Computational flow analysis for coating die manifold design

Heechan Jung* and Jaewook Nam†

* Microfluidics and Coating Process Laboratory (MCPL)
Department of Chemical Engineering, Sungkyunkwan University
Suwon-si, Gyeonggi-do, 440-746, South Korea
E-mail : hcj0103@gmail.com, web page : http://fluid.skku.edu

† Microfluidics and Coating Process Laboratory (MCPL)
Department of Chemical Engineering, Sungkyunkwan University
Suwon-si, Gyeonggi-do, 440-746, South Korea
E-mail : jaewooknam@skku.edu - Web page : http://fluid.skku.edu

ABSTRACT

A variety of products, such as battery electrodes, solar cell panels, and mobile displays, require thin and uniform films to satisfy their specifications. The continuous liquid coating process, especially the slot coating method, can produce such thin films with precise controlling the thickness in high speed.

The coating liquid is pumped to the slot die that has a large cavity inside, which is called the die manifold. Conventionally, the role of the manifold is distributing the liquid to maintain a high degree of uniformity in the cross-flow direction. The distributed liquid flows into the feed slot and ejects onto a moving substrate to form a thin wet film. Recently, significant demands on high-performance films usually require extremely thin film or highly loaded multi-functional nano- and micro-particles inside the liquid. Such requirements include 1) damping external disturbances, e.g., flow rate oscillations from a gear pump, and 2) controlling particle concentrations uniformly under complex flow patterns, e.g., recirculation or contraction flows. Apparently, new design principles are required, and computational fluid mechanics are crucial in analyzing complex flow patterns.

Here, we analyze three-dimensional suspension flows inside a coating die manifold numerically. Mass and momentum conservation equations coupled with a particle transport equation are solved by a space-time finite element method with Galerkin-least squares stabilization for large scale computations. Because there exist high shear rate regions inside a die manifold, we used a particle migration model by *Phillips et al.* (1992) which can explain the diffusive particle fluxes under the nonhomogeneous shear rate flows.

REFERENCES

[1] R.J. Phillips et al, "A constitutive equation for concentrated suspensions that accounts for shear-induced particle migration", *Physics of Fluids A: Fluid Dynamics*, Vol. **4**, pp. 30, (1992).

[2] M.Behr and T.E. Tezduyar, "Finite element solution strategies for large-scale flow simulations", *Computer Methods in Applied Mechanics and Engineering*, Vol. **112**, pp.3-24 (1994)