Hydraulic Fracturing Basics

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Outline

- General hydraulic fracturing
- Why we do it
- Evolution of fracturing techniques
- How it works
- Conventional vs. unconventional reservoirs
- Resources
General Hydraulic Fracture Process

- Inject a “pad” (fluid, no solids) at a sufficient pressure and injection rate to breakdown (crack) the formation;
- Inject a “slurry” (fluid w/ proppant) to propagate and develop the fracture;
- Shut down the injection at the surface and allow the fracture to close around the injected proppant;
- Flow back the well to clean up the fluids; and,
- Start producing the well.
Producing Zone
Oilfield Stimulation History

- Acidizing and nitroglycerin were the main stimulation services provided until the late 1940’s.
- In 1947, the first intentional fracture treatment took place in the Hugoton gas field of western Kansas. It was pumped in the Klepper Gas Unit No. 1 well and was called it a “hydrofrac”.
Hydraulic Fracturing

- Critical completion technique in low permeability sands
- In 1989, it was estimated that 35-40% of all wells completed worldwide were fractured and in the United States and that 25-30% of reserves would not be economically producible without hydraulic fracturing
- In certain areas, +95% of wells are fractured
Why we do it?

- Bypass near-wellbore damage
- Extend a conductive channel into reservoir (increases/stimulates natural productivity of well)
- Alter flow in formation
- Reservoir management
Fracturing Fluids

- Ideal properties
  1. Adequate viscosity
  2. Good fluid loss control
  3. Low residue
  4. Low friction pressure
  5. Temperature and shear stable throughout the treatment
  6. Non-damaging to formation
  7. Easy to prepare
  8. Easy to recover
  9. Cost effective
Fracturing Fluids

- Main types of fluids
  - Water-based (slickwater)
  - Oil-based
  - Acid-based
  - Multiphase (foams)
Dimensionless Fracture Conductivity

\[ F_{CD} = \frac{k_f w}{k X_f} \]

- \( k_f \) = fracture permeability, mD
- \( w \) = width of fracture, ft
- \( k \) = permeability of formation, mD
- \( X_f \) = fracture half-length, ft
Generic Proppant Types

- Sand
- Artificial or ceramics
Proppant Comparisons - Shape

- **White Sand**
- **Artificially Manufactured**
Proppant Comparisons - Shape

- Quality ceramics
- Premium sands
- Many sands

API RP60, From *Stratigraphy and Sedimentation*, Krumbein and Sloss
Simplified cross-sectional view of the fracture

1 - Fracture initiation as pumping of fluid is started

2 - Fracture propagation with fluid

3 – Proppant (usually sand) enters hydraulic fracture as it is suspended in the fracturing fluid

4 - Proppant advances further into the fracture as pumping continues

5 – Proppant advances further in the fracture and may reach the tip of the hydraulic fracture as fluid continues to leak into the permeable formation

6 – Pumping of the fluid/proppant mixture is stopped and fluid continues to leak away into the permeable formation

7 – Formation closes on proppant and a conductive path remains in the reservoir
Conventional vs. Unconventional

Resource Triangle

- Conventional Reservoirs: Small volumes that are easy to develop
- Unconventional: Large volumes that are difficult to develop

From Holditch 2001
Multiple Vertical Completions

From Green 2006
Vertical vs. Horizontal Completions

Horizontal well system

Vertical well system

From Miskimins 2008
References

- www.energyindepth.com/PDF/At-A-Glance.PDF
- www.all-llc.com
- www.garfield-county.com
QUESTIONS?