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Studies on Hydrodynamics Behaviour of Extrenal Loop Airlift Reactor for two Phase System

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Abstract : Mixing is one of the important unit operations in chemical and allied industries. Airlift reactors are known to be efficient contactors for processes involving gases, liquids and solids[1]. Airlift reactors are mostly used in biological processes, aerobic waste water treatment, fermentation processes. Air-lift reactors are attractive for slow reactions since they consist of recycle streams that allow for larger residence time with a small reactor volume when compared to (slurry) bubble columns. In the present study experiments have been conducted on hydrodynamic behavior of two phase external loop airlift reactor of column diameter 100mm and height 1000mm. Gas hold-up characteristics for various electrolytes and solvents with various concentrations have been studied. Comparisons made on both electrolytes and solvents by graphically.
Keywords: external loop airlift reactor, electrolytes, solvents, gas holdup, pressure drop.

1 Introduction

1.1 Airlift Reactor

Airlift reactor is a bioreactor used primarily for mixing without mechanical agitation. This is achieved by gas sparging. Air-lift reactors are similar to bubble column reactors, but differ by the fact that they contain a draft tube. The draft tube is always on inner tube (this kind of airlift reactor is called an internal loop) or an external tube (this kind of airlift reactor is called an external loop) which improves circulation and oxygen transfer and equalizes shear forces in the reactor. Airlift reactors are attractive for slow reactions since they consist of recycle streams that allow for larger residence time within a small reactor volume when compared to (slurry) bubble columns. They are also attractive in processes where a certain degree of agitation is required without the use of mechanical stirrers due to the nature of reactants handled, such as the cultivation of biological organisms and wastewater treatment.

The most important part of any bioprocess is the bioreactor. In the fermentation industry gas-slurry bioreactors are mainly used for aerobic fermentation. These vessels include bubble columns with modified internals, pulsed bubble columns and airlft reactors(internal and external). Pneumatic reactors, in which all agitation is due to bubbling gas, are a relatively recent invention. Airlift reactors fall under the category of pneumatic reactors[2].

1.2 Types of Airlift Reactor

- Internal-loop air-lift reactor
- External-loop airlift reactor

1.3 Applications:

- Airlift reactors are widely used in the chemical and biochemical process industries as efficient contactors for mass and heat transfer[3].

- Their main advantages are simple mechanical design, low shear rate, high capacity, good mixing, absence of mechanical agitators and low cost. However, the airlift reactors are not flexible to accommodate variations of operating conditions e.g. a minimum liquid volume should be maintained for the reactor to complete.
- Airlift reactors also have additional advantage over bubble columns, because of the higher liquid overall velocity and the higher intensity of turbulence.

1.4 Scope of the Project:

The scope of the project is that experiments has been conducted on external loop airlift reactor to find out the pressure drop and gas hold-up behavior of various electrolytes and solvents with various concentrations and comparison has been made. Now-a-days most of the industries use various solvents and electrolytes for their manufacturing process; initially we know the hydrodynamics characteristics. It is very important and used for the design of the reactors.

2 Experimental Section:

A schematic of the external loop airlift reactor used in this study as shown in figure 3 and consists of acrylic column and a diameter of 100mm and height 1000mm with a supporting screen diameter of 0.8mm.The external loop airlift column has perforated plate gas sparger with 243holes of 1mm diameter on a triangular pitch placed at the base of the column. The down-comer and riser are connected via two horizontal acrylic tubes. The gas phase that is the compressed air is injected at the bottom of the column. Water, electrolytes and solvents are used as liquid phase. The experiment has to be conducted in room temperature. Gas hold-up is one of the important parameter of airlift reactors. Gas hold-up is measured by pressure difference in U-tube manometer. To measure the hydrodynamic properties such as gas hold-up and pressure drop by varying the superficial gas velocity. The materials used in the experiments are given below in table:

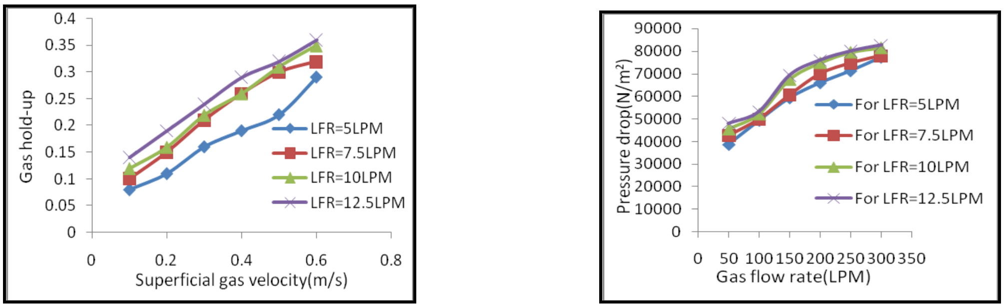
Table 1: Properties of the system

SYSTEM(vol%)	DENSITY(kg/m3)	Surface tension(x10^^{3},N/m)
Tap water	998.2	72.8
Nacl(5%)	1018.2	49.32
Nacl(10%)	1021.6	48.37
Acetic acid(5%)	1011.5	24.59
Acetic acid(10%)	1026	22.23
Methanol(0.25%)	997.7	72.1
Methanol(0.5%)	997.2	71.7
Metahnol(0.75%)	996.7	71.6
Ethanol(0.25%)	997.7	71.4
Ethanol(0.5%)	997.2	70.3
Ethanol(0.75%)	996.8	69.3

Propanol(0.25%)	997.7	71.5
Propanol(0.5%)	997.2	69.9
Propanol(0.75%)	996.7	65.1

3 Results and Discussion

3.1 Gashold-Up and Pressure Drop for Air- Water System:

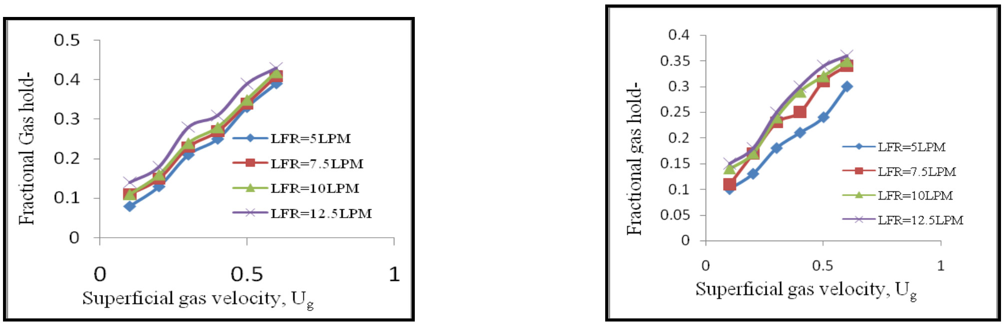


(a) **(b)**

Fig 1:Effect of gas hold-up and pressure drop with various superficial gas velocity with different liquid flow rates

From the figures 1 it can be observed that superficial gas velocity increases gas hold-up and pressure drop also increases with increasing liquid flow rates from 5 LPM to 12.5LPM.

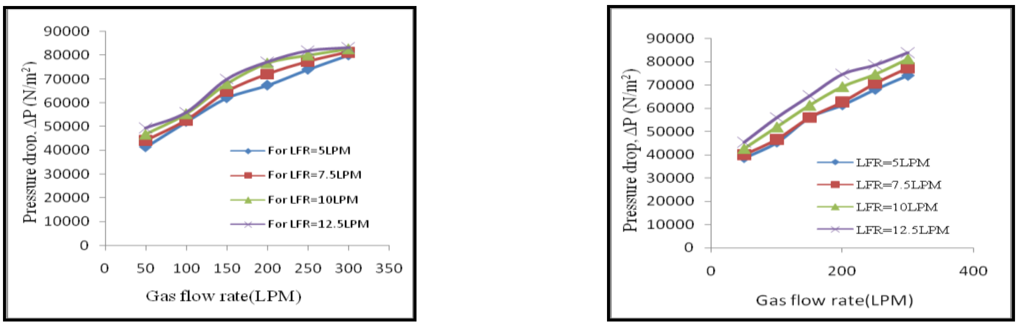
3.2 Gashold-Up and Pressure Drop for Electrolytes and Solvents by Varying Liquid Flow Rates:



(a) **(b)**

Fig: 2 Effect of superficial gas velocity on fractional gas hold-up by varying liquid flow rates(a) 5% Nacl (b) 0.25% Methanol

From the figure 2 it can be found that the fractional gas hold-up increases with increasing superficial gas velocity and increasing liquid flow rates.

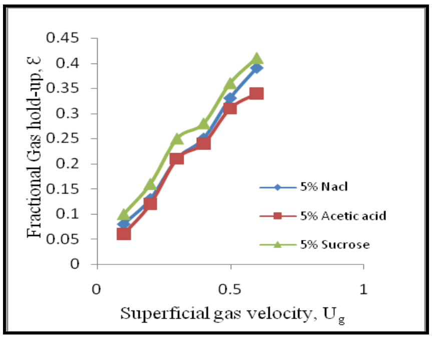


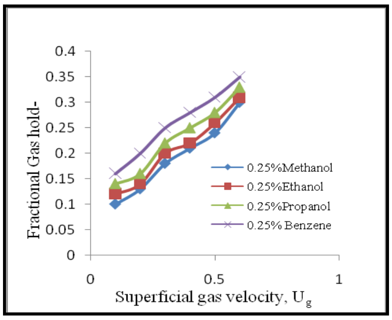
(a) **(b)**

Fig : 3 Effect of Gas flow rate on pressure drop by varying Liquid flow rates (a) 5%Nacl (b) 0.25% Methanol

From figure 3 it can be found that, for both electrolytes and solvents the pressure drop increases with increasing gas flow rate for different liquid flow rates.When we increasing the concentration of both electrolytes and solvents the same results have been noticed.

3.3 Gashold-Up and Pressure Drop for Electrolytes and Solvents by Varying Solutions:





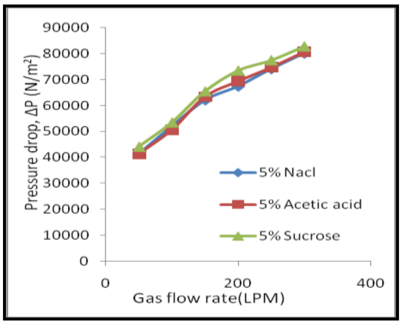
(a) (b)

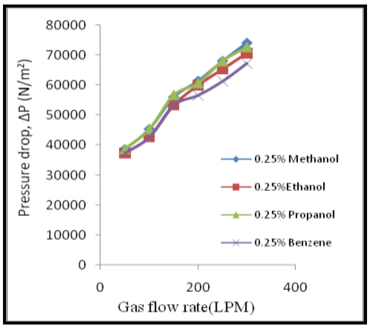
Fig: 4 Effect of superficial gas velocity on fractional gas hold-up by varying solutions at constant concentration (a)Electrolytes (b) Solvents

From the figure 4(a) it can be found that sucrose have higher gas hold-up compared to other electrolytes. Because sucrose has lower surface tension, so it yields higher gas hold-up.

From the figures 4(b) it can be observed that the gas hold increases with increasing the concentration of the solvents(0.25%,0.5% and 0.75%) and also increases with increasing the carbon atoms in the alcohol molecules. As the number of carbon atom increases the surface tension reduces it causes to create smaller bubbles. So gas hold-up rises[4] (Propanol with longest carbon chain has the maximum gas hold-up). The gas hold-up increased as:

Water < methanol< ethanol< propanol

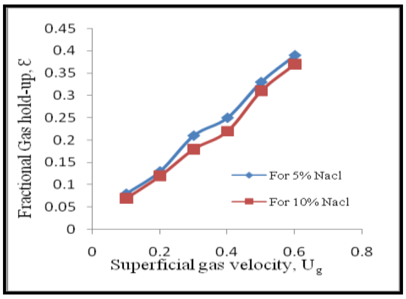


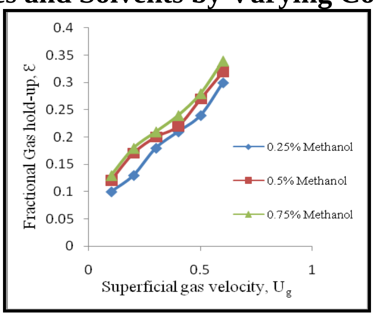


(a) (b)

Fig: 5Effect of Gas flow rate on pressure drop by varying solutions at constant concentration(a)Electrolytes (b)Solvents

3.4 Gashold-Up and Pressure Drop for Electrolytes and Solvents by Varying Concentrations:



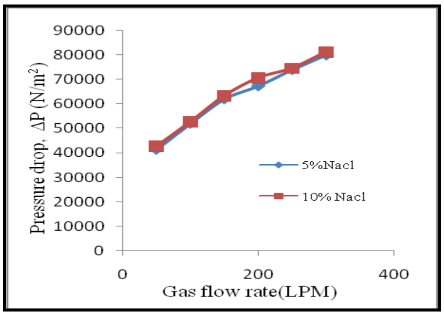


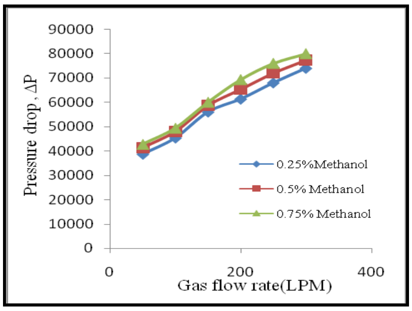
(a) (b)

Fig: 6 Effect of superficial gas velocity on fractional gas hold-up by varying concentration of solutions (a)Nacl (b) Methanol

From the figure 6(a) it can be seen that gas holdup increases with increasing the superficial gas velocity but decreases with increasing the electrolyte concentration for various liquid flow rates. Low electrolyte concentrations have no noticeable effect on the surface tension of the solution. However the ionic force in the liquid bulk reduces the bubble rise velocity and the bubble coalescence. As a result, the gas hold-up increase. For high electrolyte concentration, the interfacial tension increases, resulting in increased the bubble size and reduce gas hold-up[5].

From the figures 6(b) it can be observed that the gas hold increases with increasing the concentration of the solvents(0.25%,0.5% and 0.75%) When we increasing the concentration of the solvents the surface tension reduces it causes to create smaller bubbles. So gas hold-up rises. The alcohols with concentration of 0.75% have higher gas hold-up compared to those with concentration of 0.5% and 0.25%.





(a) (b)

Fig: 7 Effect of Gas flow rate on pressure drop by varying concentration of solutions (a) Nacl (b) Methanol

From the figure 7(a) and (b) it can be found that the pressure drop increases with increasing the concentration of electrolytes and solvents.

Conclusion:

In this study, experiments have been conducted in external loop airlift reactor by using various electrolytes and solvents as liquid phase. Gas hold-up and pressure drop studies were carried out. From this experiments it can be concluded that increasing the concentration of electrolytes the gas hold-up decreases and contrast when increasing the concentration of solvents the gas hold-up increases. For both electrolytes and solvents pressure drop increases with increasing the concentration as well as liquid flow rates.

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