LIQUID FILM INSTABILITIES IN JET WIPING

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The jet wiping is a decisive operation in coating industries using dipping techniques. The liquid film is dragged on the surface of a moving strip and undergoes the effect of air knives created by 2D slot nozzles. Its final thickness is reduced and controlled through the wiping parameters. Productivity gains are limited by the appearance of free surface instabilities downstream the wiping jets. They appear as wavelets at the surface of the film as seen in Figure 1. They are studied both theoretically and experimentally in this work.

The theoretical approach aims at predicting the instability initiation through a linear theory. It consists in deriving the Orr-Sommerfeld set of equations, which govern the propagation of pressure and stream function perturbations. The assumption of long waves allows solving it analytically, following the regular perturbation method proposed by Yih. The group velocity and the amplification factor of the waves are predicted. A dimensionless instability criterion is derived in terms of the productivity film Weber number, We*.

In the experimental approach, the instability characteristics (amplitude and wavelength) are measured on a test facility, where a rotating cylinder simulates the moving strip. Different working liquids are used. The applicability of an optical technique based on laser triangulation, is demonstrated for the measurement of wavy liquid films, in terms of time and spatial resolutions. The effect of the wiping parameters on the instability characteristics is investigated. The velocity fluctuations of the impinging jet are also analyzed in the wall jet region by means of the spectral analysis of hot wire signals. They can be correlated to some extent with the film instability measurements.

Similarity between model tests and industrial situations can be assessed through the dimensionless numbers derived in the theoretical analysis. The two approaches are finally compared through the Weber instability criterion. The agreement is good since no wavelength is found below the instability threshold as shown in Figure 2.

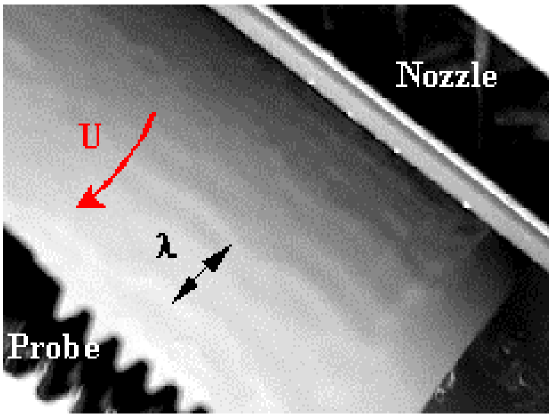

Figure 1: Flow visualization with latex paint

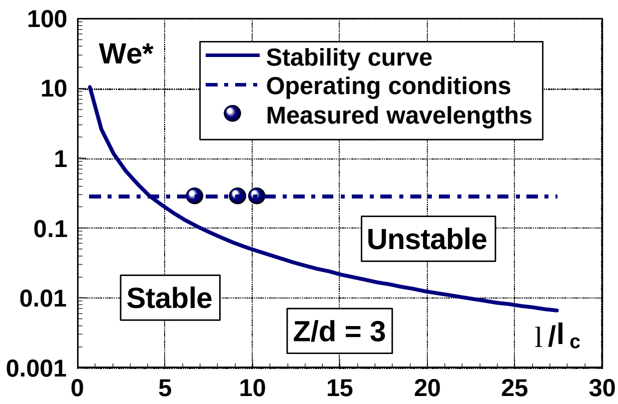

Figure 2: Comparison of the observed unstable wavelengths with the instability criterion