OPTICAL MEASUREMENTS OF LOCAL BUBBLE CHARACTERISTICS IN GAS-LIQUID STIRRED TANK EQUIPPED WITH AXIAL IMPELLERS

Baranivignesh Prakash, Milinkumar shah, Vishnu Pareek, and Ranjeet Utikar*
Department of Chemical Engineering, Curtin University
GPO Box U1987, Perth, Western Australia, 6845 Australia
*r.utikar@curtin.edu.au

Abstract

Local bubble characteristics(gas hold up, bubble size distribution and bubble rise velocity) in a gas-liquid stirred tank at industrial relevant operating conditions(impeller tip speed and gas superficial velocity) are presented here. Measurements were carried out in 0.45m tank using optical probe at all feasible axial and radial positions by varying impeller type and operating conditions. Operating conditions for different type of impellers are suggested for scale-up and optmisation based on the collected experimental data sets.

Keywords

Gas-liquid stirred tank, optical probe, local bubble characteristics, axial impellers

Introduction

The local hydrodynamic characteristics of the bubbles in gas-liquid stirred tank is one of the key parameters which governs reaction kinetics, heat and mass transfer. Rigorous studies and re-assessment of existing knowledge on this bubble data is essential for selection of impeller to improve mixing performance and scalability of stirred tanks. Several studies have previously reported measurement of gas-liquid hydrodynamics using axial and radial impellers in lab scale. While abundant data is available on liquid phase data up to industrial scale; data on gas phase (bubble characteristics) is sparse. Only a few previous studies have reported gas holdup values or bubble size at industrially relevant operating conditions (Thatte, Ghadge et al. 2004, Montante, Horn et al. 2008). Recently Mueller (2009), Lee and Dudukovic (2014) have used optical probe to measure local bubble characteristics of flow generated by axial flow impellers at lab scale.

This paper reports the gas phase hydrodynamic characteristics of gas-liquid stirred tank equipped with axial impellers at industrial relevant conditions using optical probe. The data is useful for selection of impellers and operating conditions to achieve optimized mixing and scalability as well as validate computational fluid dynamics models.

Experimental methods

Experimental set up (*Figure.1*) and operating conditions (*Table.1*) for the current work are shown here.

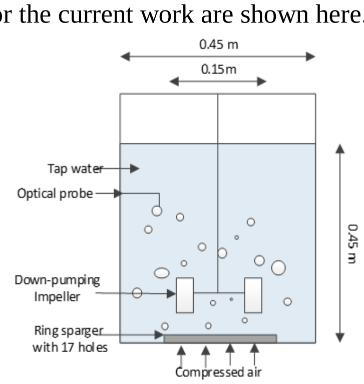

Figure.1.Experimental setup

Table.1. Probe measurement positions and operating conditions

Axial positions	IP: impeller plane-150mm from tank bottom Above-IP: 100mm above IP Below-IP:100mm below IP
Radial positions	170,150,130,110,90 and 50mm from tank wall towards impeller shaft at above IP 110,90,70 and 50mm at IP and below-IP
Tip speed	3, 4, 5 and 6m/s
Gas superficial velocity	1.05, 1.47 and 2.10cm/s

Results and discussion

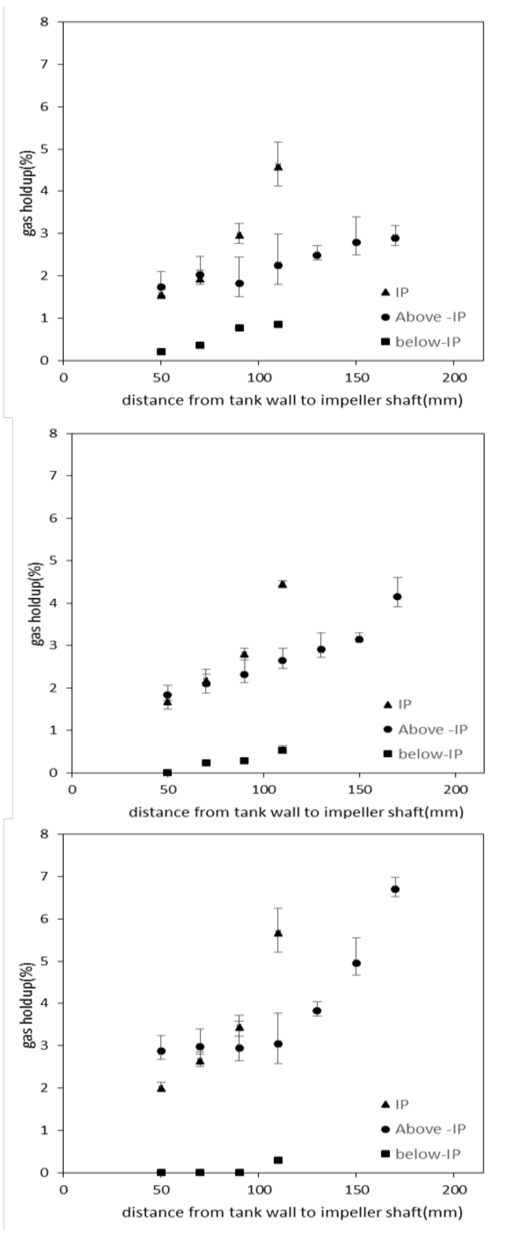

Figure.2. Effect of gas superficial velocity on gas holdup with tip speed of 3m/s a) 1.05cm/s b) 1.47cm/s and c) 2.10cm/s

Figure.2 shows the gas holdup profiles collected at various gas flowrates with fixed impeller speed of 3m/s. At low gas flow rate of 1.05cm/s (*a*), holdup value was observed to be high below-IP because less air is sparged into the system and down pumping impeller effect dominates sparger effect. At 1.47cm/s (*b*), comparatively more air is sparged into the system which leads sparger effect to dominate over impeller effect. As a result, lot of bubbles escapes via impeller blade spacing and less number of bubbles are pumped down which decreases holdup value below-IP significantly. When superficial velocity is increased further to 2.10cm/s (*c*), holdup value reaches zero since there is no bubble captured below IP zone. Thus increasing gas superficial velocity with fixed impeller tip speed results in decreased holdup values below-IP. Whereas, increasing flowrate leads to increase in holdup at IP and above-IP but at the same time the bubble size and bubble rise velocity also increases due to coalescence effect which leads to reduced interfacial mass transfer which is not desired for most industrial cases.

For the down-pumping impeller used for current experiment, desired gas holdup and bubble sizes were obtained if it is operated at 3m/s and at the gas superficial velocity of 1.05cm/s. If the gas dispersion system is demanding more gas superficial velocity, then impeller tip speed should be increased accordingly to achieve the same holdup values.

Closure

Measurement of bubble properties using optical probe for gas-liquid flow generated by axial flow impeller is reported. Experiments are conducted in a 450 mm tank at industrial operating conditions. Important data including bubble size distribution, bubble rise velocity, and gas holdup is measured and will be reported in full paper.

References

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