Advanced Fluid Jet Systems For
Increased Oil and Gas Production
Wellbore Extender

Directed Permeability Channels

From Pre-existing Vertical Wells

- Improve reservoir communication
- Increase production
- Increase reserves

- Up to 100 m in length
- 100% permeability
- Flexible diameter hole
- Penetrate multiple horizons
Wellbore Extender

....Or from Horizontal Wells
Increase drainage area

- fewer wells
- Greater production & recovery rates
Well Stimulation Value Grid

Well Stimulation at a fraction of the cost

Total AFE Cost

Effectiveness = Increased production and recovery

PetroJet Multilaterals

How are your Economics?

Lower costs = Better Economics
Core Sample
Flexible Borehole Configurations
Fluid Jet Drilling

• **Advantages**
  
  • Generally lower cost alternative
  • No weight-on-bit.
  • Can make short radial curves.
  • Can place permeability channels in desired trajectory
  • Multiple configuration options (some)
  • Utilizes less fluid than fracturing.
  • Can be used in loss circulation environments
  • Can drill underbalanced (some)
  • Can utilize variety of fluids (e.g. H₂O, N₂, frac oil, acids, abrasives etc.)
Fluid Jet Drilling

Disadvantages

• Inconsistent performance / Multiple providers / technology platforms
• No tools capable of measuring position / trajectory…yet
• Is not a precision steering instrument.
• Not well understood by industry
• Not effective for deeper wells …..yet
Coiled Tubing versus Hose

**Horsepower**

- Petrojet: 2000
- Competitor: 50

**Flow (Gallons per minute)**

- Petrojet: 250
- Competitor: 0

**Down hole pressure (PSI)**

- Petrojet: 16000
- Competitor: 0
PetroJet® History

• **Bechtal (1970s to early 1980s)**
  - Conceptual design and preliminary engineering
  - Alberta Oil Sands

• **Petrolphysics (early 1980s to 2006)**
  - Research and Development
  - Over 1,000 laterals in hundreds of wells
  - Focus on California heavy oil

• **PetroJet (2006 to present)**
  - Refine and optimize
  - Incorporate new and updated technology
    - Coiled tubing rigs
    - Higher pressure equipment
  - Commercialize
Why lack of previous commercial Success?

• How long did it take for horizontal drilling and fracturing to become accepted practice?

• Need for improvements to pumps and related high pressure equipment e.g. HP threaded pipe, coiled tubing

• Economics
  • Lower cost of support equipment
  • Fluctuating hydrocarbon prices
Recent History

Williams CBM Pilot

✓ Powder Basin, Wyoming
✓ 5 wells – 1,400 – 1,500 ft.
✓ CBM dewatering
✓ 35 ft. laterals x 4 laterals per well.

Result
✓ < 2 days per well including set up and rig move
✓ Up to 95% increase in water production
Recent History

Tight Carbonate – Pilot Well

✓ Banff Formation, Alberta
✓ Suspended Well - No production
✓ Low permeability
✓ 1,770 m depth
✓ Placed 1 x 15m lateral

Result
✓ Preliminary result: Average 1.5 m3/d + 2k m3/day gas
✓ Candidate for additional and longer laterals
**Advantages**

- Delivers higher pressure and flow to nozzle.
- Safety – High pressure flow direct from frac iron to wellhead

**Challenges**

- Workstring movement
- Requires premium thread workstring.
COILED TUBING METHOD

Advantages
- Standard wellhead
- Standard workstring
- No workstring movement

Challenges
- Higher pressure losses
- Surface pressure limits
- Cannot “work” drill string under pressure

Flow down the coiled tubing to drillstring

High pressure wellhead
Standard workstring
Drillstring is controlled by coiled tubing
Fluid flows directly from coiled tubing to drillstring
**HYBRID METHOD**

**Advantages**
- Delivers higher pressure and flow to nozzle.
- Safety – High pressure flow direct from frac iron to wellhead
- Less workstring movement
- Less risk of workstring leaks

**Challenges**
- Not yet field tested

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High pressure wellhead

Drillstring is controlled using wireline, rods or coiled tubing

High pressure workstring

Fluid flow is directed into CT via a flow-through device

Standard workstring

Initial flow through HP workstring

Flow down the coiled tubing to drillstring
PetroJet® Opportunities

Thinking Outside of the Wellbore

Connect
Measure
Manipulate
Opportunities

• Imagine what one could do in a well with PetroJet Laterals:

  • **Connect the formation**
    • Create high permeability conduits (ghost holes)
    • Penetrate barriers and baffles (Injectors and producers)
    • Install permanent lateral liners to tie back to the main liner

  • **Measure the formation**
    • Take samples
      • Oil, water, gas, bitumen or sand
    • Take measurements
      • Orientation, elevation, temperature, pressure, conductivity, gamma ray, porosity, …
    • Place permanent measurement instruments

  • **Manipulate the formation**
    • Smart completions
    • Heat the formation
      • Inject Steam, install electrical heaters, microwaves, …
      • Direct the steam to where you want it.
    • Inject fluids
      • Solvents, biogenic or biological liquids, acids, surfactants, foams, emulsifiers, de-emulsifiers, …
Opportunities

• Directed permeability channels where fracturing is ineffective or impossible.
  • Zones prone to lost circulation/leak offs
  • Zones with pre-existing fractures
  • Unconsolidated sandstone
  • Oil sands
  • Bitumen in Carbonate
  • Zones where natural fracture path is suboptimal

• Greater control over permeability channel trajectory.
• Lower fluid requirements.
• Reduced risk of fluid leak offs.
Opportunities

• Place fractures in optimal locations
• Increase length and effectiveness of fracturing.
  • Reduce flow path tortuosity = reduced friction loss = fractures further from main wellbore.
  • Alternative method for placing multiple fracs along open or cased hole
  • Alternative method for fracs along vertical or horizontal wellbores.
Opportunities

SURVEY TOOL

- Measure the trajectory of the laterals
- Incorporate gamma to log reservoir characteristics away from main wellbore
Technical Benefit Summary

1. Maximize reservoir contact and drainage area
2. Reduce pressure drawdown - mitigate sand influx and water and gas coning
3. Increase steam, water or solvent injectivity
4. Allow higher flow rates at lower pressure drops
5. Intersect natural fractures
6. Connect intervals separated by vertical barriers or permeability contrasts & gradations
7. Multiple laterals at multiple depths
8. Penetrate near wellbore damage, independent of lithology or stress state of formation
9. Utilize fluids to suit formation (e.g. \( \text{H}_2\text{O}, \text{KCl}, \text{acid}, \text{N}_2, \text{CO}_2, \text{abrasives}, \text{etc.} \))
10. Multi-Fracs from toe of laterals
Questions?