Numerical analysis of thermal convection in a liquid film on the uneven surface

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When a thin liquid film on a substrate is considered, a surface tension gradient on the gas/liquid interface causes a flow. In addition, temperature gradient inside a fluid can also cause density gradient to cause flows. Both phenomena usually can occur at the same time, which is one type of thermal convection. In general, such convection patterns cause undesired coating defects during drying process. This phenomenon has been deeply investigated for flat substrate, which is also called Bénard-Marangoni convection. However, only few studies are done so far for uneven substrates in spite of its practical significances. As the substrate shape deviates from flat, the temperature profile inside the film is also affected and can induce unique and complex patterns that can be distinguished from a thermal convection on the flat substrate. In this study, we performed two-dimensional finite element computations over a sinusoidal shaped substrate. We observed such convection pattern changes, as varying the amplitude and periodicity of sine wave. Identified flow patterns were classified with respect to operating conditions and geometrical shapes.