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Numerical study of the surfactant-covered falling film flowing down a flexible wall

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Abstract

Despite the extensive literature on liquid falling films, the majority of them have focused on clean falling films on rigid walls. In this study, the falling film contaminated with insoluble surfactant on a flexible substrate is considered in the numerical simulations. The flow dynamics of film is studied by using the Navier-Stokes equations coupled with interface tracking approach. The surfactant concentration is calculated according to the ratio between surfactant mass and the surface area of film. The fully developed solitary-like wave accompanied with front capillary ripples is obtained. The results show that the presences of interfacial surfactant and flexible substrate have a considerable influence upon the dynamics of falling film. The surfactant, which acts to reduce the celerity of interfacial wave, can suppress the dispersion as well. The wall damping plays a role to deplete the deformation energy of short-wavelength deflection. As the wall damping coefficient increases, the proceeding capillary ripples of the interfacial humps can be suppressed, and the secondary circulation flow is intensified. The wall tension, which can inhibit the flexible wall fluctuation, tends to strengthen the proceeding capillary ripples and promote the celerity of interfacial solitary-like wave.

Keywords: numerical simulation, falling film, surfactant, flexible wall, solitary-like wave

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