ABSTRACT

The Interfacial Characteristics of Gas-Liquid Plug Two-Phase Flow in A Horizontal Pipe by Using An Image Processing Technique

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Two-phase flow phenomena is often encountered in science, engineering, and fluid transportation problems. Slugging phenomena is avoided due to the flow stability and pressure fluctuation. Plug flow is acted as an initiation of the presence of slug flow. Several measurement technique has been proposed by some researchers to investigate flow characteristics, but sometimes found contradictory results. An image processing technique can be used to determine the flow pattern and interfacial characteristics from the input of flow visualization data. Those images were digitally analyzed to obtain the important flow parameters based on the study of interfacial behavior, flow topology, and bubble tracking.

This gas-liquid flow was recorded as video and extracted into sequences of images. The image processing technique including image conversion (RGB to Grayscale image), noise reduction such as: image complement, morphological operation, background subtraction, image filtering (Median and Wiener filtering), image thresholding, and binarization resulted binary images that could be automatically analyzed by digital (1 and 0) logic, depended on the threshold value. A quantitative analysis were implemented that combined with statistical calculation to find important flow data. Local analysis of each divided segment of image frame provided liquid film thickness data. The liquid hold-up data was determined by cross-sectional analysis within gas and liquid thickness and real diameters. The elongated bubble velocity was determined based on the difference of bubble nose coordinate. Real size of measurement were acknowledged by calibration procedure (pixel to millimeter). This work was carried out for 25 test data matrices where superficial velocity of gas (J_G) from 0.12 to 0.51 m/s and the superficial velocity of liquid (J_L) 0.25 to 1.13 m/s.

As the results, an apparent interfacial behavior could be determined through this technique. A prominent result between visual experiment data and image-processing-based visualization produced a good agreement of flow pattern map for horizontal plug flow. The characteristics of elongated bubble such as bubble-nose and tail contours, also the elongated bubble velocity were observed. The interfacial characteristics were presented by liquid film thickness and liquid hold up data that merged with Spectral analysis such as Power Spectral Density, Probability Distribution Function, and Cross Correlation so that wave velocity, frequency were carried out. It was found that the increase of gas superficial velocity (J_G) and liquid superficial velocity (J_L) would also increase the gas-bubble velocity. The increase of J_L in constant J_G also increase wave frequency. The increase of J_G in constant J_L show the less value of liquid hold up. A comparison with the available previous studies was also carried out.

Keywords: plug flow, image processing technique, visualization, interfacial characteristics