Coating Design with **FLOW-3D**

### Applications
- Slide Coating
- Slot Coating
- Two-layer Clot Coating
- Multi-layer Slide Coating
- Dip Coating
- Curtain Coating
- Spin Coating
- Gravure Printing
- Roll Coating
- Drying

### Why FLOW-3D?
**FLOW-3D** simulations give engineers insight into their coating designs. **FLOW-3D**’s models simulate surface tension gradients due to temperature variations (Marangoni effect), heat transfer, vaporization, condensation, solute transport and density-driven flows.

### Advantages
- Transient, Free-Surface Flows
- Surface Tension with Wall Adhesion
- Fluid Breakup and Coalescence
- Moving, Wetting and Non-Wetting Surfaces
- Dynamically Computed Fluid-Solid Contact Lines and Angles

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### Wet-Start Slot Coating
Wet-starting of slot coating aids the wetting process and results in less waste. With **FLOW-3D**, users can calculate an approach speed that will not cause buildup of liquid on the upstream surface of the die, improving performance and reducing start-up time.

### Multi-Layer Slide Coating
**FLOW-3D** can be used to model a variety of multi-layer coating processes. Multi-layer coating allows engineers to coat many layers at once. Using **FLOW-3D**, engineers can achieve uniform interlayers without causing deformation. By helping determine the windows for operability and for quality, **FLOW-3D**’s reliable results allow for a faster and more consistent coating process.

### Start-up of the Coating Process
Getting the start-up process right is critical to the manufacturing process. **FLOW-3D** simulates discontinuous start-ups, saving material costs and speeding up production. **FLOW-3D** uses a simple structured mesh and incorporates powerful methods such as TruVOF and FAVOR™ making start-up problems easy to tackle.

**FLOW-3D** simulation of multi-layer coating

*A simulated three-layer slide coating process shows the start-up over a period of 30 ms. The colors indicate the liquid viscosity, which varies from 7 to 20 poise (lowest to highest is shown in blue to red), as it slides down the 2.2 mm long die surface.*

**Wet-start of slot coating:**

*Web Speed: 13.3 cm/s*
**Capabilities**

Droplet Impact • Surface Tension • Dynamic Contact Angles • Wettability
Non-Newtonian Viscosity • Rivulet Formation • Particles • Evaporation Residue

**3-D Drying Simulations**

Drying is a critical part of the coating process—a well-applied coating can be completely undone by drying defects. During drying, temperature and solute gradients can drive flow within the coating due to density and surface tension gradients, which can potentially destroy the coating quality.

A good example is the motion of suspended solids in a drying drop on a surface being drawn towards the contact line, i.e., the “coffee ring” problem. **FLOW-3D** allows such drying-induced flows to be simulated and reduces time spent on costly physical experimentation.

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**Porous Media Model**

- Distinct saturation front or continuously varying saturation
- Complex geometries with varying porosity, permeability and wettability
- Heat transfer between fluids and solids
- Anisotropic properties
- Hysteresis—wettability varies with saturation history

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**Evaporation Residue Model**

3D view of residue formed from toluene after drying (magnified 30x)

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**Fingerling in Liquid Films**

Comparison of simulation vs. actual fingerling in liquid films on vertical surface. 0° contact angle on the left and 70° contact angle on the right.

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**Techniques**

**Advanced Fluid Surface Modeling**

TruVOF, **FLOW-3D**’s method for modeling fluid surfaces goes beyond the traditional Volume of Fluid (VOF) techniques to achieve the most accurate tracking of fluid surfaces and to apply the proper dynamic boundary conditions.

**FAVOR™ Makes Modeling Flow in Complex Structures Easy**

The FAVOR™ (Fractional Area/Volume Representation) method permits true representation of complex geometry in a simple Cartesian mesh. This permits rapid and easy mesh generation even for intricate shapes.

**Enhanced Modeling of Detailed Regions**

With Multi-Block meshing capabilities in **FLOW-3D**, users can easily and quickly capture complex geometries and apply varying degrees of resolution for sharper modeling.