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ABSTRACT

In process industries, the measurement of void fraction is considerably important for sustainable operations. It largely affects the mass flow rate of gas and liquid in a two-phase flow. The erroneous calculation of void fraction is inevitably be the cause of many industrial accidents such as loss of coolant accidents in nuclear reactor, sweet corrosions in sub-sea oil and gas pipelines and an in-efficient process control of chemical plants. The customary approach for two-phase flow measurement separates the two-phases first and then measures the mixture as individual components. These methods are not favorable as they may result in the disruption of incessant industrial processes. Due to these limitations, a non-invasive, experimental study was conducted by using Electrical Capacitance Tomography (ECT) technique and differential pressure (ΔP) technique on a co-current vertical gas-liquid flow in a bubble column. A series of experiments were performed by regulating the flow rates of air and deionized water in the co-current bubble column to investigate flow regime, void fraction and pressure drop etc. The flow characteristics were physically investigated by using visual instruments. A bubble flow regime map was developed for air superficial velocity range of 0.00218 – 0.03 m/sec and water superficial velocity range of 0.00425 – 0.034 m/sec. It also classified the gas-liquid flow in a bubble column as discrete, dispersed and coalesced bubble flow regime under the stipulated experimental conditions. The raw data obtained from ECT images used for calculating void fraction were analysed by using distribution models and simulations using COMSOL. The comparison of simulation results with experimental data shows an average percentage deviation of $\pm$ 20%. The estimation of void fraction in a bubble column via differential pressure method shows the influence of superficial gas velocity on void fraction as a linear function which agrees with the void fraction obtained from ECT measurements. Finally, the experimental data of bubble sizes and void fraction was also compared with the precedent correlations which generally show a good conformity with the results.

ABSTRAK

Di dalam industri proses, pengukuran *'void fraction'* sangat penting untuk operasi-operasi yang berterusan. Ianya memberikan kesan yang besar pada kadar aliran gas dan cecair di dalam aliran dua-fasa. Keralatan di dalam pengiraan *'void fraction'* menjadi penyebab kepada berlakunya kemalangan industri seperti kehilangan bahan penyejuk di dalam reaktor nuklear, pengaratan atau penghakisan yang berlaku secara perlahan-lahan pada rangkaian paip minyak dan gas di lautan dalam serta ketidakcekapan pada kawalan proses di kilang bahan kimia. Pendekatan secara biasa untuk pengukuran aliran gas-cecair adalah dengan memisahkan dua fasa pertama, kemudian ukur campuran tersebut secara komponen individu. Kaedah ini kurang sesuai kerana hasilnya boleh menyebabkan proses industri terganggunya secara berterusan. Disebabkan oleh kerana ianya terbatas, satu kajian secara eksperimen dilakukan dengan menggunakan teknik *'Electrical Capacitance Tomography (ECT)'* dan beza tekanan pada *'co-current vertical gas-liquid flow'* dalam ruangan gelembung udara. Beberapa percubaan telah dilakukan dengan menetapkan kadar aliran udara dan air yang telah deionisasi. Ciri-ciri aliran tersebut diselidiki dengan menggunakan instrumen visual. Pemetaan aliran gelembung udara dibentuk bagi julat halaju ketara pada 0.00218 hingga 0.03 m/saat dan julat halaju ketara air pada 0.00425 hingga 0.034 m/saat. Aliran gas-cecair ini juga diklasifikasikan sebagai *'discrete'*, tersebar dan gabungan gelembung udara yang mengalir di bawah keadaan percubaan yang ditetapkan. Data yang diperolehi secara kasar dari imej-imej ECT digunakan untuk pengiraan '*void* fraction' yang telah dianalisa dengan menggunakan model-model pengagihan dan simulasi menggunakan perisian COMSOL. Perbandingan keputusan secara simulasi dengan keputusan eksperimen menunjukkan purata peratusan sisihan sebanyak ±20%. Anggaran *'void fraction'* di dalam ruangan gelembung udara melalui kaedah beza tekanan menunjukkan pengaruh halaju gas yang ketara pada *'void fraction'* sebagai fungsi linear yang mana bersamaan dengan *'void fraction'* yang diperolehi dari pengukuran ECT. Akhir sekali, data eksperimen saiz gelembung udara dan *'void fraction'* dibandingkan dengan hubungan sediada yang pada amnya menunjukkan kesesuaian yang baik dengan keputusan eksperimen.