World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:18, No:11, 2024

Design and Testing of Electrical Capacitance Tomography Sensors for Oil Pipeline Monitoring

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Abstract : Electrical capacitance tomography (ECT) is a valuable, non-invasive technique used to monitor multiphase flow processes, especially within industrial pipelines. This study focuses on the design, testing, and performance comparison of ECT sensors configured with 8, 12, and 16 electrodes, aiming to evaluate their effectiveness in imaging accuracy, resolution, and sensitivity. Each sensor configuration was designed to capture the spatial permittivity distribution within a pipeline cross-section, enabling visualization of phase distribution and flow characteristics such as oil and water interactions. The sensor designs were implemented and tested in closed pipes to assess their response to varying flow regimes. Capacitance data collected from each electrode configuration were reconstructed into cross-sectional images, enabling a comparison of image resolution, noise levels, and computational demands. Results indicate that the 16-electrode configuration yields higher image resolution and sensitivity to phase boundaries compared to the 8- and 12-electrode setups, making it more suitable for complex flow visualization. However, the 8 and 12-electrode sensors demonstrated advantages in processing speed and lower computational requirements. This comparative analysis provides critical insights into optimizing ECT sensor design based on specific industrial requirements, from high-resolution imaging to real-time monitoring needs.

Keywords : capacitance tomography, modeling, simulation, electrode, permittivity, fluid dynamics, imaging sensitivity measurement
Conference Title : ICECECE 2024 : International Conference on Electrical, Computer, Electronics and Communication Engineering
Conference Location : Paris, France
Conference Dates : November 18-19, 2024