Soutenance de these de LUI Deqi
"Thermomechanical modeling of the solidification process of an aqueous urea solution"

Résumé :
Many liquids involve a change in volume when they freeze. For water and some aqueous solutions, the volumetric expansion during solidification may invoke a series of mechanical issues. In the automobile industry, the security of tanks of diesel vehicles is challenged by the phase-change expansion (PCE) of the freezing aqueous urea solution (AUS) in cold conditions. The work investigates the liquid solidification problem both thermally and mechanically. An analytical study of a spherical inward solidification model is performed based on a non-isotropic PCE assumption, which is confirmed by a series of pressure measurement experiments. Finally, an efficient coupled thermo-mechanical finite-element (FE) method is proposed to evaluate the thermal stress, strain, displacement and pressure in solidification problems with highly nonlinear constitutive relations. Three particular methods for treating the liquid phase with fixed-grid approaches are introduced. The thermal stress is computed at each integration point by integrating the elasto-viscoplastic constitutive equations with non-isotropic PCE. Then, the boundary value problem described by the global FE equations is solved using the full NR method. This procedure is implemented into the FE package Abaqus via a UMAT subroutine. The numerical model is validated first by the analytical solutions and then by a series of benchmark tests. In the end, a realistic study case on a real-size AUS storage tank is introduced. Advantages and limitations of the numerical method in the application are evaluated.