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The Effect of Temperature and Gas/Liquid Ratio on CO₂ Removal Performance by Water-Based Nano-Bubble Process

Jirayu Kanlaya^{1*}, Navadol Laosiripojana¹, Nutthachai Pongprasert², Varit Srilaong²

¹The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok 10140

²School of Bioresources and Technology (Bangkhuntien Campus), King Mongkut's University of Technology Thonburi, 49 Thakham, Bangkhuntien, Bangkok 10150, Thailand

* Correspondence: navadol_l@jgsee.kmutt.ac.th

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ABSTRACT

The Nano-bubble process is a novel effective technology for CO₂ removal. Its advantages are their high specific area and stagnation in the liquid phase, which increase the gas dissolution. This study proposes the application of system using swirling jet flow method for the CO₂ absorption from mixture gas consisting of 60%v/v CO₂ and 40%v/v N₂ at 1000 ml/min using water as an absorbent. The effects of water temperature and gas/liquid ratio were studied. The results indicate that CO₂ outlet concentrations were in the range of 3.1%-8.6% at gas/liquid ratio of 0.05-0.2. The CO₂ outlet concentrations reduced from 3% to 2% at 20 l/min of water. The CO₂ removal performance could be significantly improved because the decreasing of the temperature increased the viscosity of liquid and residence time of CO₂ bubbles in the column.

Keywords: Nano-bubble; CO₂ Removal; Gas Dissolution; CO₂ Absorption; Bubble Column

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THE EFFECT OF TEMPERATURE AND GAS/LIQUID RATIO ON CO₂ REMOVAL PERFORMANCE BY WATER- BASED NANO-BUBBLE PROCESS

Jirayu Kanlaya^{1*}, Navadol Laosiripojana¹, Nutthachai Pongprasert², Varit Srilaong²

¹The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok 10140

²School of Bioresources and Technology (Bangkhuntien Campus), King Mongkut's University of Technology Thonburi, 49 Thakham, Bangkhuntien, Bangkok 10150, Thailand

*navadol_1@jgsee.kmutt.ac.th

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Abstract

The Nano-bubble process is a novel effective technology for CO₂ removal. Its advantages are their high specific area and stagnation in the liquid phase, which increase the gas dissolution. This study proposes the application of system using swirling jet flow method for the CO₂ absorption from mixture gas consisting of 60%v/v CO₂ and 40%v/v N₂ at 1000 ml/min using water as an absorbent. The effects of water temperature and gas/liquid ratio were studied. The results indicate that CO₂ outlet concentrations were in the range of 3.1%-8.6% at gas/liquid ratio of 0.05-0.2 with a constant inflow rate of gas. When temperature was decreased (from 27.5 to 5°C), CO₂ outlet concentrations reduced from 3% to 2% at 20 l/min of water. The CO₂ removal performance could be significantly improved because the decreasing of the temperature increased the viscosity of liquid and residence time of CO₂ bubbles in the column.

Keywords: Nano-bubble, CO₂ Removal, Gas Dissolution, CO₂ Absorption, Bubble Column

1. Introduction

The world's energy demand is increasing rapidly both households and industrial. Among the fuel resource used in power production consists mainly of hydrocarbon and carbon dioxide (CO₂). Generally, before refining utilizing fossil fuels, CO₂ has to be removed in order to protect equipment from corrosion. There are many methods of removal of CO₂. The mainly methods are chemical absorption and gas filtration. Moreover, its regeneration energy requirement are high and it's easy to corrosion [1]. Recently, the study of Nano-bubble process is a novel effective technology for CO₂ removal. The aims of this study are to study the effects of water temperature and gas/liquid ratio on CO₂ absorption.

2. Literature Review

The Navaza et al., 2009 [2] found that increased the MDEA concentrations increased the total amount of CO₂ absorption but it had no influence on the gas absorption rate. On the other hand, the

increased gas flow rate influence on the gas absorption. Then, water has been used as an absorbent called water scrubbing. The solubility of CO₂ in water is much higher than CH₄ and H₂S. The CH₄ purity can achieve 80–99% from raw biogas. Karamah et al., 2010 [3] studied the micro-bubble ozonation in a bubble column with water as liquid phase. The authors found that with the higher the liquid and gas flow rate the volumetric mass transfer coefficient is higher.

3. Research Methods

The experimental set-up consists of a cylindrical vertical acrylic column. The size of the column is 0.3 m x 2 m. The water with gas bubbles were discharged from the swirl-type bubble generator to generate small gas bubbles then water with the small gas bubbles went to the bottom of the column. The bubble generator produced average bubble size 63.976 µm. This column was opened at the outlet gas stream. The mixture gas consists of consisting of 60%v/v CO₂ and 40%v/v N₂

at 1000 ml/min were used. Water flow rate at 15 °C was adjusted by valve from 5 to 20 l/min. Gas/liquid ratio is fixed gas flow rate at 1000 ml/min. Start, water was filled into the column at appropriate liquid level 1.8 m, then open the gas flow inlet. The temperature was controlled by cooling in the range 5-27.5°C. All the experiment were performed at 40 minutes.

4. Discussion and Conclusion

The different experiment of CO₂ absorption in water were carried out by varying the gas/liquid ratio from 0.05-0.2 (Figure 1).

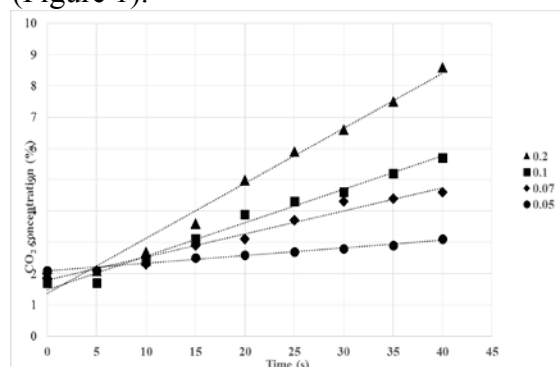


Figure 1. Effect of gas/liquid ratio varying from 0.05 to 0.2 on CO₂ outlet concentration at 15°C

The results show that at 15°C of water, outlet CO₂ concentration were 3.1%, 4.6%, 5.7%, and 8.1% at gas/liquid ratio 0.05, 0.07, 0.1 and 0.2, respectively. Decreasing gas/liquid at lower ratio resulted in higher gas absorption. This is because of the mass transfer rate between gas and liquid [4]. For the effect of the water temperature varying at 5, 15, 27.5°C as shown in Figure 2, the maximum outlet CO₂ concentration was 2.8, 3.1, and 3.5%, respectively. This behavior is due to the fact that reducing viscosity of liquid causes higher gas holdup in the column [5]. Besides, it was observed that the percentages of outlet concentration increases with time.

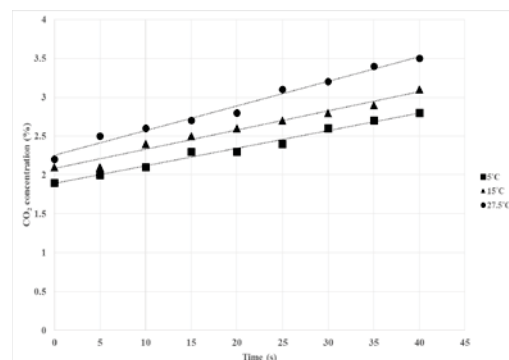


Figure 2. Effect of temperature from 5 to 27.5°C at gas/liquid ratio of 0.05 on CO₂ outlet concentration

Since feed water contains small amount of CO₂, high CO₂ content could be initially absorbed into water as the driving force is the highest value at the starting point of the process.

5. References

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