Mapping Slide Coating Window with Flow Visualization

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The complete understanding of the mechanisms of coating processes failures is usually the result of detailed flow visualization and theoretical modeling. In slot coating process, these tools have been used to successfully describe and determine the operating parameters of bead break-up at low-vacuum, high vacuum and low flow limit for Newtonian and non-Newtonian liquids.

The coating window of slide coating is not as well understood. The currently best available information appears to be Hens & Van Abbenyen (1997) and Chen (1992). They describe some of the coating defects that define the boundary of the operability window of the process. However, flow mechanisms associated with the different defects have not been addressed. One reason is that the break-up modes have not been perceptively viewed through a transparent back-up roll in a systematic flow visualization study.

In this work, we are extending Romero et al (2004) analysis of slot coating to slide coating. We are probing the bead breakup mechanisms with the aid of through-the-roll viewing of the bead at low-vacuum, high-vacuum, and low-flow limits. We are investigating the flow states that lie beyond the operability limits and operating parameters, such as web speed, vacuum pressure, gap height and slide inclination, which set them up

Schematic of the flow visualization of slide coating is shown at Fig. 1. Liquid is coated directly to a transparent glass roll and scraped immediately for recycle. The overhang configuration of the glass with mirror installed inside allows for visualization of coating bead from the front, especially location of both upstream and downstream menisci and their shapes in the cross-web direction.

Snapshots of the coating bead breakdown at low vacuum limit are shown at Fig. 2. As vacuum pressure falls, the upstream meniscus moves downstream and invades the liquid film on the foot of the slide. The once uniform coating is transformed into an alternating dry and coated line called rivulets.

At high-vacuum limit, as shown at Fig. 3, the bead breakup is also initiated from the upstream meniscus, where it travels along the die-face and after it reaches the edge of the face, leaks liquid towards the vacuum chamber. The coating is no longer uniform due to the partial loss of the liquid.

At low-flow limit and with sufficiently high applied vacuum, the bead breakups is initiated from the downstream meniscus, as shown at Fig. 4. Air fingers poke through the bead and form rivulets.

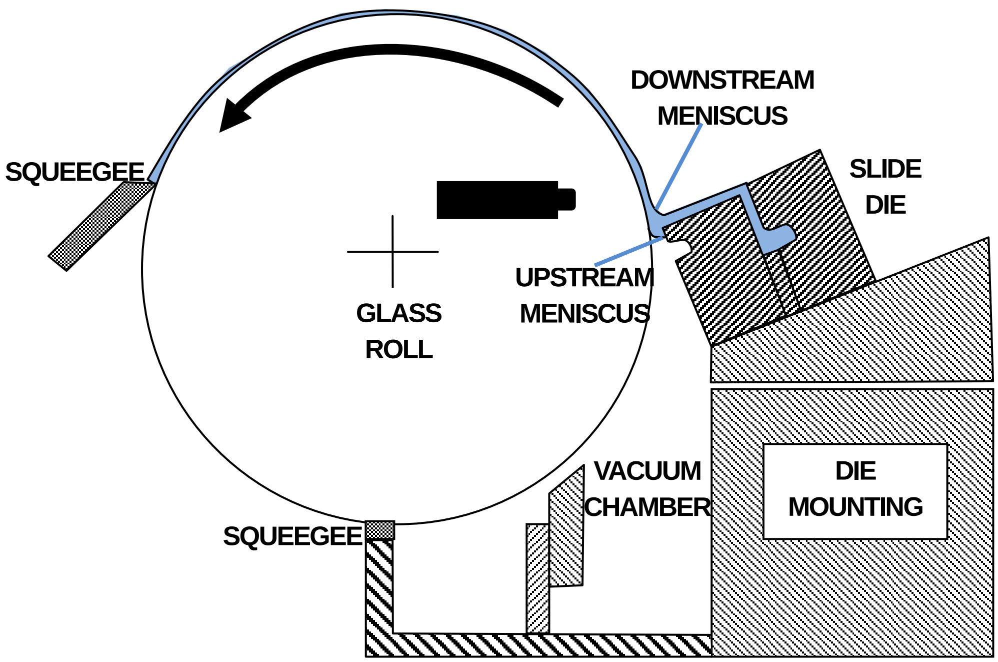

Figure 1 Schematic of the Slide Coating Flow Visualization

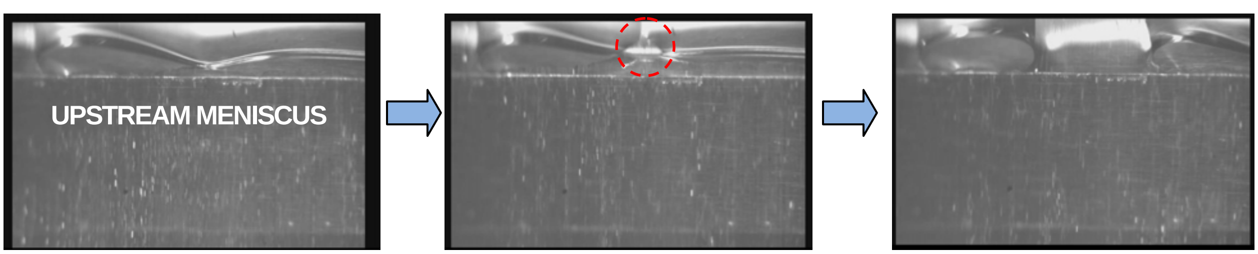

Figure 2 Bead Breakup Mechanism at Low-Vacuum Limit

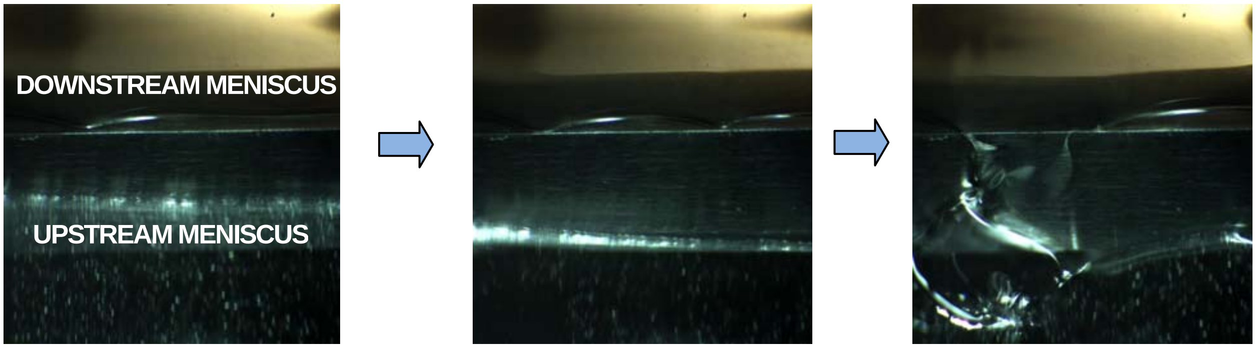

Figure 3 Bead Breakup Mechanism at High-Vacuum Limit

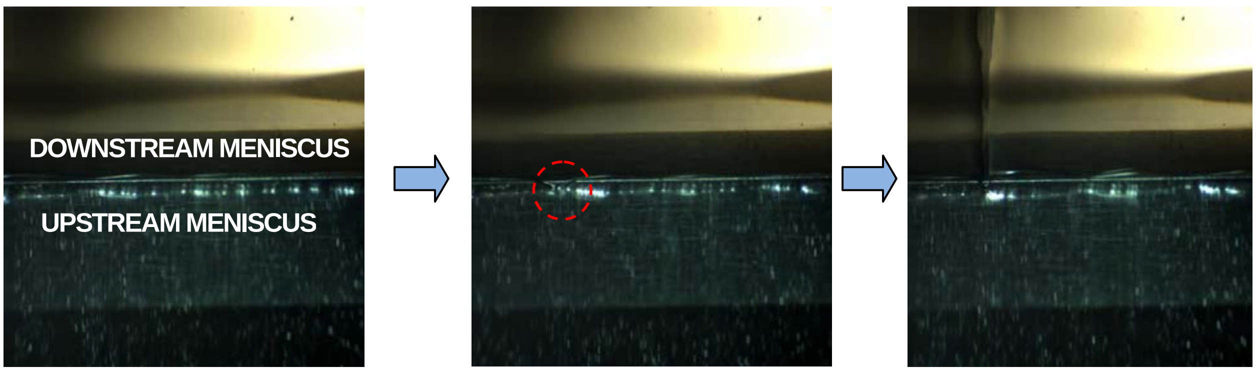

Figure 4 Bead Breakup Mechanism at Low-Flow Limit

References:

1. K. S. Chen 1992 "Studies of Multilayer Slide Coating and Related Processes" PhD Thesis University of Minnesota, Minneapolis
2. J. Hens and W. van Abbenyen 1997 "Slide Coating" in S. F. Kistler and P. M. Schweizer (eds) *Liquid Film Coating* chapter 11b: 427-462 Chapman and Hall, London, UK.
3. O. J. Romero, W. J. Suszynski, M. S. Carvalho, and L E. Scriven 2004 "Low-Flow Limit in Slot Coating of Dilute Solutions of High Molecular Weight Polymer" *J. Non Newt. Fluid Mech*. **118**: 137-156