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Non Linear Stability of Non Newtonian Thin Liquid Film Flowing down an Incline

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Abstract : The effect of non-Newtonian property (power law index n) on traveling waves of thin layer of power law fluid flowing over an inclined plane is investigated. For this, a simplified second-order two-equation model (SM) is used. The complete model is second-order four-equation (CM). It is derived by combining the weighted residual integral method and the lubrication theory. This is due to the fact that at the beginning of the instability waves, a very small number of waves is observed. Using a suitable set of test functions, second order terms are eliminated from the calculus so that the model is still accurate to the second order approximation. Linear, spatial, and temporal stabilities are studied. For travelling waves, a particular type of wave form that is steady in a moving frame, i.e., that travels at a constant celerity without changing its shape is studied. This type of solutions which are characterized by their celerity exists under suitable conditions, when the widening due to dispersion is balanced exactly by the narrowing effect due to the nonlinearity. Changing the parameter of celerity in some range allows exploring the entire spectrum of asymptotic behavior of these traveling waves. The (SM) model is converted into a three dimensional dynamical system. The result is that the model exhibits bifurcation scenarios such as heteroclinic, homoclinic, Hopf, and period-doubling bifurcations for different values of the power law index n. The influence of the non-Newtonian parameter on the nonlinear development of these travelling waves is discussed. It is found at the end that the qualitative characters of bifurcation scenarios are insensitive to the variation of the power law index.

Keywords : inclined plane, nonlinear stability, non-Newtonian, thin film
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