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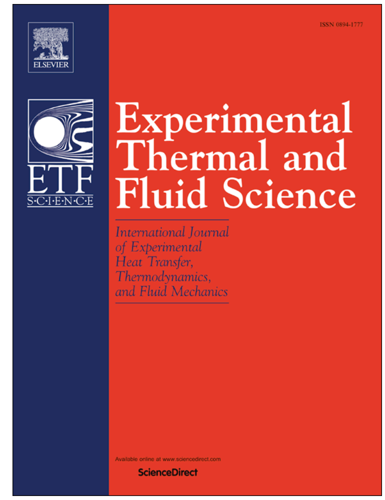

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PII: S0894-1777(18)30073-6
DOI: https://doi.org/10.1016/j.expthermflusci.2018.03.035
Reference: ETF 9432

To appear in: *Experimental Thermal and Fluid Science*

Received Date: 26 January 2018
Revised Date: 27 March 2018
Accepted Date: 28 March 2018

Please cite this article as: Q. Liu, Z. Lin, X-p. Chen, Z-c. Zhu, B-l. Cui, Surface wave generation via a gas-jet penetration into a liquid sheet, *Experimental Thermal and Fluid Science* (2018), doi: https://doi.org/10.1016/j.expthermflusci.2018.03.035

Surface wave generation via a gas-jet penetration into a liquid sheet

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Abstract

The mechanism and frequency of surface wave generated by normal wall-jet impingement at a vertical gas–liquid interface were experimentally characterized for a gas-jet penetrating into a liquid sheet. The oscillatory gas–liquid interface accompanied by surface wave generation and propagation were captured with a high-speed camera. Periodic oscillations of the vertical gas–liquid interface were revealed in the context of energy transfer from the wall-jet to surface waves. In addition, wave generation was considered as a means of releasing the maximum interfacial elastic energy. The radial distance between the waist and neck of the wavy interface was defined as the amplitude and the characteristic amplitude was adopted to reveal periodic deformation of the wavy interface during dynamic oscillations. Furthermore, the characteristic wavelength, i.e. vertical distance between waist and neck, was about one third of the liquid sheet thickness, irrespective of penetration parameters, such as gas flow rate, jet height, and liquid sheet thickness. The effects of those parameters on the surface wave generation frequency were analyzed. A combined dimensionless parameter of Froude number and the ratio of jet height to nozzle diameter was used to normalize the surface wave generation frequency with all the penetration parameters. It was found that the frequency could be expressed by a natural exponential function with the combined dimensionless parameter for normalization via fitting analysis. This work should be helpful to characterize interfacial motion in actual industrial applications.

Keywords: Surface wave, Wall-jet, Liquid sheet, Oscillation, Generation frequency

1. Introduction

The behavior of gas–liquid interface in two-phase flow is an important issue in many scientific fields. One well-known is the bubble formation by desorbing gas in solution when increasing the heat flux. Due to bubble formation, the interaction between gas and liquid became greatly stronger and accordingly intensified the convection effect in solution, which served as the major mechanism of enhancing heat transfer [1-3]. And, the physical characteristics of nucleate and rate of bubble formation were often focused on to reveal its relationship with the heat flux in diverse liquids [4-6]. When increasing the heat flux during the flow boiling in nanofluids, thermal performances of that were also significantly intensified due to the fast bubble formation and agitation in nucleate boiling region [7-9]. In addition, the performance of bubble formation can be improved by the deposition of the nano-particles in nanofiluds [10]. However, the behavior of bubbles formed in nanofluids can negatively affect the stability of nanofluids [11]. The effect of mixed convection of nanofluid on heat

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