

ABSTRACT

Investigation of Taylor Bubble Properties and Their Reaction on the Co-Current Upward Slug Flow from Experimental Database of Ultrafast X-Ray Tomography

Akmal Irfan Majid

Supervised by:

Deendarlianto ¹⁾, Manuel Banowski ²⁾, Dirk Lucas ²⁾

¹⁾ Department of Mechanical and Industrial Engineering, Faculty of Engineering, Gadjah Mada University – INDONESIA

²⁾ Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf - GERMANY

Slug flow is a complex two-phase flow pattern that characterized by the presence of Taylor bubbles and liquid slugs with small bubbles inside. Due to the intermittent and irregular natures, the pattern might causes high mechanical impact to the pipeline, corrosion and high pressure fluctuation. Therefore, it is common avoided in engineering applications. On the other hand, the rapid developments of new Computational Fluid Dynamics (CFD) models need to be supported by high quality experimental database to validate and improve the simulation models. Investigations about detail properties of Taylor bubbles are necessary to obtain physical mechanisms of slugging phenomena.

At the Helmholtz-Zentrum Dresden-Rossendorf, experiments on co-current upward air-water flow in 54.8 mm diameter vertical pipe with various gas-liquid superficial velocities were performed. As measurement technique, an ultrafast dual-layers X-ray tomography was developed to fulfil the requirement of an accurate measurement with high spatial and temporal resolutions. Results of tomography scanning were reconstructed and segmented to carry out each gas bubble size and parameters. A bubble pair algorithm is to estimate the instantaneous movement of each bubble. This method is able to assign the correct paired bubbles from both measurement layers by considering the highest probability of position, volume, and velocity. Therefore, each gas-bubble individual characteristics can be revealed. A statistical analysis was also used to support the data analysis.

General characteristics of slug flow were explained in the form of qualitative observation and quantitative explanation of void fraction characteristics. Taylor bubble properties such as the velocity, frequency, and length were observed and reasons of velocity distribution were carried out. The presence of Taylor bubble generates different flow behaviors for small bubbles around it such as bubbles in falling film region and behind area of the Taylor bubble. Reasons of the Taylor bubble velocity distributions were explained. Relationship between Taylor bubble properties and as well liquid slug to the velocities are also revealed. The increase of axial station along the pipe influences flow pattern, void fraction, and properties of Taylor bubble and liquid slug as well. Bubble pair method was able to reveal the Taylor bubble properties and slug flow characteristics. A relevant agreement between the previous studies was carried-out.

Keywords: Bubble, Slug flow, Taylor bubble, Bubble pair algorithm, Ultrafast X-ray tomography