Inertialess Instabilities in Three-Layer Flow Along a Moving Web

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ABSTRACT

It is well known that interfacial wave instabilities may arise as liquid layers come in contact on the inclined surfaces of a slide-coating die when there are viscosity differences between the layers. Under typical coating conditions, such flows have non-negligible inertia, which augments detrimental wave growth. A less-studied wave instability arises between liquid layers on the web immediately after coating when the web path is inclined and the liquid layers are still mobile. When viewed in the frame of reference moving with the web, the characteristic Reynolds number of the gravity-induced flow is small, and a zero Reynolds number approximation is warranted. In this talk, we theoretically and experimentally examine the extremely large growth rate instabilities that arise along the liquid-liquid interfaces in flows having three or more layers. It is found experimentally that water diffusion between layers on the web can alter delivered layer viscosities to yield viscosity configurations prone to wave growth. Experimental results are in agreement with theoretical predictions, and the observed morphology of waves in cross sections of dried coating samples is in excellent agreement with nonlinear theoretical simulations.