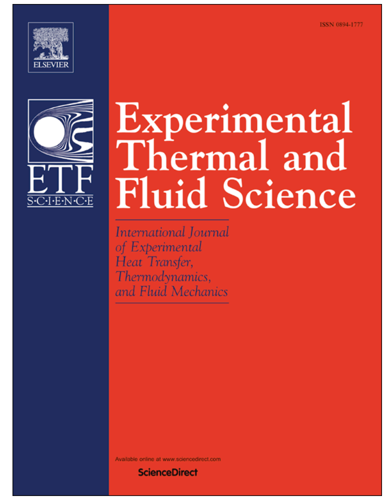

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Intensification of wavy behavior of fully-developed falling film using electric field implied by a novel wire-plate electrode arrangement

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Abstract

This paper describes an experimental investigation to study the effect of an Electrohydrodynamic (EHD) phenomenon on the hydrodynamic behavior of fully-developed film falling upon an inclined plate. A new configuration of electrodes has been introduced to create the electric field. This field has been applied on the liquid film by five pairs of overhead high-voltage wire electrodes and the grounded flush mounted plate electrodes perpendicularly. Transformer oil has been used as the working fluid over Reynolds numbers spanning the range 10-120 in the laminar-wavy regime at three different inclination angles of 15°, 30° and 45°. The experiments have been further conducted by changing DC high voltage over the range of 11-15 kV for two different wire electrode heights of 10 mm and 14 mm that restrict the value of applied voltage. Based on the measured film thickness, the statistical analysis of the falling film with and without EHD has been performed by image processing to derive more information such as mean film thickness, wave frequency, and liquid velocity. Film thickness and wave frequency without the electric field have been validated by other experimental data. The results indicate that the produced electric field by the wire-plate electrode configuration does not disturb the original structure of falling film and intensifies the wavy behavior of laminar falling film; therefore, it can be proposed to either suppress or enhance the heat/mass transfer rate, specially, in falling film absorber. Assuming the obtained results, the effect of the applied high voltage and the wire electrode height on the interfacial waves has been also discussed.

Keywords*:* EHD, falling film, fully-developed, dielectric, image processing, wire-plate electrode.

1. Introduction

Falling film, as a particular instance of two-phase flow, is an outstanding flow, which is abundantly used in industrial processes associated with heat/mass transfer, such as evaporators and falling film reactors, direct contact condensation units, and gas absorption tower. Intensification of instability and waviness of falling film is identified as the most effective technique to augment the heat/mass transfer from falling films. Extensive experimental and numerical studies have shown that the rate of heat/mass transfer in these flows is severely dependent on the films' hydrodynamic characteristics, and in particular, the waviness of the gas-liquid interface [1–3].

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