Experimental Hydrodynamic Study in Two Phase Airlift Reactor and Effective Parameters on Column Gas Hold up

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Abstract: One of the major and modern equipments that play a vital role in chemical engineering is bubble column reactor for promoting gas-liquid contact. It is particularly suitable where higher interfacial areas between phases are desirable and where absolute temperature control is required. These are gaining more importance recently because of higher residence time, higher transfer rate per unit volume, minimum space requirement and less investment cost. Here we focus the effect of various parameters like superficial gas velocity ($V_G$), height to diameter ratio (H/D) and also the effect of different electrolytes like BaCl2, MgCl2, NaOH with various concentration on fractional Gas Hold up for air-water system. The sparger which used here in this column has 20 circle holes with 1 mm diameter as has shown in the picture.

Key words: Gas hold up, interfacial area, bubble coalescence, electrolyte

INTRODUCTION

Bubble column reactors are mostly used as a gas-liquid contactor and liquid aeration. Vertical sparged reactors are used in most chemical process like as coal liquefication, fisher tropsch synthesis and production of liquid fuels from biological materials and in some case for increasing interfacial areas between phases they fit internal stirrer in the column. These kinds of reactors are simple in construction and have low operation costs the major advantages of this column are the absence of moving parts, the ability to handle solid particles without plugging of parts, good heat and mass transfer coefficients in bubble column reactor, gas bubbles flow upward through a slower moving or stagnant liquid. The bubbles draw liquid in their wakes and thereby induce back mixing in the liquid. Bubble column reactors are used where higher interfacial areas between phases are desirable and also are used for slow reactions where the rate-limiting step is the liquid phase. Also bubble column reactors are used for polymer reactions like ethylene dimerisation. For the past two decades in hydrodynamic, heat and mass transfer in bubble column (Laari & Ikka Turunen 2003; Deckwer et al., 1980; Degeleesan et al., 1993; Hikita et al., 1980; Joshi & pandit, 1983).

Gas hold up is a key parameter in these reactors.supercial gas velocity ,height to diameter ratio and physical properties of gas and liquid phases are very important for determining dispersed phase hold up (Kirk & Othmer, 2004; Perry 1997; Sultana et al., 2002; Thorat & Joshi, 1998).

In this work the effect of superficial gas velocity,concentration of electrolyte and H/D ratio on gas hold up is studied.the experiments are carried out in a plexy glass column with the sparger at the bottom of it to predict gas hold up for electrolytes(NaOH,Ba Cl2,MgCl2) at different H/D ratio,different superficial gas velocity and various concentration of electrolytes.

Our main aim of this work is to increase the gas hold up.the rise in gas hold up will increase the interfacial area of contact between phases and also is will lead to higher residence time of gas bubbles in the continiuus phase.at least these will increase the mass and heat transfer coefficient.

Experimental:

The experimental set up is shown in figure below.the column is of 80 cm hight and 5mm thikness and 8cm ID. the bottom of the column is fitted with a sparger.the sparger is very vital as it is responsible to sparge the column.A compressore supplied the air needed for sparging the column.a rotameter of (0-100) lpm range is used to measure flow rate of air.the fractional gas hold up is measured by visual observation.

the initial hight of water, which is retained inside the column stagnantly, is measured air is bubbled from the bottom of the column.the final height is noted down.the change in height divided by the initial height gives the gas hold up.

The $\epsilon_g$ is measured for different H/D ratio of the column. the effect of the electrolyte addition on $\epsilon_g$ is also studied.the concentration of each electrolyte is (1%-2%-5%-10%).
RESULTS AND DISCUSSION

Effect of superficial gas velocity:

Superficial gas velocity is found to be a vital parameter which affects the gas hold up for this purpose. The superficial gas velocity was varied in the range of 3.32 cm/s to 13.27 cm/s for six times. The effect of gas velocity on gas hold up is shown in the figs. 2 and 3. From the graphs it could be seen that for an increase in $V_G$, gas hold up increase vigorously initially ($V_G$ up to ...). This is because of the accumulation of less number of gas bubbles which in turn causes the flow to be laminar in the continuous phase. Moreover, the frequency of coalescence which is the function of collision frequency and efficiency per collision is the most influencing parameter for analysing $\varepsilon_g$. This coalescence frequency between the gas bubbles would be less at lower $V_G$ than at higher $V_G$. Also the formation of protective film around the gas bubbles prevents the coalescence at lower $V_G$. But at higher gas velocity gas hold up increase slowly or doesn't show more deviation among them. This is because of the turbulence created by the higher flow rate.

Effect of electrolytes on $\varepsilon_g$:

The bubble coalescence results in the formation of more bubbles which causes more dispersed phase of bubble. This is due to the addition of electrolytes. This is verified by conducting experiments using electrolytes such as NaOH, MgCl₂, BaCl₂ of various concentration. The effect of addition of electrolytes increase gas hold up initially. But further electrolyte addition in excess concentration doesn't affect gas hold up considerably because of decrease in drag force. This causes the bubbles to coalesce very slowly. In the case of NaOH solution, the easy electrolysis of it contributes more free ions which are responsible for more bubble formation. The gas hold up increase with the addition of electrolyte in the following trend: MgCl₂ < BaCl₂ < NaOH.

The coalescence of bubbles generally occurs in two steps. First, the liquid drains from the space between the surfaces of two approaching bubbles until a certain minimum film thickness is reached in the following step.
the film ruptures and bubble coalesces. the rate of coalescence will therefore depend on the rate of drainage of the liquid which thereby depends on the thickness and the strength of the remaining film. In a pure liquid the interface of the approaching bubbles are free to move along and the rate of thinning is controlled only by the inertia of the liquid pushed away by the film while ionic forces between the ionic species of a film and water molecule makes them more cohesive. this increases the strength of the film against the bubble coalescence and decrease s the bubble size and the overall results of the two effects are a higher gas hold up as compared to that of other systems.

**Fig. 5:** Effect of various concentration of NaOH solution on gas hold up

**Fig. 6:** Effect of different solution on gas hold up.

**Effect of H/D ratio:**

The H/D ratio is also an important parameter for the design of the bubble column. The effect of H/D ratio is shown in fig... as the graph shows the increase in H/D ratio decrease the gas hold up gradually. At higher H/D the gravitational force exerted by continuous phase on bubbles would be dominant over the buoyancy force exerted by the bubbles. this condition decreases the frequency of coalescence which in turn makes $\varepsilon_g$ to be less at higher H/D ratio.

**Fig. 3:** Effect of superficial gas velocity on gas hold up

**Fig. 5:** Effect of various concentration of NaOH solution on gas hold up

**Conclusions:**

1) The fractional gas hold up increase with the increase in gas velocity.
2) The gas hold up increase for electrolytic solution when compared with pure water.
3) The addition of electrolyte increase gas hold up initially but further addition of electrolyte of excess concentration doesn’t effect the gas hold up.
4) The gas hold up increases with the addition of electrolyte in the following trend: MgCl2 < BaCl2 < NaOH.
5) The increase in H/D ratio decrease the gas hold up gradually.
REFERENCES