

ABSTRACT

Two-phase gas-liquid flow monitoring is important because phase distribution changes can affect flow stability and operational safety. This study developed an eight-electrode Electrical Resistance Tomography (ERT) prototype for laboratory-scale *in situ* two-phase flow measurement. The system consisted of an AD9833 signal generator, an Improved Howland Current Source, four ADG1408 multiplexers, a signal-conditioning circuit, a rectifier-filter circuit, an ADS1115 analog-to-digital converter, and an Arduino Mega controller. An adjacent measurement strategy was used to acquire 40 boundary-voltage data points in each *frame*.

System performance was evaluated through functional testing, single-resistor testing, calibration, static phantom testing, and dynamic air-water testing. The single-resistor test showed a linear response in the 10 k Ω to 97.4 k Ω range, with seven of eight measurement points having absolute errors below 5%. Static phantom reconstruction using Gauss-Newton Tikhonov and GREIT successfully indicated anomaly directions corresponding to positions E0, E2, E4, and E6. The reconstruction repeatability was high, with Intraclass Correlation Coefficient values ranging from 0.9940 to 0.9958. However, Position Error and IoU50 results indicated limited accuracy in reconstructing the anomaly shape and radial position.

During dynamic testing, the system detected temporal gas-phase distribution changes through boundary-voltage variations and reconstructed images. The ERT-based relative *void fraction* estimate ranged from 0.054 to 0.236, with an average of 0.131. The fluctuation pattern, reconstructed images, and visual observation indicated bubbly-flow characteristics. The prototype demonstrates initial feasibility for detecting conductivity changes and relative gas-phase distribution in laboratory-scale two-phase flow.

Keywords: Electrical Resistance Tomography, two-phase flow, image reconstruction, relative *void fraction*, *bubbly flow*.

INTISARI

Pemantauan aliran dua fase gas-cair penting dilakukan karena perubahan distribusi fase dapat memengaruhi kestabilan aliran dan keselamatan operasional. Penelitian ini bertujuan untuk merancang prototipe Electrical Resistance Tomography (ERT) delapan elektroda untuk pengukuran aliran dua fase secara *in situ* pada skala laboratorium. Sistem yang dikembangkan terdiri atas pembangkit sinyal AD9833, sumber arus Improved Howland Current Source, empat *multiplexer* ADG1408, rangkaian pengkondisi sinyal, rangkaian penyearah dan filter, *analog-to-digital converter* ADS1115, serta Arduino Mega sebagai pengendali. Strategi pengukuran *adjacent* digunakan untuk menghasilkan 40 data tegangan batas pada setiap *frame*.

Pengujian dilakukan melalui pengujian fungsional, pengujian resistor tunggal, kalibrasi, pengujian phantom statis, dan pengujian dinamis air-udara. Pengujian resistor tunggal menunjukkan *respons* linear pada rentang resistansi 10 k Ω hingga 97,4 k Ω , dengan tujuh dari delapan titik pengujian menghasilkan error absolut di bawah 5%. Rekonstruksi phantom statis menggunakan metode Gauss-Newton Tikhonov dan GREIT menunjukkan arah anomali yang sesuai dengan posisi aktual pada E0, E2, E4, dan E6. Nilai Intraclass Correlation Coefficient sebesar 0,9940 hingga 0,9958 menunjukkan repeatabilitas rekonstruksi yang tinggi. Namun, nilai Position Error dan IoU50 menunjukkan bahwa bentuk anomali belum direkonstruksi secara presisi.

Pada pengujian dinamis, sistem mampu mendeteksi perubahan distribusi fase gas melalui perubahan tegangan batas dan citra rekonstruksi. Estimasi *void fraction* relatif berbasis ERT berada pada rentang 0,054 hingga 0,236 dengan rata-rata 0,131. Hasil tersebut, bersama pengamatan visual, mengindikasikan karakter *bubbly flow*. Prototipe menunjukkan kelayakan awal untuk mendeteksi perubahan konduktivitas dan distribusi relatif fase gas pada aliran dua fase skala laboratorium.

Kata kunci: Electrical Resistance Tomography, aliran dua fase, rekonstruksi citra, *void fraction* relatif, *bubbly flow*.