Simulation of Geomechanical Reservoir Behavior During SAGD Process Using COMSOL Multiphysics®

X. Gong[1], R. Wan[1]

[1]University of Calgary, Calgary, AB, Canada

Abstract

Steam-Assistant-Gravity-Drainage (SAGD) has become one of the most commonly used thermal recovery processes to extract heavy oil from oil sand reservoirs, especially in Northern Alberta, Canada. However, interbedded shales (IBS) in the reservoir act as barriers due to their low permeability and as such hinder the progression of the steam chamber above the injection well. The integrity of the cap rock above the reservoir also needs to be ensured to prevent steam breakthrough. Therefore, a comprehensive investigation of coupling between thermal multiphase fluid flow and geomechanics is required in modeling SAGD processes to properly address the above issues.

In this paper, the THM (Thermo-Hydro-Mechanical) behavior of the reservoir was studied through a proper constitutive modeling of the porous media. Specifically, a generalized density-stress-fabric dependent elasto-plastic model with stress-dilatancy and plastic damage as main ingredients was implemented into COMSOL Multiphysics®, a commercial finite element programming environment, to model geomechanical behavior during SAGD process. The user defined PDE models together with solid mechanics were adopted to simulate such strongly coupled processes. Figures 1 and 2 show the maximum plastic strain for the homogeneous and non-homogeneous reservoir cases, respectively. For the homogeneous reservoir case, localized shear zones form in a "V" shape from the top of reservoir, while a network of multiple localized shear zones develop in the non-homogeneous case.

The present study shows that interesting failure patterns in the form of strain localization can be captured in a reservoir within a multiphase flow analysis coupled with an advanced elasto-plastic model with density-stress-fabric dependencies. Such a failure analysis performed as a coupled multiphysics problem in COMSOL provides insights that will help optimizing the SAGD process.

Figures used in the abstract

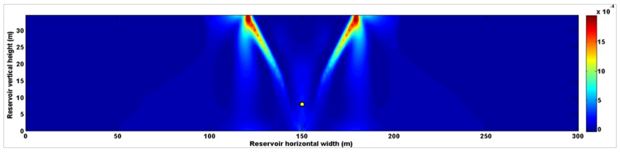

Figure 1: Plastic shear strains from 798 to 859 days (homogeneous reservoir case).

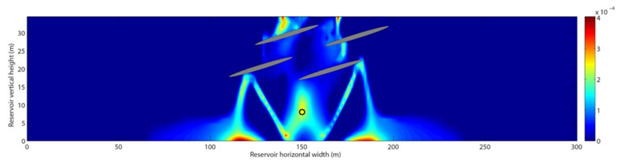

Figure 2: Plastic shear strains from 996 to 1080 days (non-homogeneous reservoir case).