Laser-induced luminescence technique for the measurement of local temperature distributions in thin wavy liquid films

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Keywords: falling film, wave induced enhancement of heat transfer, local heat transfer coefficient

1. Introduction

Comprehension of the kinetic phenomena which lead to an increase of heat transfer in falling liquid films requires high spatiotemporal resolved experimental data of local temperature distributions. For this purpose a non-invasive measuring method based on luminescence indicators has been developed.

2. Basics

The examination of heat transfer in an aqueous film is accomplished with the indicator biacetyl. After excitation with UV-light biacetyl emits phosphorescence and fluorescence. The fluorescence emission is temperature independent and proportional to the local film thickness. The intensity and the lifetime of the phosphorescence are complexly correlated with the temperature distribution in a heated liquid film. With a model-based evaluation method the temperature distribution is reconstructed from the measured signal.

3. Measurement System

The measuring device is in principle a phosphorescope. A scheme of the measurement system is given in Fig. 1. The source of the primary UV laser beam is a nitrogen pumped dye laser with a pulse frequency of 50 Hz. To excite two probe volumes in the film with a diameter of 1.5 mm a beam splitter optic is used. The emission of the indicator is measured with photo-multipliers equipped with edge filters to separate the reflected excitation light from the indicator emission. The analogue signals of the photo-multipliers are converted by a fast A/D-conversion card with a frequency of 1 MHz per channel. The measuring time after one laser shot is about one millisecond.

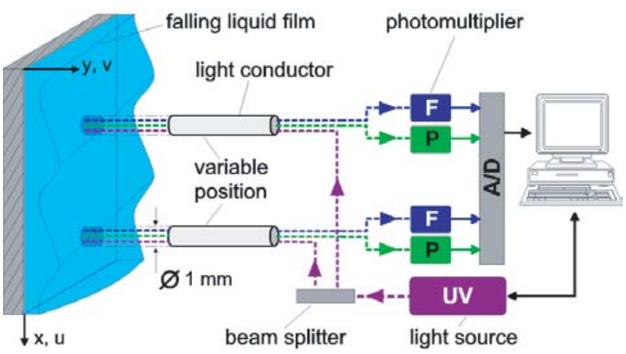

Fig. 1 Scheme of the measurement system.

4. Experiments and Results

Experiments to examine the heat transport in laminar-wavy water films flowing down a heated plane were set up with a Reynolds number of 126 and an inclination angle of 2° of the plane with respect to horizon. Evaluation of the measured luminescence gives the temperature distributions shown in Fig. 2. The determined temperature distributions are used to determine the local heat transfer coefficient within a single wave, see Fig. 3. The local heat transfer coefficient has a maximum in front of the wave hump and a minimum below the wave hump. Numerical simulations of Adomeit et al. (2000) show qualitatively the same course of the local heat transfer coefficient. It can be concluded that enhancement of heat transfer in wavy films is dominated by the high frequent motion in the capillary wave region in front of the wave hump.

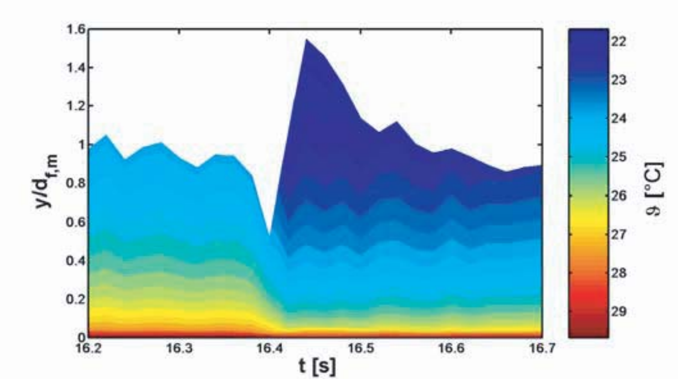

Fig. 2 Temperature distributions in a single wave.

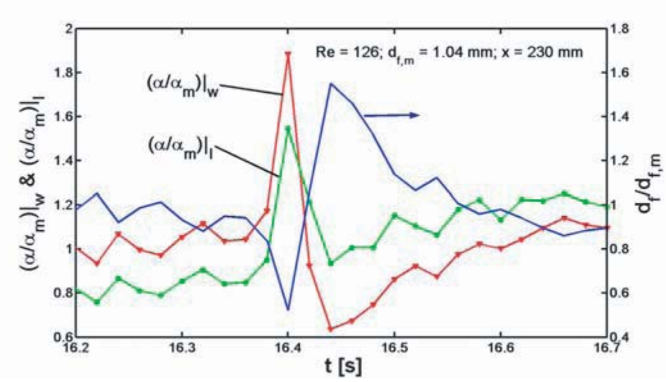

Fig. 3 Local heat transfer coefficient.

Reference

Adomeit P., Leefken A., Renz U. (2000) Experimental and numerical investigations on wavy films, Proceedings of the 3rd European Thermal Science Conference, 2:1003-1009.