Motivation and Approach

We are interested in understanding the physics for 3D metal additive manufacturing; a process heavily influenced by surface tension, temperature, and metal composition. The heat from the laser and the surfactants within the metal affects the surface tension and thus the flow of the melt pool. Controlling these factors may be critical for quality of 3D printed parts or welded joints.

The newly developed fully implicit, high order, Reconstructed Discontinuous Galerkin (rDG) method is used inside the Arbitrary Lagrangian and Eulerian 2D and 3D (ALE3D) multiphysics simulation package developed at LLNL to accurately capture the surface tension effects. The code demonstrates capabilities of capturing complicated physics.

Concentration Effects – Tears of Wine

Water has a high surface tension, ethanol does not, as ethanol evaporates from the wine surface the water molecules increase the surface tension creating a gradient. The wine responds by climbing up the glass to reduce the surface tension.

Marangoni Flow

- Driven by surface tension effects
- Surface tension depends on temperature, its gradients, and chemical composition
- Surface thermocapillary action changes sign at the critical point

The flow field is dependent on mass gradient, critical temperature, and surface tension. The surface tension decreases with increasing temperature until the melt reaches the critical temperature, at which the surface tension changes direction (graph to right).

Future Direction

Analysis of results will continue for a range of problem conditions including convergence studies, and understanding laser size and power. A soon to be available preconditioner for the rDG model will provide efficient simulation at high mesh resolution. It is also desired to determine the effect of surfactants more thoroughly by examining what occurs when the surfactants are not uniformly distributed throughout the simulation. Adding mass transport for the surfactant particles will give a more accurate picture of the true flow and surfactant influence.

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