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Models for Bread Baking: Moisture Transport and Diffusive Instability

In this talk we discuss two related multiphase models for simultaneous heat and mass transfer process during bread baking. Our main objective is to provide an explanation and a remedy to the observed erroneous and/or divergent results associated with the instantaneous phase change model used in the literature. We propose a reaction-diffusion model based on the Hertz–Knudsen equation, where the phase change is not instantaneous but determined by an evaporation/condensation rate. A splitting scheme is designed so that a relation between these two models can be established and the non-intuitive numerical instability associated to the instantaneous phase change model can be identified and eliminated through the reaction-diffusion model. The evaporation/condensation rate is estimated from balancing these two models and reasonable and consistent results are produced by using the estimated rate. For the evaporation/condensation rate beyond the estimated value oscillation, solutions with multiple regions of dry and two-phase zones is observed. We show that these are caused by an instability intrinsic to the model (which we call diffusive instability) and the effect of the diffusive instability to the bread-baking simulation is also explained through a linear stability analysis and supported by numerical tests.

This is a joint work with P. Lin and W. Zhu.