IMAGE PROCESSING METHOD IN ESTIMATION OF BUBBLE COLUMN'S WORK

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Summary This paper presents an experimental study of identification and analysis of two phase gas-liquid flow using image processing method. The process of two phase flow has been realized in bubble column. The continuous and dispersed phases were water and air, respectively. The gray level value of the obtained recordings from gas-liquid flow was the basic parameter for process investigation. Based on this parameter it was possible to calculate and determine many important statistical characteristics of two phase gas-liquid flow.

This paper presents an experimental study of identification and analysis of two phase gas-liquid flow using image processing method. The process of two phase flow has been realized in two dimensional bubble column (1300/300/20mm). The continuous and dispersed phases were water and air, respectively. Recorded realizations (by CCD camera), were put into analysis either by the use of own software and commercial product (MATLAB). The gray level value of the obtained recordings from gas-liquid flow was the basic parameter for process investigation. Based on this parameter it was possible to calculate and determine many important characteristics of two phase gas-liquid flow.

Authors presents modified version of the bed expansion method, due to volume fraction calculation. This method was supported by image analysis technique. On the recorded images edge detection filters was used. This allowed for calculation of the area of both the dispersed bed and static column which directly led to volume fraction determination.

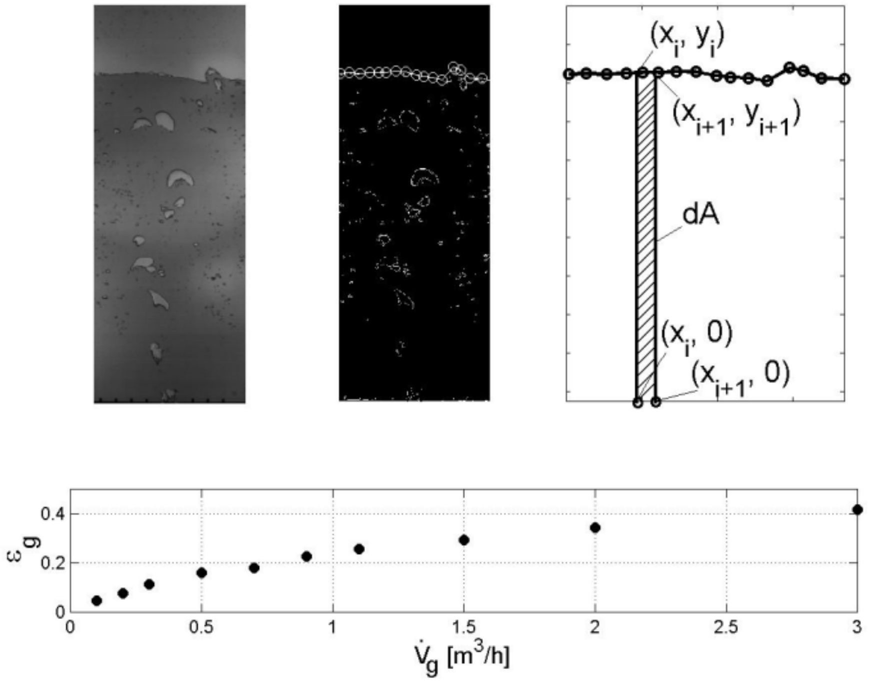

Fig.1. Volume fraction's determination method. This parameter is calculated strictly from the area of the two phase bed.

Another primary parameter which was calculated was the velocity of the gas phase. In this part of the research the particle image velocimetry (PIV) technique was applied. Mentioned method is based on calculating of displacement of bubbles between two consecutive images, which were captured with camera, in known time interval. Captured images are divided into interrogation areas. For every interrogation area, the average bubble displacement between two images is calculated with a numerical procedure based on cross correlation. The results are velocity fields for gas phase and graphs representing bubble trajectories (figure 2).

The gray level value is representing the discrete distribution of the illumination in the area of bubble column. The range of this parameter can change from 0 (black) to 255 (white). For better contrast between water and air, the first one was colored by inert dye. After this procedure both phases had representative range of the gray level value. Based on this fact authors showed the change of volume fraction along and broadwise the bubble column. Analyzing the change of the gray level value in time (calculated from various interrogation areas) the pattern recognition in bubbly flow regime was possible (figure 3).

The last part of this research is the stochastic analysis. The change of the gray level value was taken into consideration. From each obtained courses authors determined a series of statistical parameters such as amplitude, minimum, maximum, standard deviation, skewness, kurtosis and average value. Those values helped in pattern recognition in bubbly flow regime. Except statistical parameters also stochastic functions have been calculated (PDF, PSD, ACF).

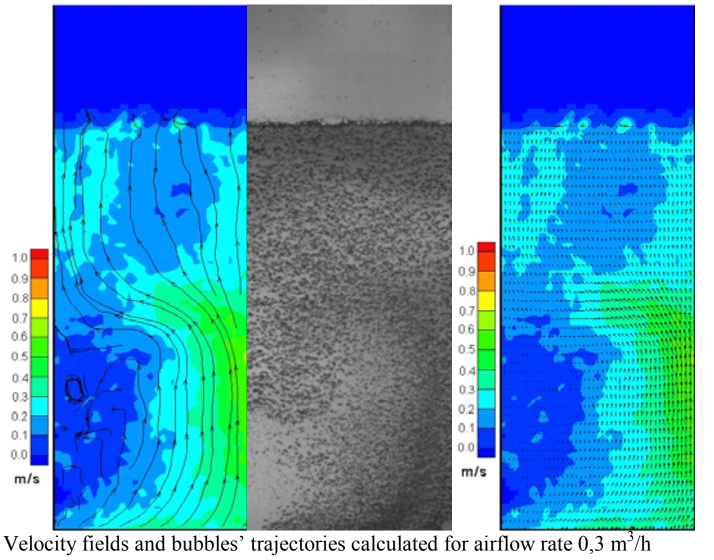

Fig.2 Velocity fields and bubbles' trajectories calculated for airflow rate 0,3 m^3/h

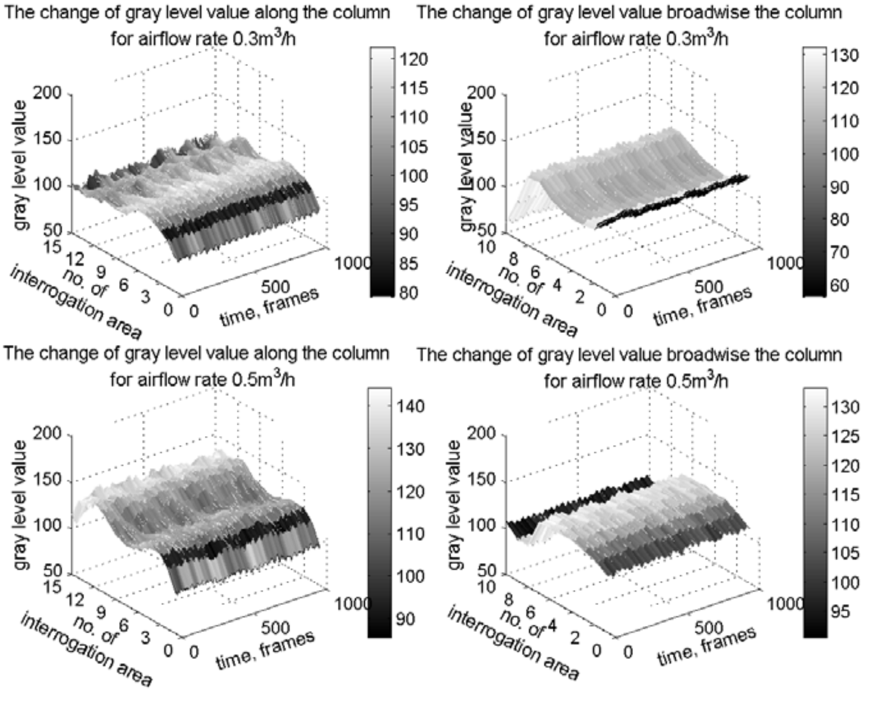

Fig. 3 The change of the gray level in time in airflow range 0.3÷0.5 m^3/h. Diagrams on the left illustrates the change along the apparatus (interrogation area no. 1 – bottom, no. 15 – top of two-phase bed) and diagrams on the right illustrates the change broadwise the column (1 – left side, 10 – right side of the bed). 1000 frames=9.7 s.

To sum up, the gray level value showed to be suitable parameter for two-phase flow conducted in bubble column analysis. The DIP method allowed obtaining many very important statistical characteristics of the flow. The results illustrate the change of volume fraction in time and plane (in both; along and broadwise the column) for the whole airflow range. This allows for the analysis of the dispersion's behaviour as well as for distributor's work assessment (because in bubble column's work, as a result the uniform air phase distribution is desirable). Additionally stochastic parameters and functions showed to be a good tool for two-phase flow pattern recognition.