57c Transport Limited Pattern Formation in Catalytic Reactors

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We consider a two-phase system of n-particles in a catalytic reactor and assume that the fluid phase is well-mixed and a single exothermic reaction of the type A → B occurs in the solid phase. The stability of the uniform state in the solid phase with respect to perturbations in the solid and fluid phases was examined to determine the possibility of non-uniform states in the solid phase. The linear analysis revealed that steady non-uniform patterned states emerge from the unstable middle branch of the uniform state of the particles. These patterned states correspond to some of the particles in the high temperature state while the other particles either in the intermediate or low temperature states. For all the cases studied (n = 2, 3 or 5) the patterned states always emerge as unstable branches but become stable after one or two limit point bifurcations. Moreover, the stable branches emerge from the unstable branches after going through a hysteresis (on the patterned branch). For the case n=2, the non-uniform states appear sub-critically near the ignition point and super-critically near the extinction point, while for n > 2, the non-uniform state are either supercritical or transcritical near the ignition point and sub-critical or transcritical near the extinction point. For a fixed set of kinetic constants, the range of Damköhler numbers over which the stable patterned states exist increases with increased heat and mass transfer resistances between the phases or with decreased heat conduction between the solid particles. These transport limited stable patterns can only exist between the ignition and extinction point of the homogeneous branch. In addition, the temperature of any non-uniform state never exceeds the adiabatic temperature rise. Analogous results will also be presented using the one and two dimensional continuum models for the solid phase in the catalytic reactor.