Adaptive Electrical Capacitance Volume Tomography for Hot Unit Applications

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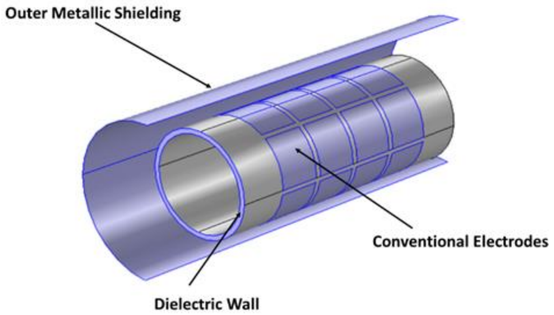
Adaptive Electrical Capacitance Volume Tomography

Motivation and Background

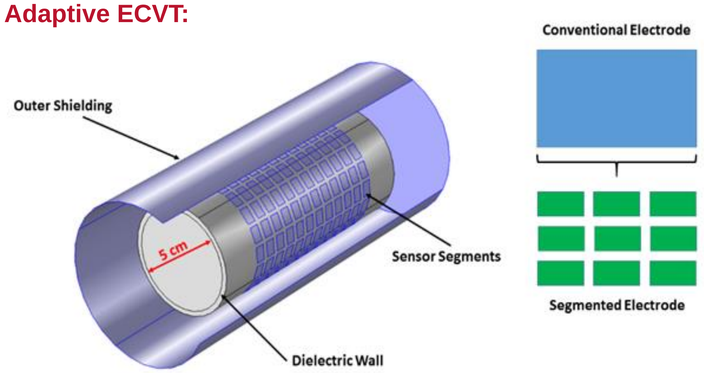
- Adaptive Electrical Capacitance Volume Tomography (AECVT) is a newly developed technology that can provide 3-D imaging of multiphase flow behavior in real-time.
- AECVT employs reconfigurable synthetic plates composed of many smaller plates (segments) while maintaining the minimum area for given signal-to-noise ratio (SNR) and acquisition speed requirements.
- Synthetic plate formation is possible through advancements in the data acquisition system technology that enabled rapid separation in activation sources and combination of aggregated response from each synthetic plate segment.
- AECVT provides low profile sensors, fast imaging speed and scalability to different section sizes, low operating cost, and safety.
- The flexibility of AECVT sensors enable them to be designed around virtually any geometry, rendering them suitable to be used for measurement of solid flows in exit and inlet regions, for example.

Basic Principle

Conventional ECVT:

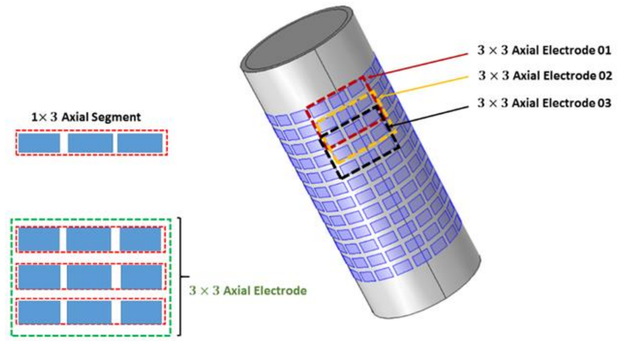


Adaptive ECVT:

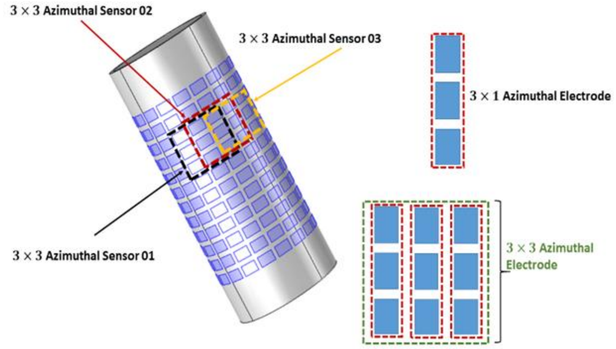


Reconfigurable Synthetic Electrodes

Example 1: Axial synthetic electrode partition

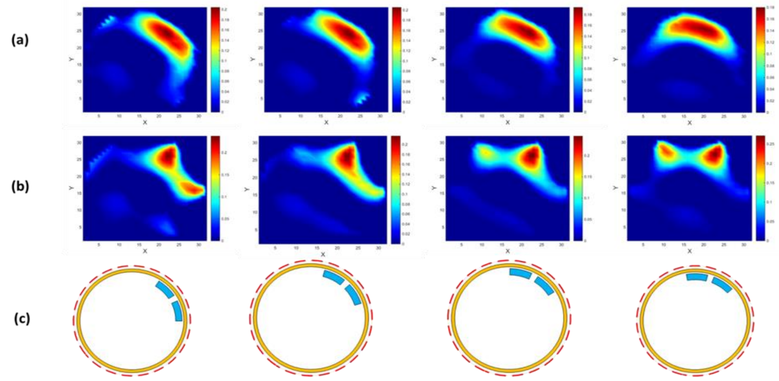


Example 2: Azimuthal synthetic electrode partition



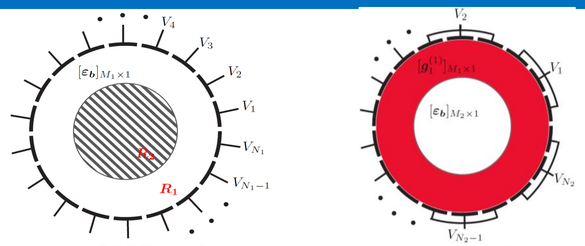
- **Many other electrode partitions are also possible.**

Performance comparison (example)



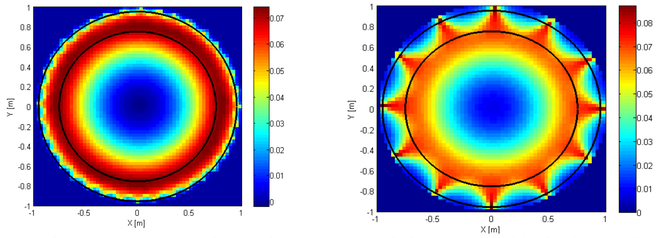
(a) AECVT and (b) conventional ECT images of an arc-shaped object shown in (c) at different locations in the peripheral region of the imaging domain.

Spatial-Adaptive Reconstruction Technique (SART)



Basic, two-step SART: (a) Step 1, where acquisition mode 1 is used to image the periphery region indicated in white color. (b) Step 2, where acquisition mode 2 is used to image the center region in white color using the reconstruction results of Step 1 in red color as input (a priori) data. 3-D reconstruction and multiple steps, involving more than two spatial regions, can also be employed.

Reconstruction results



Imaging of a ring-shaped object, located at r=0.85m and with thickness is 0.2m, with 36 capacitor plate segments, where the plates are placed around in a 1 m radius circle around the imaging domain with 2^0 separation between each plate. Left: Simulation setup for the same ring object with 12 synthetic plates composed of 3 segments each. (c) SART Image reconstruction result. Right: Conventional mage reconstruction result with artifacts.

Conclusions

- Segmenting capacitance plates and combining them with enabled reconfigurability for synthetic plate formations in AECVT has enabled higher resolution.
- A data acquisition design was developed and also verified.
- The capacitive response of smaller capacitance segments was also tested at high temperatures to demonstrate the feasibility of AECVT technology for high temperature applications.
- A mass flow model was developed successfully to measure solid-mass circulation rate in a CFB.

Acknowledgment

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- Q. Marashdeh, F. L. Teixeira, and L.-S. Fan, "Adaptive electrical capacitance volume tomography," *IEEE Sensors Journal*, pp. 1253-1259, 2014.
- Z. Zeeshan, F. L. Teixeira, and Q. Marashdeh, "Sensitivity map computation in adaptive electrical capacitance volume tomography with multielectrode excitations," *Electronics Letters*, pp. 334-336, 2015.