

**VERTICAL TWO-PHASE FLOW UNDER THE INFLUENCE OF  
DIAMETER SIZES AND BENZALKONIUM CHLORIDE SURFACTANTS**

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**ABSTRACT**

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or slug velocity/ Reynolds number

The effects of pipe diameter size and surfactant additive on the two-phase gas/liquid flows regimes, pressure gradients, bubble sizes and velocities were investigated. Experiment were carried out using three vertical transparent tubes with inner diameters of 10.75, 19, and 53.15 mm and the length of 3 m. Water, octylbenzyltrimethylammonium chloride solutions ( $C_8H_{17}-C_9H_{13}NCl$ ) and hexadecylbenzyltrimethylammonium chloride solution ( $C_{16}H_{33}-C_9H_{13}NCl$ ) were used as the working fluids. The boundaries of the flow regimes for a given  $Re_{water}$  increase nonlinearly with increasing tube diameter. Adding the surfactant lowers the critical air Reynolds numbers for the bubble-slug flow and the slug flow regimes. The friction factors or the dimensionless pressure gradients are distinctively different depending on diameter and type of liquids used (water, ( $C_8H_{17}-C_9H_{13}NCl$ ) and ( $C_{16}H_{33}-C_9H_{13}NCl$ )). The normalized bubble or slug dimension for pipe diameter of 10.75 mm is always greater than those of the pipe diameter of 19 mm and 53.15 mm at any  $Re_{air}$  and  $Re_{water}$ . The normalized bubble or slug dimension for pure water is greater than those of ( $C_8H_{17}-C_9H_{13}NCl$ ) solution and ( $C_{16}H_{33}-C_9H_{13}NCl$ ) solution. The normalized bubble and slug velocities of pipe diameter 10.75 are always greater than those of pipe diameters of 19 mm and 53.15 mm. The normalized bubble and slug velocity for pure water is lower than those of ( $C_8H_{17}-C_9H_{13}NCl$ ) solution and ( $C_{16}H_{33}-C_9H_{13}NCl$ ) solution due to surface tension effect.

## บทคัดย่อ

ศุภชัย ชูธงชัย : ขอบเขตของการไหลในแนวตั้งแบบสองเฟส ภายใต้อิทธิพลของความแตกต่างของขนาดท่อ และสารลดแรงตึงผิว benzalkonium chloride (Vertical Two-Phase Flow under the Influence of Diameter Sizes and Benzalkonium Chloride Surfactants)  
 อ.ที่ปรึกษา : รศ.ดร. อนุวัฒน์ ศิริวัฒน์ และ ศ. เจมส์ โอวิลค์ 533 หน้า

อิทธิพลของขนาดท่อและสารลดแรงตึงผิวที่เติมลงไปในระบบการไหลแบบสองเฟสในท่อแนวตั้ง ได้ถูกนำมาศึกษาหาความแตกต่างของ ความดัน ขนาดของฟองอากาศ และความเร็วของฟองอากาศ อุปรณ์ในการทดลองประกอบด้วยท่อใส 3 ขนาด (ขนาด 10.75 มิลลิเมตร, ขนาด 19 มิลลิเมตร และ ขนาด 53.15 มิลลิเมตร) ความยาวของท่อทั้งสาม คือ 3 เมตร น้ำ, สารละลาย octylbenzyl dimethyl ammonium chloride และ สารละลาย hexadecylbenzyl dimethyl ammonium chloride ถูกใช้เป็นของไหลในการศึกษา ขอบเขตการไหลของน้ำเพิ่มขึ้นเมื่อเพิ่มขนาดของท่อ และเมื่อใส่สารลดแรงตึงผิว ขอบเขตการไหลจะลดลงในช่วง การไหลแบบฟองอากาศและแบบกระสุน เมื่อความดันถูก normalized แล้วก็จะสามารถนำมาเปรียบเทียบอิทธิพลของขนาดท่อและสารลดแรงตึงผิวได้ โดยจะพบว่าความดันที่แตกต่างกันนั้น เป็นเพราะ ขนาดของฟองอากาศ, Eotvos number และ property parameter,  $Y$  เมื่อทำการ normalized ขนาดของฟองอากาศแล้วจะพบว่า ขนาดของฟองอากาศของน้ำจะใหญ่กว่าของสารลดแรงตึงผิว ( $C_8H_{17}-C_9H_{13}NCl$ ) และ ( $C_{16}H_{33}-C_9H_{13}NCl$ ) เพราะว่สารลดแรงตึงผิวสามารถชะลอการรวมตัวของฟองอากาศได้ เมื่อ normalized ความเร็วของฟองอากาศจะพบว่าความเร็วของฟองอากาศในท่อขนาด 10.75 มิลลิเมตรจะเร็วกว่าท่อ 19 มิลลิเมตร และท่อ 53.15 มิลลิเมตร เสมอ และพบอีกว่า ความเร็วฟองอากาศของน้ำจะช้ากว่าความเร็วฟองอากาศของ สารลดแรงตึงผิว ( $C_8H_{17}-C_9H_{13}NCl$ ) และ ( $C_{16}H_{33}-C_9H_{13}NCl$ )

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