Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Modeling deformation bands in thermal softening and fluid infiltrating porous solids at finite strain

Sun, WaiChing, wsun@columbia.edu, Columbia University, United States; Tamagnini, Claudio, Università degli Studi di Perugia, United States

ABSTRACT

Onset and modes of deformation bands are often influenced by nonmechanical loading triggered by seepage of pore fluid and thermal effects. Experimental evidence has established that temperature changes can alter the shape and size of the yield surface and cause shear band to form in geomaterials that are otherwise stable. Understanding this thermo-hydro-mechanical responses are important for many engineering applications, such as carbon dioxide storage and extraction of hydrocarbon in which hot or cool fluid are often injected into deep porous rock formations. The purpose of this research is to simulate this coupled process using a thermoporoplasticity model with extended hardening rules. A key feature of this model is that evolution of internal variables is governed by both the plastic dissipation and the change of temperature. An adaptively stabilized monolithic finite element model is proposed to simulate the fully coupled thermo-hydro-mechanical behavior of porous media undergoing large deformation. We first formulate a finite-deformation thermo-hydro-mechanics field theory for nonisothermal porous media. The corresponding (monolithic) discrete problem is then derived adopting low-order elements with equal order of interpolation for the three coupled fields. A projection based stabilization procedure is designed to eliminate spurious pore pressure and temperature modes due to the lack of the two-fold inf–sup condition of the equal-order finite elements. To avoid volumetric locking due to the incompressibility of solid skeleton, we introduce a modified assumed deformation gradient in the formulation for nonisothermal porous solids. Finally, numerical examples are given to demonstrate the versatility and efficiency of this model.