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Stability of a generalized Newtonian fluid film flowing down an inclined plane with respect to two-dimensional and three-dimensional disturbances

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Stability of a generalized Newtonian fluid film flowing down an inclined plane with respect to two-dimensional and three-dimensional disturbances

M.H. Allouche, S. Millet, V. Botton, S. Dagois-Bohy, F. Rousset, H. Ben Hadid and D. Henry

This presentation will focus on the possibility, or not, to extend Squire's theorem to film flows on inclined planes involving generalized Newtonian fluids. For this purpose we have combined numerical stability analysis and Squire relationships when available. Indeed Squire's theorem states that the two-dimensional instabilities are more dangerous than the three-dimensional instabilities for some specific flow configurations. It has never been shown for generalized Newtonian fluids on inclined planes.

Among the Squire relationships obtained for flows down inclined planes, there is always one involving the slope of the inclined planes. This relationship leads to the conclusion that the Reynolds number associated with a two-dimensional wave is smaller than that for an oblique wave, but this oblique wave being obtained for a larger slope. Physically speaking, this prevents the possibility to directly compare the thresholds at a given slope. The goal of the presentation will be then to reach a conclusion about the predominance or not of two-dimensional instabilities at a given slope, which is of practical interest for industrial or environmental applications.

For a Newtonian fluid, it is shown that, for a given slope, oblique wave instabilities are never the dominant instabilities. Both the Squire relationships and the particular variations of the two-dimensional wave critical curve with regard to the inclination angle are involved in this result. For a generalized Newtonian fluid, no Squire relationships can be derived and the numerical stability results show that the thresholds for oblique waves can be smaller than the thresholds for two-dimensional waves at a given slope, particularly for large obliquity angles and strong shear-thinning behaviors (Figure 1). The conclusion is then completely different in that case: the dominant instability for a generalized Newtonian fluid flowing down an inclined plane with a given slope can be three dimensional.

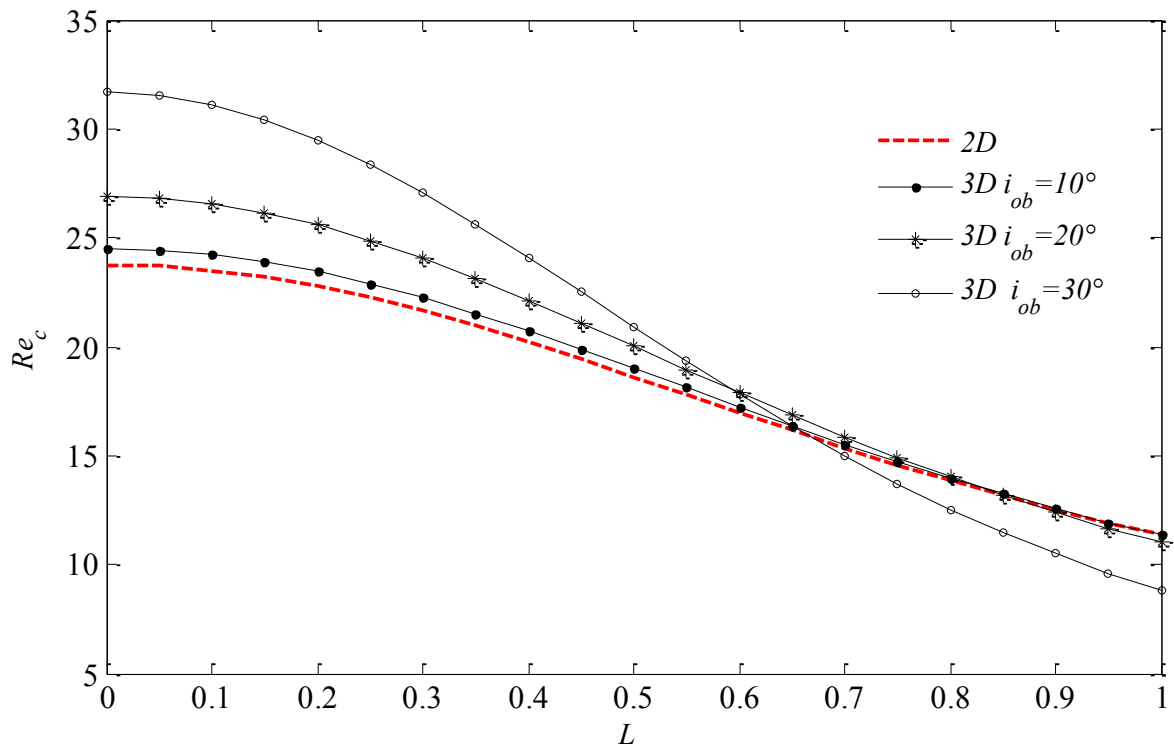


Figure 1: Critical Reynolds number as a function of shear-thinning parameter L in the case of 2D waves (dotted line) and 3D waves with different obliquity angles (solid lines)