Thermocapillary instability of liquid sheets in motion

L.A. Dávalos-Orozco *

Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México, Apartado Postal 70-360, Delegación, Coyoacán 04510, Mexico

Received 12 August 1998; accepted 24 February 1999

Abstract

In this paper the linear thermocapillary instability of a viscous liquid sheet in motion through a gas which has two free deformable surfaces with different temperatures is investigated. This temperatures difference is supposed to be due to a temperature gradient in the ambient gas. It is found that thermocapillary instability affects in an important way the viscosity-enhanced instability investigated by Li and Tankin (J. Fluid Mech. 226, (1991) 425). For the sinuous mode and small Weber numbers the viscosity destabilizes and thermocapillary effects destabilizes through the Marangoni number coupled to the Ohnesorge number, representing Viscous effects. The thermocapillary instability has growth rates far more larger than those of the pure viscosity-enhanced instability. For large Weber numbers Li and Tankin showed that the viscosity stabilizes and that the aerodynamic instability is the more important, however thermocapillarity destabilizes increasing the growth rates with the Ohnesorge number in such a way that for some Marangoni numbers the thermocapillary instability is the more important. Plots of the maximum growth rate against the Marangoni number are given in which new features of this maximum are observed such as a steep increase of its magnitude in a relatively small range of Marangoni numbers due to the onset of thermocapillary convection. It is shown that from the thermocapillary point of view the Weber number plays a stabilizing role. The varicose mode can not be changed notably by thermocapillarity and the curves almost remain the same as those of the pure viscosity-enhanced instability. For large enough values of the Marangoni and Ohnesorge numbers the sinuous mode has the larger maximum growth rate. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Liquid sheet; Aerodynamic instability; Viscosity-enhanced instability; Thermocapillar instability; Marangoni instability

1. Introduction

The stability of liquid sheets in motion has recently attracted the attention of researchers due to its potential applications in, for example, swirl nozzles in gas burners where a hollow cone is formed by the thin liquid sheet. In general, the stability of liquid sheets is important in applications where the formation of drops is necessary to improve evaporation. This occurs after the break up of the liquid sheet due to non saturated growth of the perturbations. The form of a non perturbed liquid sheet is shown in Fig. 1A and two modes of the perturba-