Estimation Of Phantom Vortex Size For Liquid Gas Separation Using Electrical Tomography

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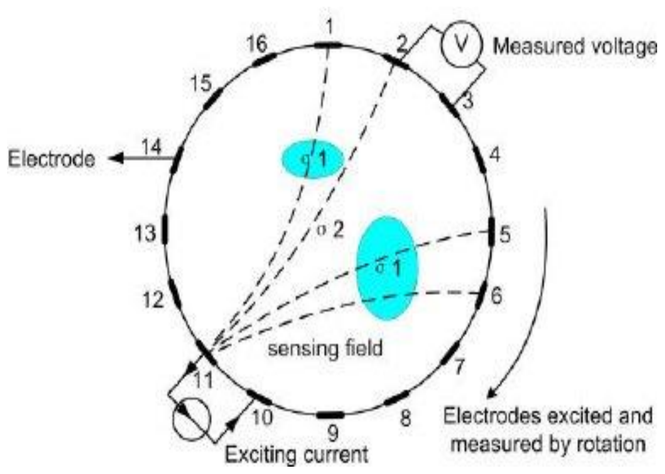
TOMOCON
Smart Tomographic Sensors for Advanced Industrial Process Control

Introduction

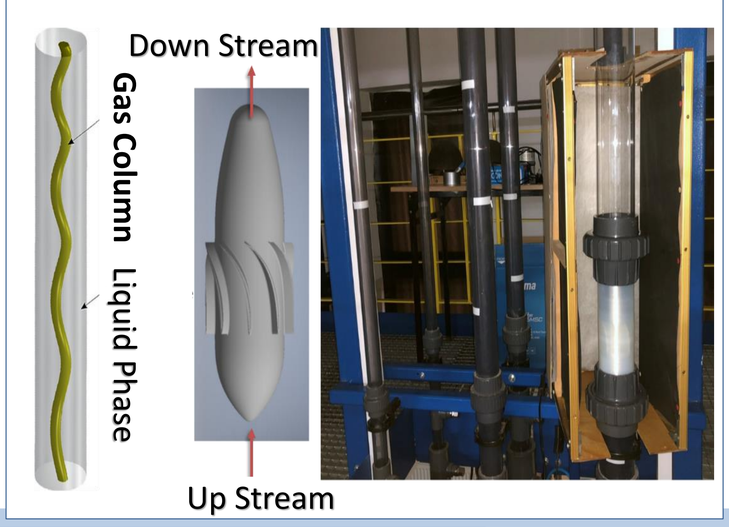
- Gas-liquid separation using a swirl element mounted is a new approach being used in process industries[1]
- The principle of separation in decaying type swirling flow is based upon the density difference[2]
- The vortex created by the swirl element varies in shape and size. To improve the split efficiency, the size of the vortex should be known
- Electrical Tomography as a non-intrusive visualisation method to estimate the size of the vortex
- The electrical conductivity of a medium can be defined by the following equation [3]:

$$\sigma = \frac{L}{RA}(S/m)$$

- The main aim of this research was to detect the phantom vortex which can vary in size and shape

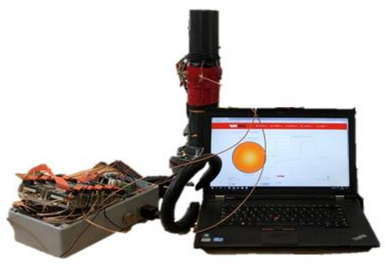


- Two sensors were designed with different electrodes sizes
- Size of the phantom vortex is noted through advanced image processing techniques (Otsu and GAC) and change in average conductivity values



Measurement System

- **Pipe Sensor:**
  - 8 stainless steel pin-shaped electrodes
  - 3mm each was evenly distributed
  - 70mm diameter PVC pipe



- **Swirl Element:**
  - 8 stainless steel electrodes
  - 8mm each
  - 90mm 3-D printed pipe

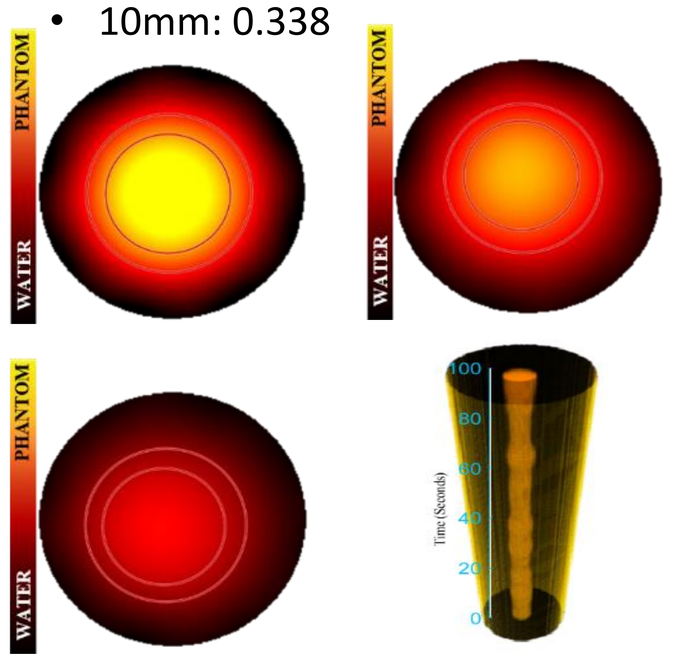
- **Phantoms and Target media**
  - Three hollow phantoms of sizes 22.5mm,20mm and 10mm sealed on both ends to simulate vortex were designed
  - Salt water with conductivity of 10.4(S/m) was used as a targeted medium
- **Data Acquisition and Image Reconstruction**
  - Flow watch a 16 channel device by Roscole Ltd with data acquisition rate of 16Hz was used.
  - Dynamic Bayesian estimation [4] Method is used for Image reconstruction

Results

- 2-D and Pseudo 3-D Image reconstruction
- Image processing for size retrieval: OTSU and Geodesic active contour (GAC)
- The more significant segment shows the estimation using Otsu, and smaller shows GAC technique
- For 20mm rod:
  - Pipe : 190 Pixels
  - Actual Rod: 54 Pixels
  - Ostu: 117 Pixels
  - GAC: 87 Pixels
- More accurate size retrieval is done using change in average conductivity values

$$\sigma_{avg} = \frac{1}{V_\Omega}\int_\Omega \sigma(x)\,dV$$

- Values of average conductivity:
  - Water: 0.349
  - 22.5mm: 0.327
  - 20mm: 0.332
  - 10mm: 0.338



Conclusions

- The methods of static testing shows promising results
- Image processing show limitations when the object has a size close to the spatial resolution
- New approach of raw data analysis is more valuable for obtaining small size objects
- Size above 10mm can be satisfyingly detected using Electrical Tomography
- The designed sensors will now be mounted on the flow installations, and with size, other geometrical parameters will be observed using both images processing and raw data analysis techniques

References

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