Integration of Microseismic Data and an Unconventional Fracture Modeling Tool to Generate the Hydraulically Induced Fracture Network: A Case Study from the Cardium Formation, West Central Alberta, Canada

Xin Yu, Jim Rutledge, Scott Leaney, Jianchun Sun, Piyush Pankaj, Xiaowei Weng, Hitoshi Onda, Michael Donovan, Jacob Nielsen, Schlumberger, and John Duhault, LightStream Resources

Abstract

Geometries of fractures, both natural and hydraulically induced, are commonly represented by a discrete fracture network (DFN) in reservoir simulations. Although microseismic data is the best diagnostic tool for imaging the volume of rock fractured, its incompleteness in representing the total deformation presents a challenge in interpreting the complex fracture networks from hydraulic fracturing. While microseismicity under-represents most of the tensile fracture volume created, the hydraulic fracturing modeling software can, in principle, generate the full hydraulically induced fracture network. Unlike other simulation methods that assume simple planar geometry, the unconventional fracture model (UFM) simulates complex fracture structure, but requires a reliable description of natural fractures in the formations with determined locations of the fracture patches as the input. The DFNs derived from measurements such as well bore image logs and seismic properties have large uncertainties due to gross differences in scale of measurement compared with the hydraulic fracture process. Microseismic data can be used as direct evidence of hydraulically induced fracture propagation to calibrate the fracture model, as a constraint to the DFN used in UFM to recover information such as the effective surface area, aperture and retained permeability.

This study presents a workflow to use the microseismic data including source mechanism information in UFM for complex fracture calibration and simulation. A dual well monitoring data set from 8-stages of a 30 stage sliding-sleeve hydraulic fracturing treatment in the Cardium formation, west central Alberta, Canada is used as a case study to demonstrate the workflow. First, moment tensor inversion is conducted to estimate the fault plane solutions. Second, a DFN is extracted from the microseismic event locations and fault plane solutions. Third, rheology and geomechanics models generated from the well logs from the offset wells are calibrated by applying the DFN from the second step as the input into UFM to match the microseismic geometry and treating pressure. Last, the simulated complex fracture networks with full information, such as aperture and conductivity, are input to reservoir simulation for production simulation and reservoir management. This approach is compared with a traditional P3D fracture model. The results shows that using the DFN extracted from the microseismic data reduces the uncertainty of the models input into the hydraulic fracturing modeling and results in better pressure and geometry fitting.

Introduction

Conventionally, the hydraulically induced fracture has been assumed as a bi-wing planar fracture. Several models, such as PKN (Perkins and Kem, 1961) and Planar 3D (P3D) (Mack and Warpinski, 2000), have been introduced to describe the relationships between the pumping parameters and the fracture geometry. The geometries of fracture length, height and aperture can be simulated through solving several coupled equations of governing the geomechanics