Tracking birth of vortex in slot coating flows

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Vortices can be found in many flows associated with industrial processes. They are characterized by the rotational motion of fluid parcels around a common center and can be identified by flow visualization or theoretical and computational methods. Vortices are often treated as undesirable phenomena as they can give rise to potential problems in many industrial processes. In the slot coating process, the presence of vortex may lead to numerous defects in the end product by trapping particles, desorbing dissolved gases, causing fluid coagulation, and affecting widthwise uniformity. Thus it is important to map the vortex-free conditions into the parameter space such that unwanted vortex formation can be avoided if possible.

In this study, we examine the vortex birth conditions by means of a simple model describing the coating bead flow of non-Newtonian fluids. The calculated results are validated by the two-dimensional finite element method which solves governing equations augmented with equations describing the vortex birth conditions. It is revealed that the criteria derived from the simple model satisfactorily account for the vortex birth in the actual coating bead flow.