Dynamics of Solitary Waves on a Liquid Film under Strong Gas Shear

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Presence of strong gas shear, overcoming the effect of gravity, exerts essential influence on wavy pattern on the surface of thin liquid film. Gas shear causes sharp changes in waves' characteristics: increase in velocity and passing frequency, decrease in amplitude and wavelength. Using laser-induced fluorescence technique it was established [1] that under strong gas shear there appear two new types of waves. The primary waves stand out by large values of velocity, lifetime and amplitude. These waves are separated by relatively large distances of base film and can be considered as solitary waves. On the back slopes of primary waves, small-scale secondary waves are generated. These waves travel over the base film with lower velocity and end by being absorbed by the following primary waves. Investigation of the behaviour of liquid film surface in three dimensions (longitudinal and circumferential coordinates and time) showed that both primary and secondary waves are characterized by limited circumferential size [2].

In present work, new algorithm of automatic data processing is developed. It consists of three main steps. The first one is the identification of characteristic lines of primary waves in several longitudinal sections of the channel. The identification is based on Canny method of edges detection [3]. At the second step, characteristic lines of primary waves were used to recover the three-dimensional structure of the waves. For these purpose, the contours of the primary waves were defined as the lines where local film thickness crosses the threshold value of film thickness (Figure 1). At the third step, areas of the base film between primary waves were obtained, the contours of secondary waves at much lower threshold value were found and behaviour of secondary waves in space and time was recovered using cross-correlation analysis.

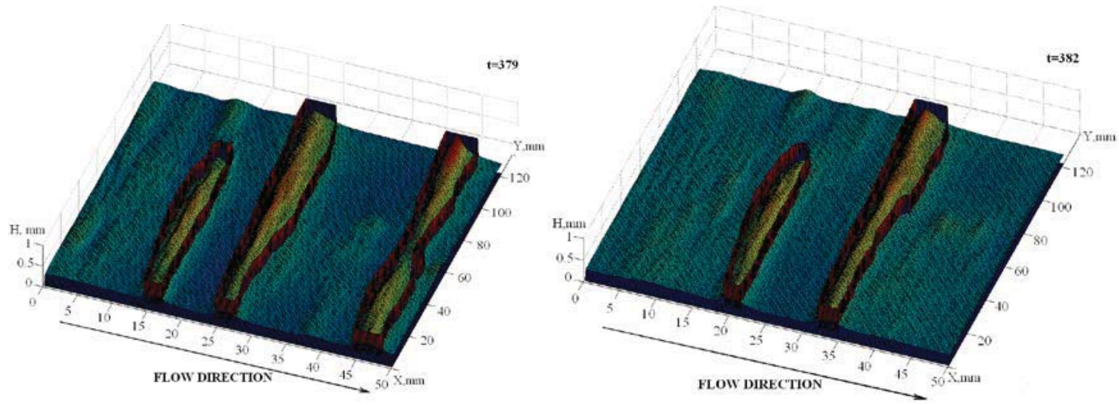

Fig. 1. Contours of primary waves in two time moments, separated by 6 ms. Liquid Reynolds number 18, gas velocity 18 m/s, working liquid – water-glycerol solution with viscosity $3*10^{-6}$ m^2/s.

Degree of circumferential asymmetry of wavy structure is estimated for different flow rates of gas and liquid. Spatial and temporal dynamic of primary and secondary waves, including generation of secondary waves and interaction of primary and secondary waves in three dimensions, is investigated.

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References

[1] S.V.Alekseenko, V.A. Antipin, A.V. Cherdantsev, S.M. Kharlamov, D.M. Markovich. "Two-wave structure of liquid film and waves interrelation in annular gas-liquid flow with and without entrainment", Phys. Fluids **21**, 061701 (2009).

[2] S. Alekseenko, A. Cherdantsev, M. Cherdantsev, S. Isaenkov, S. Kharlamov, D. Markovich. "Application of a high-speed laser-induced fluorescence technique for studying three-dimensional structure of annular gas-liquid flows", Exp. Fluids, DOI: 10.1007/s00348-011-1200-5 (2011)

[3] J. Canny. "A computational approach to edge detection", IEEE Transactions on Pattern Analysis and Machine Intelligence, **PAMI-8**, 679 (1986).