High fidelity simulations of the wiping of low viscosity liquid films

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The jet wiping is a contactless metering technique used in the hop-dip galvanization process to accurately control the zinc coating weight on steel substrates. A planar gas jets impinges perpendicular to the film, reducing the thickness of the coating dragged by a moving strip, and developing a runback flow as sketched in Figure 1(a). For some operating conditions, the final product is affected by the appearance of long-wavelength patterns in Figure 1(a), usually referred to as undulations, due to a two-phase flow instability between the gas jet and the liquid film[1,2].

We investigate the hydrodynamic mechanism responsible for the undulation using CFD simulations. The numerical model has been validated with experimental data in laboratory conditions and combines the Volume of Fluid (VOF) and Large Eddy Simulation (LES) methods[3]. In this work, we analyse an air-water wiping configuration of special interest due to the similarity of the liquid film flow with respect to the one in industrial galvanization. The computations are parallelized in 512 processors, requiring approximately 2000 h of computational time per second of real flow, and generating more than 10 TB of high-quality data as illustrated in Figure 1(b). The data is post-processed using multiscale modal analysis to detect the main undulation patterns and to correlate them with specific features in the gas jet.

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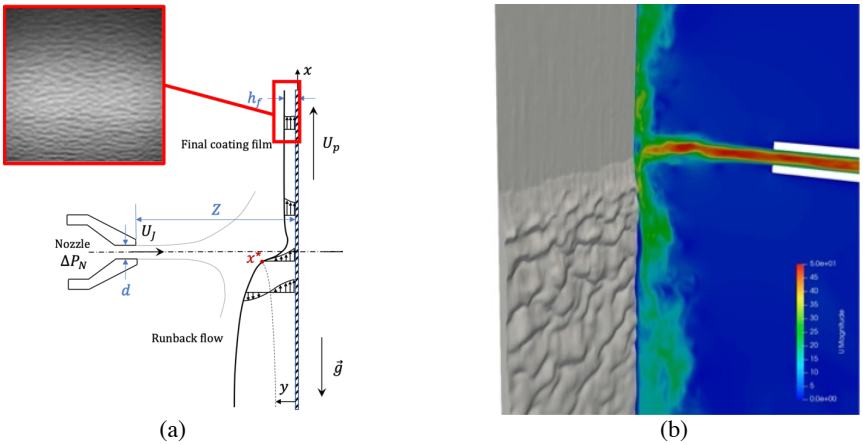
[1] Gosset et al., *Exp. Therm. Fluid Sci.* **103**, 51-65 (2019).

[2] Mendez et al., *Exp. Therm. Fluid Sci.* **106**, 48-67 (2019).

[3] Barreiro-Villaverde et al., *Phys. Fluids* **33** (2021).



(a) (b)

Figure 1: (a) Sketch of jet wiping and experimental visualization of the undulation. (b) 3D representation of the liquid film with the velocity field at the midplane of the domain.