Hydraulic fracturing in reservoir rocks: Experiment & simulation

Srutarshi Pradhan

SINTEF Petroleum Research
9th Euroconf., October 19, 2011

Collaborators:
Jørn Stenebråten, Haitham Alassi, SINTEF
Alex Hansen, Bjørn Skjetne, NTNU

Funding: NFR; through CLIMIT Programme
Objective: To improve our knowledge on hydraulic fracturing in porous media including fracture propagation & pattern.

Methods: We use different methods at different length scale
1) Fracturing test on core sample
2) PFC at pore scale
3) Beam-lattice model at mesoscopic scale
4) MDEM at macro scale (even reservoir scale)

Application:
1) Planning safe & efficient drilling (geothermal, shale-gas)
2) Reservoir characterisation (CO₂ storage)
3) Prediction of well collapse & leakage
4) Enhance production by increasing permeability.
SINTEF Laboratory

TerraTek system

MessTek system
Triaxial cell instrumentation

- Pore pressure (fluid flow)
- Steel piston
- Acoustic transducer
- Sintered plate
- Sleeve
- Axial strain LVDT
- Directions of radial strain measurements

Sample
Test 1: Red sandston
Medical scan image
CT Scan Image
Amp. Vs. time
AE data: Amplitude distribution
AE data: Location
Test 2: Limestone
CT scan image
Amp vs. Time
AE data: Amplitude distribution
Event location
Pore scale modeling: using PFC

- PFC (Particle Flow Code) is a code based on the Discrete Element Method (DEM).
- PFC solves the equations of motion directly.
- In each time step, the movements of all the particles are calculated according to the motion law, and the forces at all the contacts are calculated according to a contact law.
Hydraulic fracture: PFC 2D
Fracture modeling at mesoscopic scale

Bjørn, NTNU

Elastic beam lattice model

Fracture pattern and pressure distribution

s0039.avi
Macro-scale modeling: MDEM
Haitham, SINTEF

Fixed boundaries

$\sigma_h - \sigma_d = 2.0 \text{ MPa}$
Pore pressure $P_i = 1.0 \text{ MPa}$

Wellbore

Well injection pressure $P_{inj} = 2.0 \text{ MPa}$

Fixed boundaries
Effect of Poisson’s ratio

Poisson’s ratio = 0.25

Poisson’s ratio = 0.4
Conclusions

- **Lab test on core sample:** Fracture pattern depends on strength & brittleness of the cores.

- **PFC:** Ratio between tensile & shear strength influences fracture pattern & numbers.

- **Beam-lattice:** Disorder in strength and pressure distribution are responsible for different fracture pattern.

- **MDEM:** Number of fracture branches depends on Poisson ratio.

- **Effect of pre-existing fractures ??**