Sand Control For Horizontal Wellbores

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Vertical Wellbores

- Old approach was to sump our tubing below the perfs to act as a natural gas anchor
- The cellar in the wellbore would act as natural place where sand could fall and collect
- As long as the sand did not accumulate near your tubing or your perfs you were in good shape
- Unfortunately these principals no longer apply to Horizontals
Agenda

- Overview of Trilogy’s Kaybob North Montney oil development
- Where the sand is coming from?
- Where is sand accumulating?
- Horizontal plugging and theory
- Sand cleanouts
- New downhole configurations to prevent sand
- Questions
Kaybob Montney Oil Development

- Located 2.5 hours NW of Edmonton by Fox Creek, AB
- 107 wells drilled into the pool since 2010
- 29 wells were drilled in 2014
- In 2014 the pool averaged 10,214 boe/d (62% Liquid Volumes)
- Cumulative Production as of Feb 2015 is 13,050,662 boe (66% Liquid Volumes)
Kaybob Montney Oil Development

- Wells are currently being completed with:
  - 7” production casing
  - 4.5” PackerPlus liner system
  - 20-30 stages 10 tonne fracs
  - Mile long horizontals
  - Pump jacks are the main artificial method

- Original development had us drill 4 wells per section, after a few years of development we moved to a 8 well per section program by drilling infills off pre-existing pads
Kaybob Montney Oil Development

North Kaybob Montney-Workovers

- Sand issues in the field start
Sand Sources & Accumulation

- +95% of all sand being seen at surface and in downhole equipment is 20/40 frac sand
  - Fracing directly in offset wellbores through natural fractures in the reservoir
  - Slow accumulation of sand that is coming out of the fractures with production
  - Sand from the original frac that never made it into the reservoir.
- Sand is being deposited in three areas
  - Separators & pipelines at surface
  - Pumping equipment
  - The horizontal itself
Frac Interference Example

- The original horizontal wellbores were drilled in 2011 and have been producing for the longest length of time.
- In Q1 2014 we drilled 3 infill wells into section 2 to decrease our well spacing from 400m to 200m.
  - 1st Offset was 102/05-02
  - 2nd Offset was 102/13-02
  - 3rd Offset was 102/12-02
102/05-02 Frac Interference

Frac Stages 1-12

- Stage 1: 10:10
- Stage 2: 10:45
- Stage 4: 11:40
- Stage 6: 12:25
- Stage 7: 12:45
- Stage 10: 13:40
- Stage 12: 14:10

Surface Solutions
Shut the well in 2 days before hand to build up pressure
Shut the well in 2 days prior before the Frac on the offset.
During the frac we injected 200 L/min of produced water down the casing to pull the well on vacuum so there was a solid hydrostatic head on the wellbore.
102/12-02 Frac Interference

Frac Stages 1-12

Trilogy Energy
100/05-02-064-18W5/00
Start Test Date: 2014/04/10
Final Test Date: 2014/04/11
Preventing Frac Interference

- Working with geoscientists to identify areas that have natural fractures that could be prone for communication
- Avoid infill situations where we could see drainage
- Injecting produced water down the casing to maintain pressure on the offsets while fracing the infills.
Other Sand Sources

- Slow accumulation of sand that is coming out of the fractures with production
  - Looking into resin coated sands

- Sand from the original frac that never made it into the reservoir
  - Figure out better ways to perform initial cleanouts

- Formation sand from the sandstone reservoir itself
  - Accounts for less than 5% of all sand seen
Sand Accumulation

- Where is sand building up?
- Any place that features a velocity drop
  - Surface equipment
    - Separators
    - Pipelines
  - Pumping equipment
    - In the pump
    - In the gas anchor
  - Horizontal itself
Surface Facilities

- Where are we installing sand separators
  - High pressure wellbores
  - High GLR +2000 m³/m³ wells
  - High flow rates +80E3m³/d
  - “Flumping” wells that produce significant volumes up the casing
- The main goal is to avoid eroding out valves and line breaks
- Typically the sand separators are phased out after a few months of production
Production Equipment-Gas Anchor

- Poor Boy Gas Anchor
  - CASING
  - TUBING
  - PLUNGER
  - PUMP BARREL
  - SEATING NIPPLE
  - INTAKE
  - DIP TUBE
  - MUD ANCHOR
  - PRODUCTION ZONE

- Packer Style Gas Anchor
  - RODS
  - CASING
  - PUMP
  - TUBING PERFS
  - SUCTION TUBE
  - PACKER
  - PRODUCTION ZONE
Gas Anchor-Veraperm Sand Screen

- Sized to prevent 20/40 sand from entering the tubing
- Placed below the packer on the packer style gas anchor
- Used as the intake screen on the poor boy gas anchor
Gas Anchor-Veraperm Sand Screen
Horizontal Wellbores

High-Side: 321.0°
Deviation: 092.9°

167°F

30/10/2012 12:02:08
03:05:49

6473.55ft
**Vertical Section: Stokes Law**

\[
F_{net} = \left( \rho_{fluid} - \rho_{particle} \right) \frac{\pi g D^3}{6} + C_d \frac{\pi}{4} D^2 \rho_{fluid} \frac{V^2}{2}
\]

- **D** = Diameter of sand particle
- **V** = Velocity of the fluid flow
- **\( \rho \)** = Density
- **g** = Gravitational constant
- **\( C_d \)** = Drag Coefficient for a sphere is 0.47

**Assumptions**
- Spherical particles
- Smooth surface
- Homogenous composition
- Particles don’t interfere with each other
- Laminar flow

**The Big Takeaway: Velocity Is King**
Pseudo-Homogenous Suspension: For high velocity flows where sand could be distributed evenly throughout the fluid and gas phase.

Heterogeneous Suspension: Most of the sand will move along the bottom part of the horizontal pipe in the liquid phase, with increased concentration at the lower part of the pipe.

Moving Beds: Particles move as a continuous bed of sand along the bottom of the horizontal pipe, no particles are stationary.

Dunes: For low fluid velocity flows where the sand at the bottom of the pipe will remain stationary which overtime other particles will build around it to form dunes. The dunes will move their way down the pipeline.

Stationary Beds: For the very lowest velocities, top surface of the sand is smooth with some ripples which will indicate higher velocities.
Horizontal Sand Movement

- Sand is building up in the horizontal and gradually moving to accumulate
  - Low lying sections of the horizontal
  - Moving with the fluid flow to the heel of the well
- Velocity drops in the fluid from the 4.5” liner to 7” casing will further lead to sand to collect
- Overtime sand buildup will impact production volumes by increasing pressure drops in the fluid
Horizontal Plugging

Sudden Drop In Production Rates → Confirmation with a Dyno and Fluid Level → Water Injection Down The Backside → Sand Cleanout Operation
Horizontal Plugging Example

103/03-07-064-18W5/00
• Drilled and Completed in Q1 2014
Horizontal Plugging Example

103/03-07-064-18W5/00 Production

- Green line: Oil Production
- Red line: Gas Production
- Blue line: Water Production
Horizontal Plugging Example

- Oct 17\textsuperscript{th}, 2014: We took 40m3 of produced water and injected it down the annulus of the wellbore.

- Oct 19\textsuperscript{th}, 2014: The wellbore was tested and it made 105m3 of oil, 19E3M3 of gas and 22m3 of water.

- We believe that the velocity of the water simply busted up the dunes/sand beds that sit in the heel of the wellbore and redistributed the sand to allow the well to produce.

- Flushes on other wellbores where the fluid level and production has dropped dramatically have worked equally well.
Water Injections

\[ Re = \frac{\rho V D_H}{\mu} \]

- We want to create a turbulent flow down hole with the water in order to pick up and redistribute sand particles.
- Water works better than oil due to its higher fluid density allowing us to create a more turbulent flow.
- Using gels to hold sand in suspension in the fluid won’t work because the gelled fluid won’t pick up the sand initially.

- Re=Reynold’s Number
- \( D_H \)=Hydraulic diameter of the pipe
- \( V \)=velocity of the fluid
- \( \rho \)=density of the fluid
- \( \mu \)=viscosity of the fluid
Sand Cleanouts-Examples

- Flushes can work to a degree but some sand packs won’t release or are too large
- Other sand cleanout methods are needed
  - N2 and water cleanouts with endless tubing
  - Sand bailer with jointed pipe
  - Jet-Vac cleanouts with concentric coil
Sand Cleanouts

- **Coiled tubing cleanouts**
  - Pro: Able to get deeper into your horizontal if your ports are not milled out
  - Pro: Able to move large amount of sand without doing multiple trips
  - Con: Have to pull tubing due to bull plug on the end
  - Con: Tough time getting the sand to surface due when reservoir pressures are low

- **Sand bailer with jointed pipe**
  - Pro: Easy to get sand to surface
  - Pro: Good for cleaning out the heel
  - Con: Limited by the physical space of bailer to move sand
  - Con: Limited by the OD of the tool for reaching into the horizontal

- **Jet-Vac cleanouts with concentric coil**
  - Pro: Some of the best results of removing sand deep in the horizontal
  - Con: Limited amount of concentric coil available in Western Canada
  - Con: OD of the tool on the end of the coil restricts how deep we can get into the horizontal when ports have not been milled out
Post Coil Cleanout

High-Side: 340.5°
Deviation: 084.9°

43°C

15/07/2012 1:05:02 PM
03:49:17

2177.10m
Moving Forward

We’ve moved ahead and installed 3 Production Plus systems downhole in March, 2015

We’re running a 2 3/8” syphon tube with a seal bore packer on the end, down to the horizontal to increase the velocity of the fluid.

This fluid is then crossed over to the 7” casing and collects in the annulus where it loses velocity and drops out sand.

Sand would then drop out in the annulus and collect in the heel where it would not interrupt the production flow.

Fluid then reenters the tubing and pump and rods would then lift the fluid to surface.

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**Diagram: Fluid Flow Process**

- Fluid Production Will Be Pumped Up Our Tubing
- Downhole Pump
- Rods
- Fluid Enters 2-3/8” Tubing
- Mixed Fluid Stream
- FDVS- Cross Over Tool That Spins Out Fluid
- Gas Production Will Rise Up The Annulus
- Sand Will Fall Out Will Accumulate Outside The Flowpath
Conclusions

• Trilogy’s North Kaybob Montney oil development is seeing sand from 4 sources
  • Proppant from offset fracs through natural fractures
  • Proppant leaking out of the fracs
  • Proppant that never made it into the reservoir
  • Sand from the Montney

• Sand is accumulating
  • In surface facilities
  • In the gas anchor
  • In the horizontal

• The key factor in sand deposition is fluid velocity

• Water flushes seem to make a major impact in clearing out inflow reducing sand dunes

• All three types of sand cleanouts have their strengths and weaknesses

• New downhole configurations need to be looked at to better produce Horizontals
Questions