THIN-LAYER FLOW MODELING OF THIXOTROPIC LIQUIDS

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Abstract

We study the effect of thixotropy in the hydrodynamic behavior of thin films. The rheological properties of the material are assumed to evolve over time due purely to changes in its internal structure. These changes are modeled by introducing a single structural variable. Neither elastic nor yielding liquids are taken into account. More specifically, the constitutive relation used in the model is that proposed by Moore and it is known to cover a wide range of thixotropic materials. We first develop a hydrodynamic model for leveling of a thixotropic liquid on an horizontal substrate. A linear analysis yields a generalization of Orchard's law of leveling for Newtonian liquids. We can predict the nonlinear leveling history of the liquid as a function of the initial microstructural state, the rheological parameters, and the initial disturbance of the liquid free surface.

1. Introduction

Thin film hydrodynamics studies taking into account thixotropic effects have received little attention. Many studies incorporate such non-Newtonian effects as visco-plasticity or shear-thinning, but generally without accounting for any dependency upon flow history. Many attempts have been made to describe thixotropy by rheological models. Thixotropy is usually defined as the reversible variation of viscosity with time, whether elastic effects are present or not. According to Barnes [1], thixotropic liquids have gel-like properties which disappear when sheared, but reappear when put to rest. The rheological properties of such liquids depend on the time needed by their microstructure to evolve from one state to another. Structural changes in a flowing thixotropic liquid are due to two competing effects: break-down due to flow stresses and build-up due to collisions of the particles which make up the microstructure.