Effects of C_{A0} on $k_g a$ for different nozzle for set up 3 (a) with $C_{B0} = 0.79$ (b) with $C_{B0} = 0.57$ (c) with $C_{B0} = 0.11$	133
Figure 4.4.15	Effects of $C_{Ag,in}$ on interfacial area for different nozzle for set up 3 (a) with $C_{B0} = 0.79$ (b) with $C_{B0} = 0.57$ (c) with $C_{B0} = 0.11$	133
Figure 4.4.16	Effects of $C_{Ag,in}$ on k_g for different nozzle for set up 3 (a) with $C_{B0} = 0.79$ (b) with $C_{B0} = 0.57$ (c) with $C_{B0} = 0.11$	134

Figure 4.5.1	Removal efficiency (Y) versus gas concentration (X_1) for constant liquid concentration ($X_2 = 0.4$) for nozzle N1	145
Figure 4.5.2	Removal efficiency (Y) response surface versus gas concentration (X_1) and liquid concentration (X_2) for nozzle N1	145
Figure 4.5.3	Contour plot for Removal efficiency (Y) for nozzle N1	145
Figure 4.5.4	Predicated removal efficiency (Y) versus observed removal efficiency (Y) for nozzle N1	146
Figure 4.5.5	Residual Plot for nozzle N1	146
Figure 4.5.6	Removal efficiency (Y) versus gas concentration (X_1) for constant liquid concentration ($X_2 = 0.4$) for nozzle N5	147
Figure 4.5.7	Removal efficiency (Y) response surface versus gas concentration (X_1) and liquid concentration (X_2) for nozzle N5	148
Figure 4.5.8	Contour plot for removal efficiency (Y) for nozzle N5	148
Figure 4.5.9	Predicated removal efficiency (Y) versus observed removal efficiency (Y) for nozzle N5 for setup – 3 with no. of nozzle – 1	148
Figure 4.5.10	Residual plot for nozzle N5	149
Figure 4.5.11	Removal efficiency (Y) versus gas concentration (X_1) for constant liquid concentration ($X_2 = 0.4$) for nozzle N6	150
Figure 4.5.12	Removal efficiency (Y) response surface versus gas concentration (X_1) and liquid concentration (X_2) for nozzle N6	150
Figure 4.5.13	Contour plot for removal efficiency (Y) for nozzle N6	151
Figure 4.5.14	Predicated removal efficiency (Y) versus observed removal efficiency (Y) for nozzle N6	151
Figure 4.5.15	Residual plot for nozzle N6	151
Figure 4.3.16	Removal efficiency (Y) versus gas concentration (X_1) for constant liquid concentration ($X_2 = 0.5$) for nozzle N7	153

Figure 4.5.17 Removal efficiency (Y) response surface versus gas concentration (X_1) and liquid concentration (X_2) for nozzle N7 153

Figure 4.5.18 Contour plot for removal efficiency (Y) for nozzle N7 153

Figure 4.5.19 Predicated removal efficiency (Y) versus observed removal efficiency (Y) for nozzle N7 154

Figure 4.5.20 Residual plot for nozzle N7 154