Flow Science
Coating Design with *FLOW-3D*

Applications in Coating Design with *FLOW-3D*:

- Slide coating
- Slot coating
- Two-layer slot coating
- Multi-layer slide coating
- Dip coating
- Spin coating
- Curtain coating
- Gravure printing
- Roll coating
- Drying

The *FLOW-3D* Advantage

- 3-D Simulations
- 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

FLOW SCIENCE

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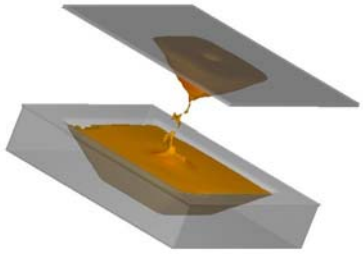
FLOW-3D simulations give engineers insight into their coating designs. ***FLOW-3D***'s models simulate surface tension gradients due to temperature variations (Marangoni effect), heat transfer, vaporization, condensation, solute transport and density-driven flows.



With ***FLOW-3D***, you can:

Increase production

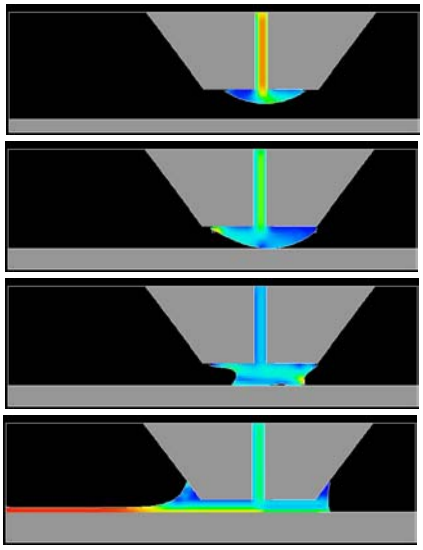
Minimize waste

Avoid product defects

Reduce costs

Start-up of the Coating Process

Getting the start-up process right is critical to the manufacturing process. ***FLOW-3D*** is a 3-D transient CFD package that 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.



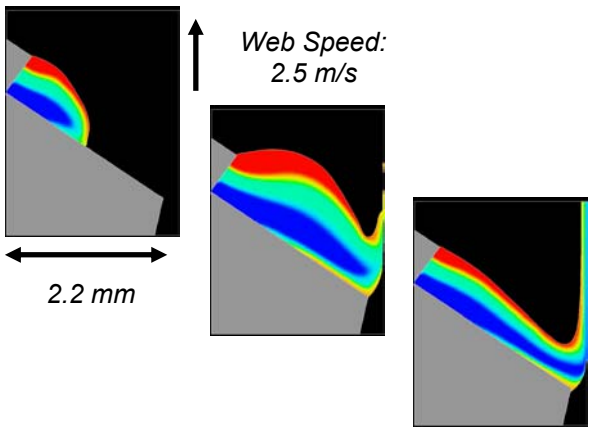
Wet start of slot coating: Web Speed: 13.3 cm/s

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

Multi-layer coating allows engineers to coat many layers at once. Using ***FLOW-3D*** engineers can achieve uniform inter-layers 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.



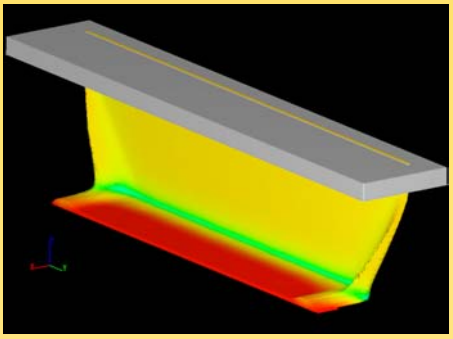
***FLOW-3D* simulation of multi-layer coating**

*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 cpoise (lowest to highest is shown in blue to red), as it slides down the 2.2 mm long die surface. **FLOW-3D** can be used to model a variety of multi-layer coating processes.*

How Does *FLOW-3D*® Work?

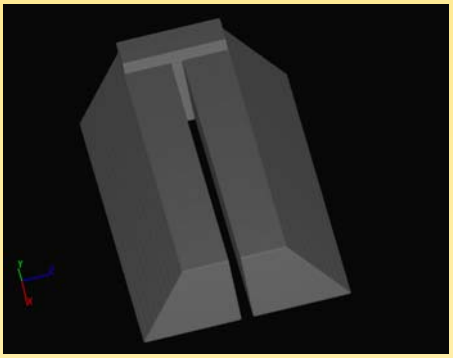
Advanced Fluid Surface Modeling

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.



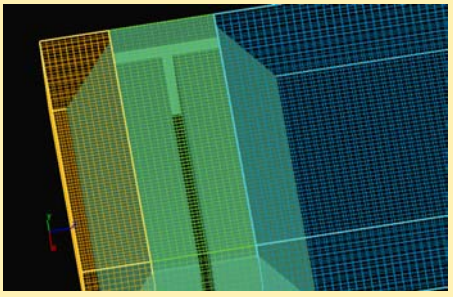
FAVOR™ Makes Modeling Flow in Complex Structures Easy

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.



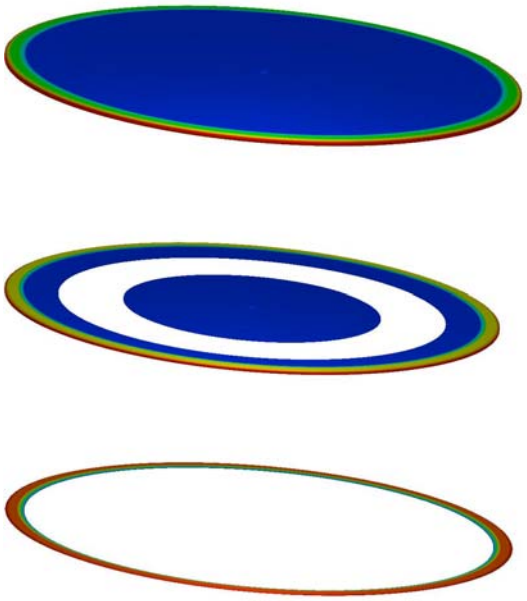
Enhanced Modeling of Detailed Regions

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.

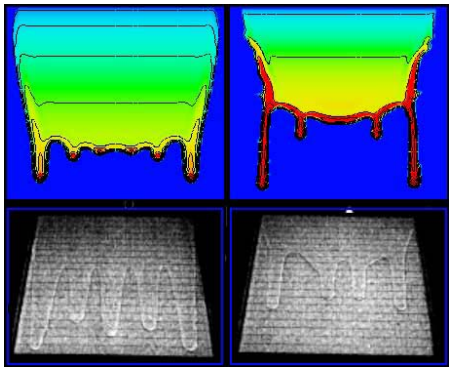


3-D Drying Simulations

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***'s broad range of physical models allows such drying-induced flows to be simulated and reduces time spent on costly physical experimentation.



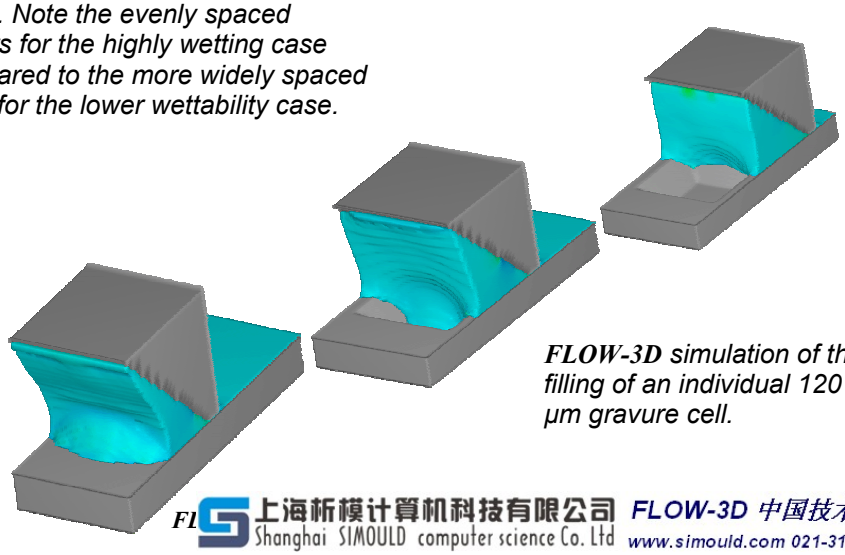
Above is a series of images showing a 1.8cm drop of water containing suspended solids which is evaporating in air. The color indicates the concentration of deposited solid. The concentration of solid builds at the perimeter of the drop due to the pinning effect of the deposited solids and the enhanced evaporation there.



Comparison of simulation vs. actual fingering in liquid films on vertical surface. Left image and simulation shows the case for a 0° contact angle; on right a 70° contact angle. Note the evenly spaced fingers for the highly wetting case compared to the more widely spaced ones for the lower wettability case.

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



FLOW-3D *simulation of the filling of an individual 120 μm gravure cell.*

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