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Effect of Gas Hold Up in Tapered Bubble Columns with Same Taper Angle Using Water: Columns Diameter and Liquid Height

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Abstract

Bubbler columns are extensively used in process industries. Conventional bubble column is either cylindrical or rectangular in shape. The taper bubble columns are fabricated and experiments using air as continuous phase and water as stagnant phase. Gas holdup characteristics and effects of operating variables are investigated.

***Keywords:* Bubble columns; Newtonian liquid; Gas holdup**

Introduction

The bubble columns are extensively used in the field of biotechnology, food processing, pharmaceutical processes and waste water treatment. Bubble columns are used for chemical processes involving oxidation, chlorination, alkylation, polymerization and hydrogenation reaction [1,2]. Examples of such methods are partial oxidation of ethylene to acetaldehyde, wet-air oxidation, [3] oxidation of cumene to phenol and acetone, [3] liquid phase methanol synthesis, Fischer-Tropsch (FT) synthesis, [4] and hydrogenation of maleic acid.

Bubble column reactors are also employed in the processes of oxidation of acetaldehyde to acetic acid, oxidation of p-xylene to dimethyl terephthalate, synthesis of hydrocarbons, hydrolysis of phosgene, oxychlorination of ethylene to 1,2-dichlooroethane, Hydroformylation (Oxo) processes [4].

Few literatures are reported gas holdup using air-water and other Newtonian liquids [5-13] studied the gas holdup using the air-water system with and without internals in 8-inch diameter bubble column. Researchers [14,15] reported the gas holdup

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behaviour for the presence of electrolyte in bubble column [16-18], examined the effect of taper angle in the hydrodynamics of the taper bubble columns for non-Newtonian liquids. The present study reported the experimental investigation on the gas holdup in taper bubble columns with respect to the column diameter for air-water system.

Experimental Details

Details of the experimental setup and procedure are published in our earlier paper [16]. The schematic diagram is shown in FIG. 1. The dimension of the columns and the range of variables are shown in TABLE 1. All experiments are conducted at temperature of 30 ± 2°C.

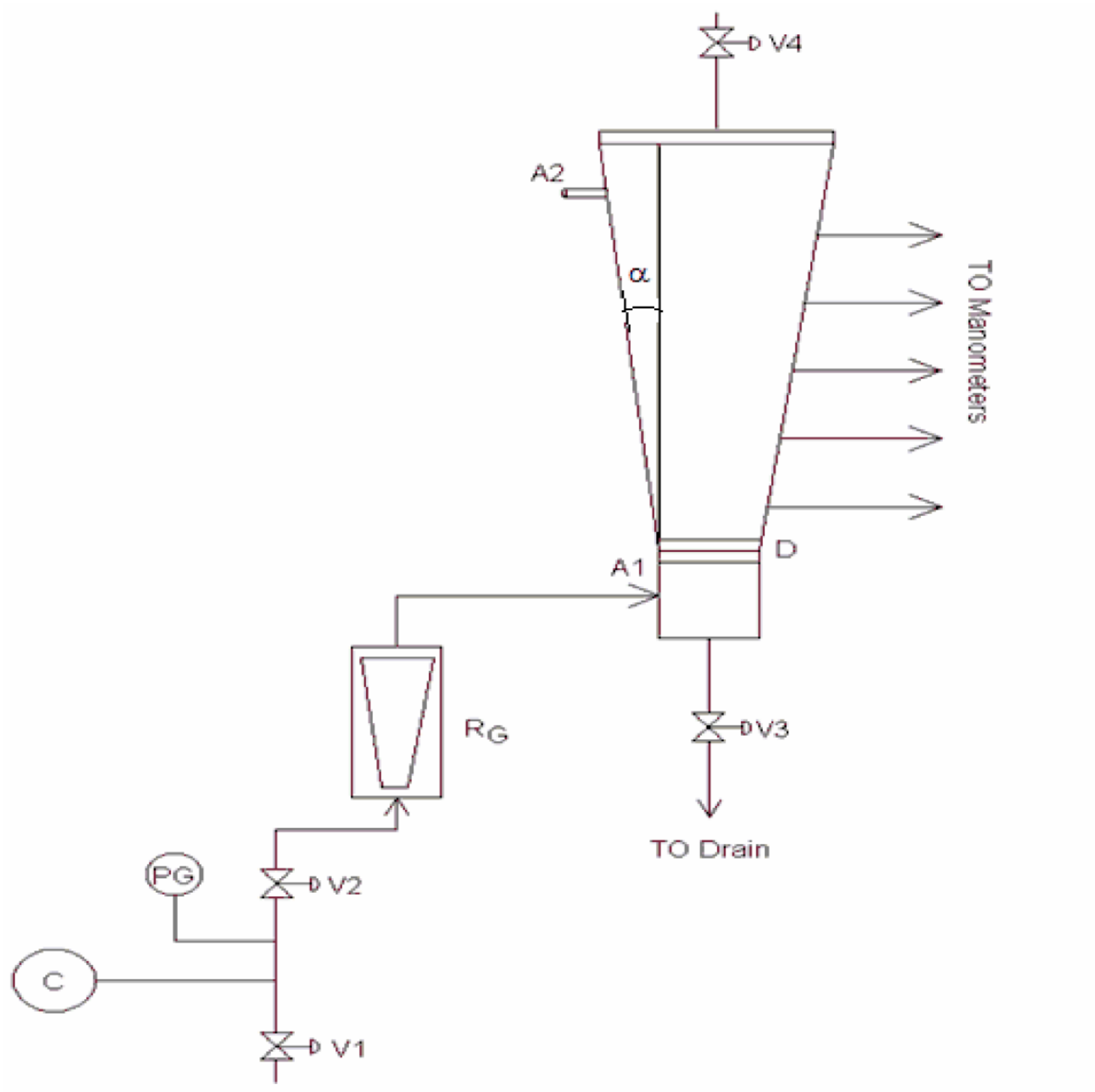

FIG. 1. **Experimental setup.**

A1: Air inlet; A2: Air outlet; Manometers; D: Distributor; C: Compressor; PG: pressure Gauge; R_G: Rotameter for gas; V1-V4: Control valves.

Characteristic parameters	**Larger Tapered Bubble Column TB2**	**Smaller Tapered Bubble Column TB1**
Thickness of Perspex sheet, m	0.0127	0.0127
Height of column, m	1.83	1.83
Top plate area, m^2	0.1016 × 0.1016	0.0762 × 0.0762
Bottom plate area, m^2	0.0508 × 0.0508	0.0254 × 0.0254
Average diameter of column, m	$0.0692 \leq D_c \leq 0.0710$	$0.04313 \leq D_c \leq 0.04504$
Hole diameter of the air inlet and outlet, m	0.0127	0.0127
Taper angle(deg)	0.86	0.86
Hole diameter of different sieve plates used, m	0.00277	0.00277
Hole number of sieve plate	50	50
Pitch	Square	Square
Range of variables		
Liquid height, m	1.20, 1.17. 1.22	1.20, 1.17. 1.22
Air flow rate, m^3/s	$0.2 \times 10^{-4} \leq Q_g \leq 6.6 \times 10^{-4}$	$0.1 \times 10^{-4} \leq Q_g \leq 3.9 \times 10^{-4}$
Air pressure, kg/m^2	1.0	1.0
Flow pattern	Bubble and Plug	Bubble and Plug

TABLE 1. **Dimension of bubble columns and range of variables investigated.**

The experiments were repeated number of times to ensure the reproducibility of the data. The gas hold up based on liquid bed volume expansion was determined. The overall value of gas hold up (ε_g) ratio was determined from this equation.

$$\varepsilon_g = \frac{V - V_0}{V} \qquad (1)$$

Where V is the volume of the liquid and air in the column and V_o is the volume of only liquid present in the column.

Results and Discussion

The effects of gas holdup with gas flow rate at different bed height are shown in FIG. 2. The gas holdup increases with gas flow rate due to increase in the amount of gas but decreases with the increase of bed height. For higher bed height the bubbles are coalescences more, the gas rise velocity increases and decreases the residence time in the column.

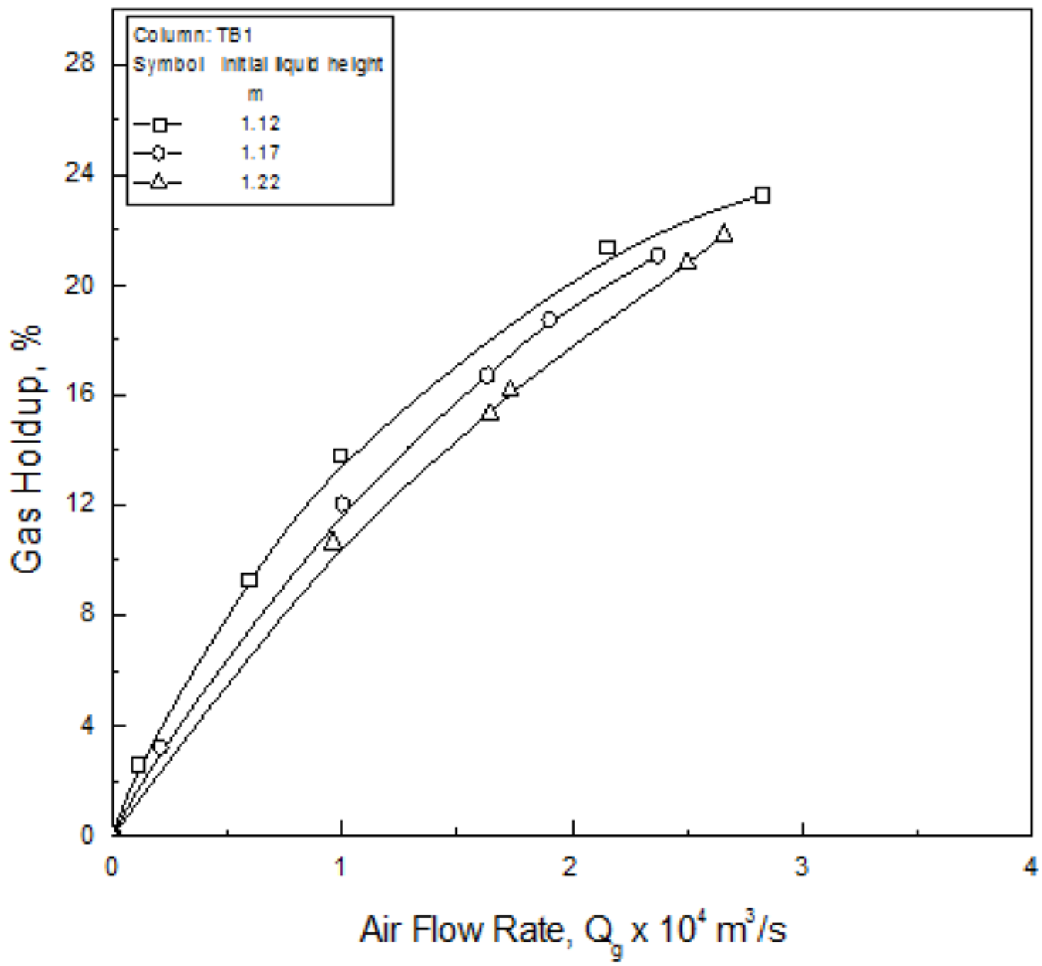

FIG. 2. **Effects of gas holdup.**

The effect of gas holdup with gas flow rate, column size as parameter, is shown in FIG. 3. At very low air flow rate the bubbles of equal size are forms and homogeneous flow region exist. Increase in air flow rate strong convective motion developed which resulted bubble coalescences to occur. Bigger sized bubbles are formed due to coalescences and the bubble rise velocity increases. The bigger sized bubble are rising in the centre portion of the column, carrying considerable amount of liquid and also small bubbles in their path. Once the bigger sized bubbles reach the liquid surface, the smaller bubbles are entrained by the liquid down flow and these are swept in the downward direction at the sides of the column. Hence the flow pattern consists of two zones, i.e. central zone and annular region [16] in the central zone bubble rise occur and in annular region down flow of smaller sized bubble occur. Thus intensified the mixing process observed. In the smaller sized bubbles the recirculation in the annular region is more, hence the gas holdup increases. For higher diameter column recirculation occur in the annular zone but also a stagnant layer of liquid adhere to the wall exist, i.e. unaffected in the process, hence the gas holdup decreases. In larger diameter column the bubble coalescences are less due to the pitch of the orifice in the orifice plate is more and also less recirculation of bubbles observed due to increase in size in the upper half of the column.

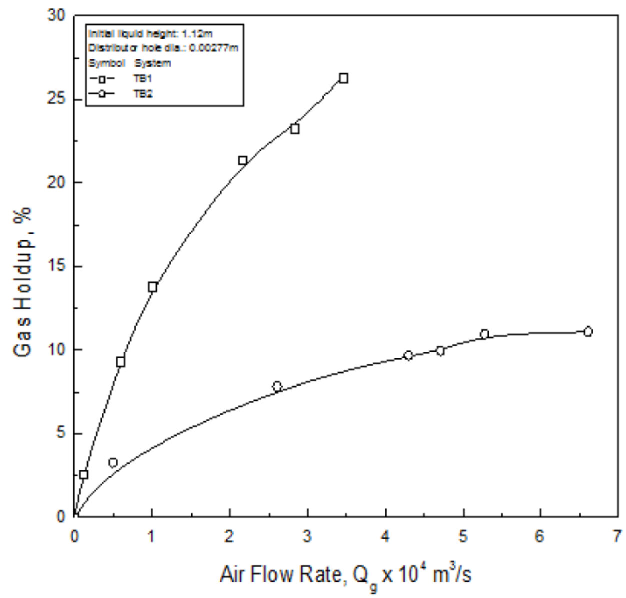

FIG. 3. **Effect of the column diameter on holdup.**

Conclusion

The gas holdup has been measured in two different tapered bubble columns for air-water system. The gas holdup decreases with increase in bed height and is due to bubble coalescences in the column which raises the bubble velocity. The gas holdup increases with decrease in the column diameter and is due to less recirculation in the upper half of the column.

Nomenclature

D_c = Average diameter of column, m.

Q_g = Gas flow rate, m^3/s.

TB1 = Smaller tapered bubble column.

TB2 = Larger tapered bubble column.

V = Volume of the column with air, $m^{3.}$

V_0 = Volume of liquid without air in column, $m^{3.}$

Greek letters

α = Taper angle, deg.

ε_g = Gas hold-up, dimensionless.

Subscripts

g = Gas.

c = Column.

0 = Without aeration.

REFERENCES

1. Shah YT, Kelkar BG, Godbole SP, et al. Design parameters estimations for bubble column reactors. AIChE J. 1982;28(3):353 79.
2. Fan LS, Series in Chemical Engineering, Butterworths, Boston, 1989.
3. Deckwer W. Bubble column reactors. John Wiley & Sons, 1991.
4. Wender I. Reactions of synthesis gas Fuel Process. Technol. 1996;48(3):189-297.
5. Hughmark GA. Holdup and mass transfer in bubble columns. Ind Eng Chem Proc Des Dev. 1967;6(2):21820.
6. Akita K, Yoshida F. Gas holdup and volumetric mass transfer coefficient in bubble columns effects of liquid properties. Ind Eng Chem Proc Des Dev. 1973;12(1):7680.
7. Hikita H, Kikukawa H. Liquid-phase mixing in bubble columns effect of liquid properties. Chem Eng J. 1974;8(3):191-7.
8. Kumar A, Degaleesan TE, Laddha GS, et al. Bubble swarm characteristics in bubble columns. Can J Chem Engg. 1976;54(5):503-8.
9. Hikita H, Asai S, Tanigawa S, et al. Gas hold up in bubble columns. Chem Eng J. 1980;20(1):59-67.
10. Deshpande NS, Joshi JB. Simultaneous measurements of gas and liquid phase velocities and gas hold-up using laser doppler velocimeter. Chem Eng Comm. 1997;162(1):151-68.
11. Chen W, Hasegawa T, Tsutsumi A, et al. Scale-up effects on the time-averaged and dynamic behaviour in bubble column reactors. Chem Eng Sci. 2001;56(21 22): 6149-55.
12. Besagni G, Inzoli F. Comprehensive experimental investigation of counter-current bubble column hydrodynamics Holdup flow regime transition, bubble size distributions and local flow properties. Chem Eng Sci. 2016;146:259 90.
13. Youssef AA, Dahhan MHA. Impact of internals on the gas holdup and bubble properties of a bubble column. Ind Eng Chem Res. 2009;48(17):8007-13.
14. Syeda SR, Reza MJ. Effect of surface tension gradient on gas hold-up enhancement in aqueous solutions of electrolytes. Chem Eng Res Des. 2011;89(12):2552-59.
15. Jana SK, Das SK. Effect of gas holdup enhancement using aqueous solutions of electrolyte in taper bubble column. Chem Xpress. 2015;8(1):42-47.
16. Jana SK, Biswas AB, Das SK. Gas holdup in tapered bubble column using pseudoplastic non-Newtonian liquids. Korean J Chem Eng. 2014;31(4):574-81.
17. Jana SK, Biswas AB, Das SK. Pressure drop in tapered bubble columns using non-Newtonian pseudoplastic liquid-experimental and ANN prediction. Can J Chem Eng. 2014;92(3):578-84
18. Jana SK, Biswas AB, Das SK. Gas holdup in tapered bubble column using pseudoplastic non-Newtonian liquids. Chem. Xpress. 2014;6:116-20.