



Intermittent structures in vertical gas-liquid flow

Dafyak., L, Hewankandamby., B, Fayyaz., A, Hann., D

Introduction

- When gas and liquid flow simultaneously in circular conduits, either dispersed or separated flow patterns are formed; most often, both.
- Understanding the flow patterns/structures in multiphase fluids is crucial to the development of innovative solutions for flow assurance challenges, particularly in the energy industry.

Aim

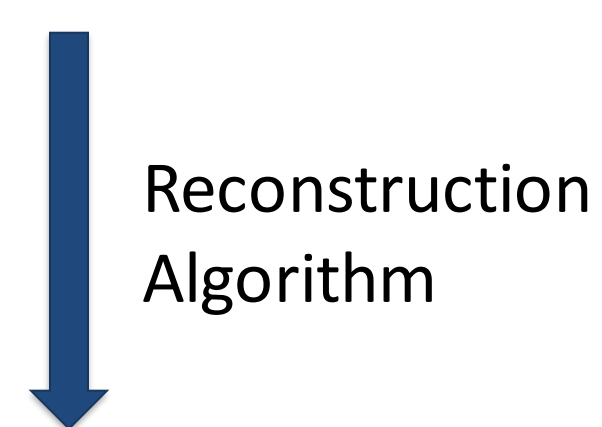
- To identify and classify flow patterns in a vertical pipe using Probability Density Function (PDF) technique.

Methodology

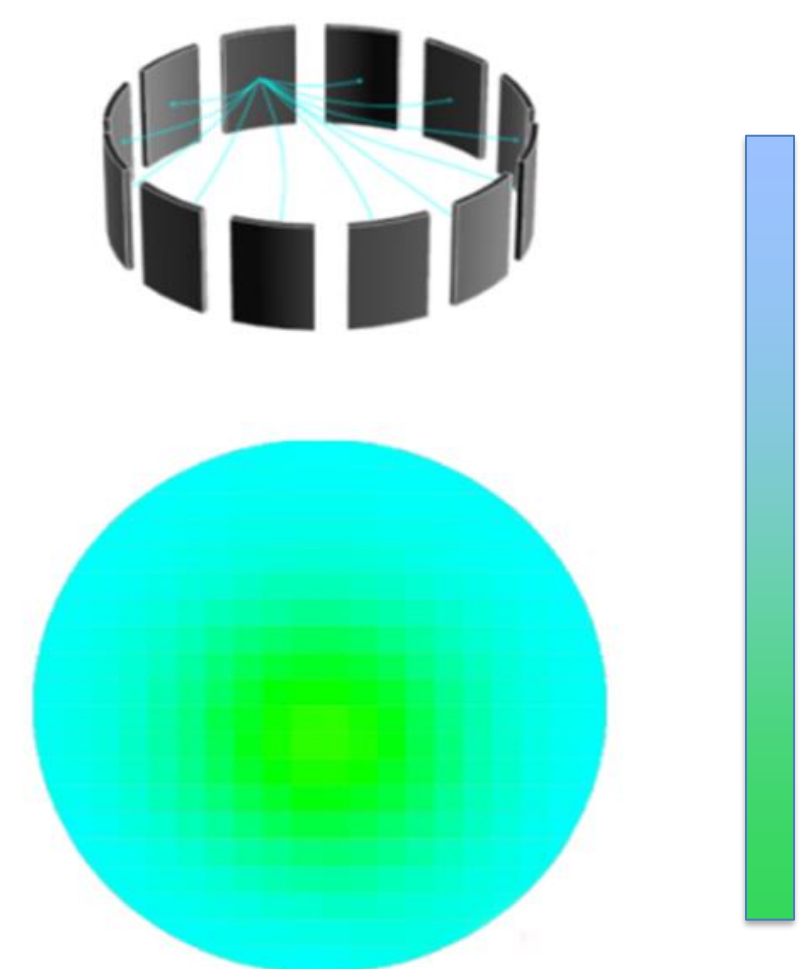
An experiment was conducted to measure the time-series void fraction of a gas-oil mixture at varying gas and liquid velocities.

Electrical Capacitance Tomography (ECT) tool

Evenly distributed ECT electrodes, flush-mounted around the periphery of the pipe



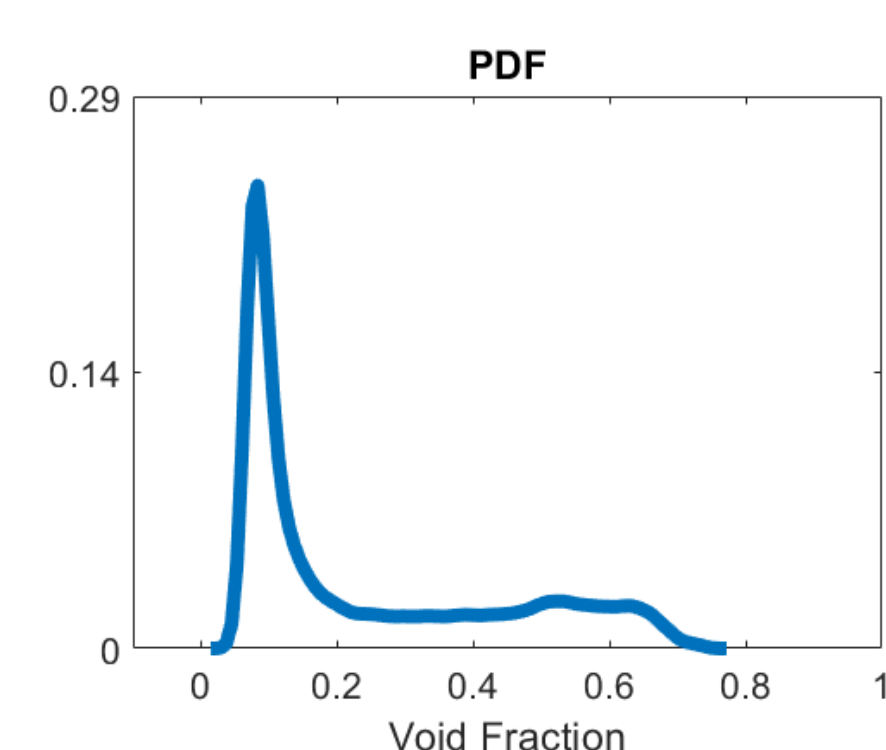
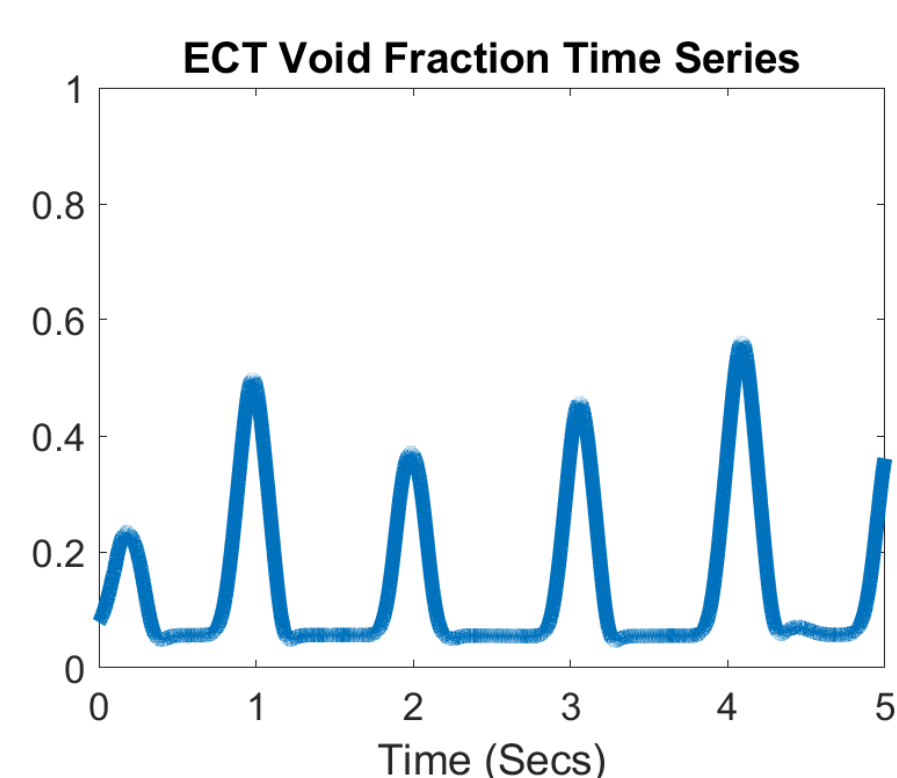
2-D image of the two-phase fluid across the cross section of the pipe



The difference in capacitance between dielectric materials is exploited to quantify the volume fraction of each fluid within the enclosed pipe.

Cap Bubble

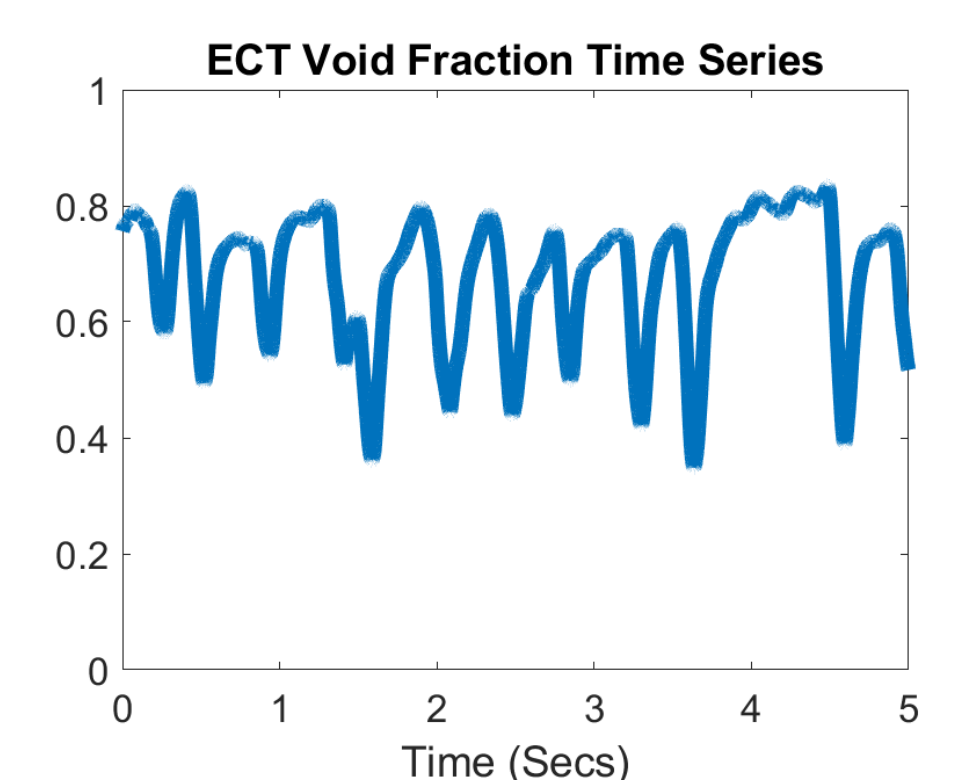
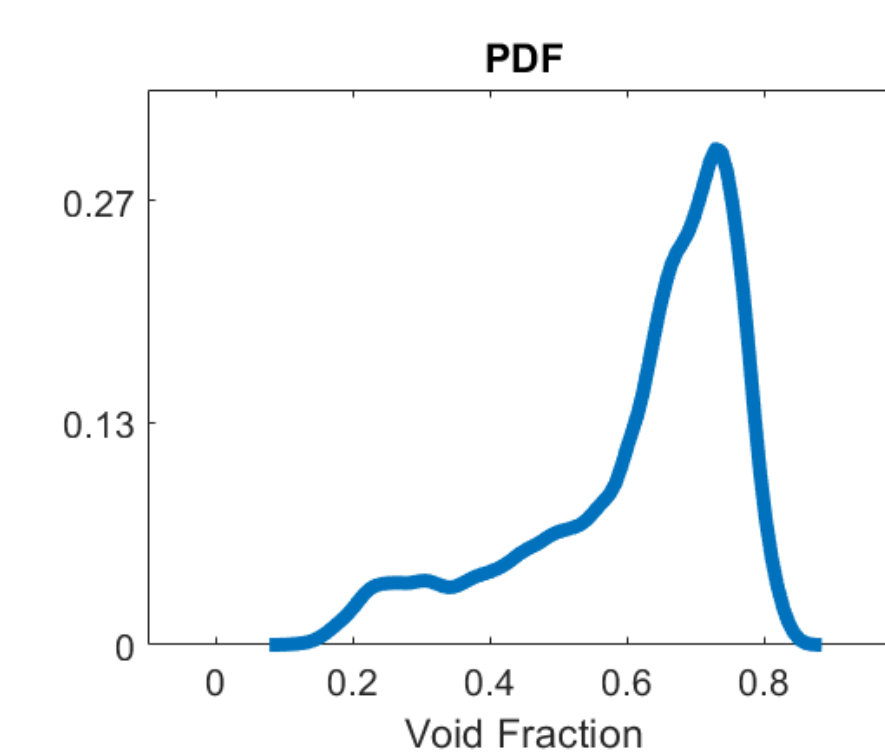
At low mean gas fraction, < 0.3 , axis-symmetric bubbles are formed^[1]. Unlike slug flow, these **cap bubbles [CB]** have no cylindrical body.



Churn

Churn flow [C] is a chaotic intermittent flow pattern

The gas dominated structures are distorted with no clear boundary between them and the liquid dominated structures.



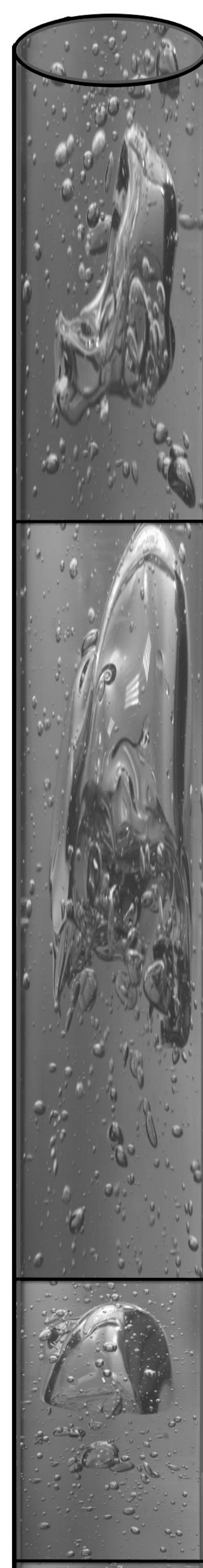
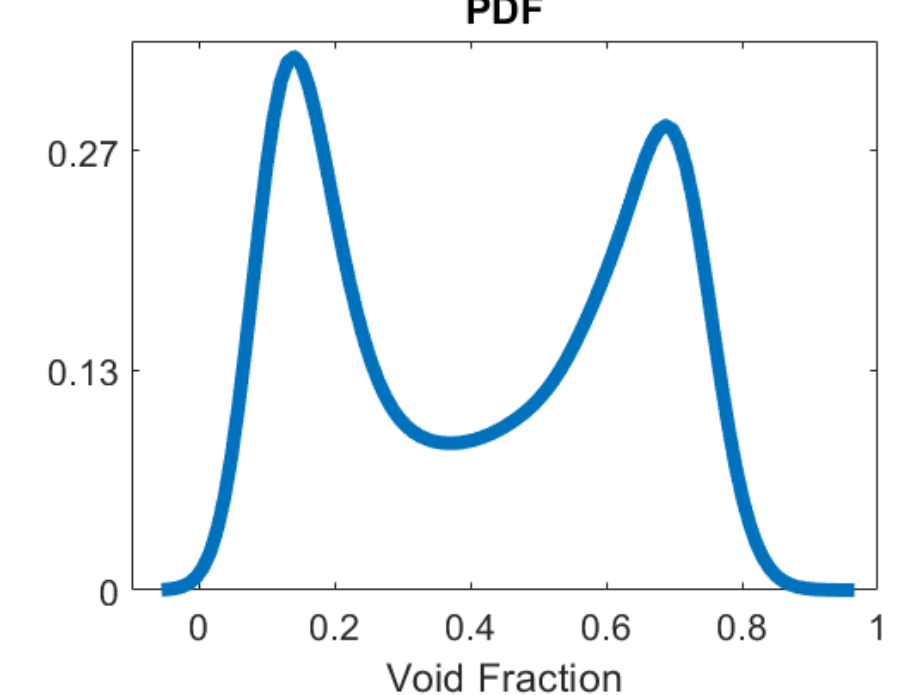
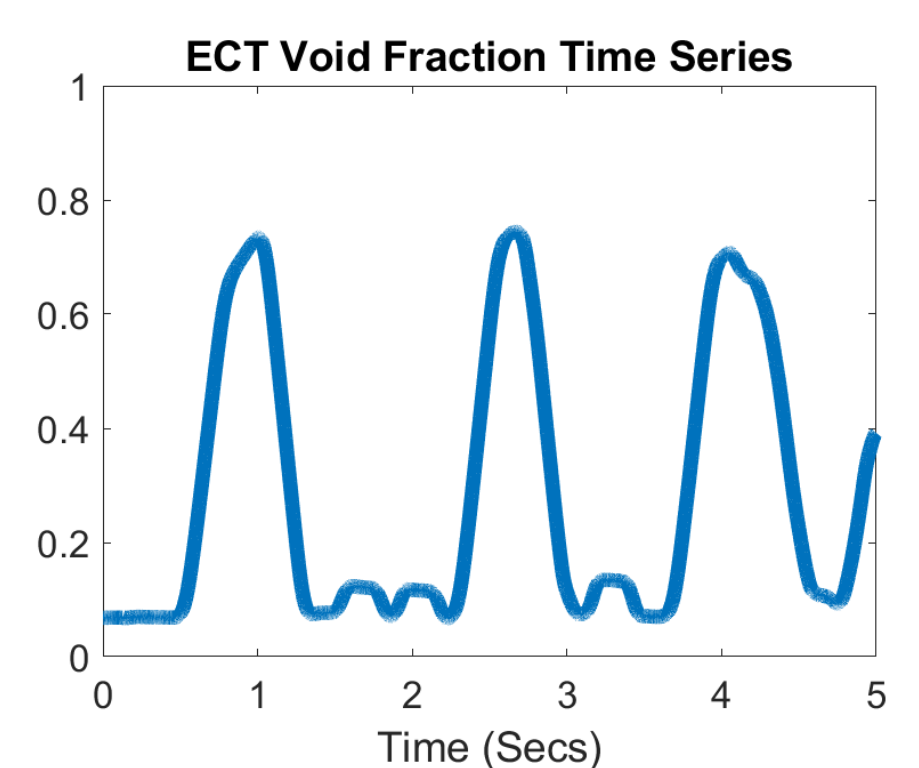
The liquid slugs continuously fall into the large gas structures because they are highly aerated and unstable.

Slug

Characterised by bullet shaped bubbles (Taylor bubble) and occupies $> 60\%$ of the pipe cross-section^[3].

Taylor bubbles are separated by liquid slugs with tiny bubbles dispersed in it.

A twin peaked PDF is identified as **slug flow [S]**



[C]

[S]

[CB]

Stacked High-Speed Camera (HSC) images of cap bubble, slug and churn flows for a gas-oil mixture in a transparent vertical pipe

38%

of the energy mix by 2050 is projected to be liquid and gaseous fuels

Pipelines are the **safest** means of transporting oil and gas

Conclusion

Flow patterns largely depend on flow rates, fluid properties and pipe geometry/orientation. Although cap bubble, slug and churn flows are all classified as intermittent flows, their characteristics differ. Proper identification of flow patterns is essential for optimal two-phase flow analysis in pipelines.

Reference

- [1] Gokcal, B., et al. (2009). Effects of high oil viscosity on drift velocity for horizontal and upward inclined pipes. *SPE Projects, Facilities and Construction*. [2] Energy 2050 : Insights from the ground up, Mckinsey (2016). [3] Abdulkadir, M., et al., (2021). Experimental investigation of the characteristics of the transition from spherical cap bubble to slug flow in a vertical pipe. *Experimental Thermal and Fluid Science*.

