Advanced High-Pressure Coiled-tubing Drilling System

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Project Review

Conventional Coiled Tubing

High Pressure Motor

High Pressure Bit
Project Objective

- To develop a high-pressure jet assisted drilling system that uses coiled tubing to convey the fluid to the bit and motor avoiding the problems of leaks that occurs with jointed pipe.
Project Structure

- Phase I – Feasibility study
- Phase II – Development of high-pressure motors, bits and other critical components.
- Phase III – Field testing and commercialization
Phase I & II Results
Coiled-Tubing

- Confirmed feasibility of coiled-tubing system
- Calculated fatigue life of coiled tubing
- Developed improved tubing (QT1200)
<table>
<thead>
<tr>
<th>CT Diameter (in.)</th>
<th>Wall Thk. (in.)</th>
<th>Burst Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.109</td>
<td>20,800</td>
</tr>
<tr>
<td>1.25</td>
<td>0.156</td>
<td>24,160</td>
</tr>
<tr>
<td>1.50</td>
<td>0.175</td>
<td>22,670</td>
</tr>
<tr>
<td>1.75</td>
<td>0.188</td>
<td>20,910</td>
</tr>
<tr>
<td>2.00</td>
<td>0.203</td>
<td>19,800</td>
</tr>
<tr>
<td>2.375</td>
<td>0.203</td>
<td>16,670</td>
</tr>
<tr>
<td>2.875</td>
<td>0.203</td>
<td>13,770</td>
</tr>
<tr>
<td>3.500</td>
<td>0.203</td>
<td>11,310</td>
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</tbody>
</table>
CT Burst Pressure

Burst Pressure (psi)

2.00 inch OD

- QT-1000
- Incoloy-625
- Composite

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CT FATIGUE LIFE

(based on MEI CTLIFE model)

Fatigue Life (trips)

Internal Pressure (psi)

- 1.75"
- 2.00"

QT-1000

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Fatigue Test Machine

CT Sample

Hydraulic Actuator

Straight Bending Form

Curved Bending Form

Pressure Controller

Pump
Fig. 7-2: Tubing Fatigue Tests
(R. Stanley, 2000)

- Actual Cycles for QT-1200
- Model Cycles for QT-1000
- Model Cycles for QT-800

(0.156” Wall)
High-Pressure Motor

- Designed HP power section
- Developed labyrinth seal
- Proved Diamond bearing technology
- Laboratory tested motor
- Manufactured HP PDC bits
Motor Labyrinth Seals

Housing

Fluid Flow

Shaft

Upper Restrictor

Lower Restrictor

5"

5"
Motor Labyrinth Leakage

Four 5” Labyrinths
10,000 psi

Flow Rate (gpm)

Leakage Clearance (w)

0.004”
8.1
0.006”
12.1
Thrust Load on Bearing

10,000 PSI

Seal

Housing

34,000 lb Force

Thrust Bearing

Bit
Candidate Bearings

Ball Bearing

PDC Bearing
Bearing Load Comparison

100 Hours @ 300 rpm

- Ball Bearing: 5600
- PDC Bearing: 16,800
High-Pressure Coiled Tubing Motor

- Titanium Drive Shaft
- PDC Thrust Bearings
- PDM Multilobe Rotor/Stator (3 1/8”)
- 2 3/8” CT
- High Pressure Jet Bit
- Radial Bearings/Flow Restrictors
- Solid Titanium Flexshaft
- Solid Rotor
- Titanium Flexshaft
- Filter
High Pressure Jet-Drilling Rates

Jet Drilling Rate (ft/in)

<table>
<thead>
<tr>
<th>Bit Weight</th>
<th>Texas Cream Limestone</th>
<th>Leander Limestone</th>
<th>Glacier Bluff Dolomite</th>
<th>Pecos Red Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit Weight = 2000 lbs</td>
<td>1500</td>
<td>910</td>
<td>68</td>
<td>120</td>
</tr>
<tr>
<td>Bit Weight = 1000 psi</td>
<td>780</td>
<td>255</td>
<td>142</td>
<td>110</td>
</tr>
</tbody>
</table>

(WOB = 1000 lbs)
10,000 PSI JET DRILLING
Jet Slotting

- Developed 1-11/16 HP motor
- Developed jet slotting
- Developed gear box for jet slotting
- Confirmed ability to jet in over pressure condition
Fig. 13
Jet Slotting Stimulation

- Slots
- Formation Damage
- High Pressure Jets
Fig. 14
Jet Slots In Glacier Bluff Dolomite
10,000 psi Jet Pressure
Axial Velocity 140 in/min
Rotary Speed 6 rpm
Slot
**Fig. 11**

**DRC Wellbore Simulator Drilling Stand**

- Cuttings Removal Screen
- Choke
- Borehole Pressure
- Drilling Fluid Input
- Shaft Seal
- Pressure Chamber
- Rock
- Formation Pressure
Fig. 12
Effect Of Wellbore Pressure
(High Pressure Drilling)

Texas Cream Limestone
2000 lb Bit Weight

Wellbore Pressure = 2000 psi
Jet Pressure = 9300 psi

ROP (ft/hr)
0 psi
1010
920
2000 psi

Wellbore Pressure

0
200
400
600
800
1000
1200
1400
1600
1800
0 psi 2000 psi

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Cement Tubing

High Pressure Jets

Drilling Cement

Tubing

Cement

ROCK
Barite Scale Removal

- Tubing
- High Pressure Jets
- Barite Scale
High Pressure Jets

Cleaning Slotted Liners

- Open slots
- Jetting slots
- Tubing
- Plugged slots
- High Pressure Jets
Hole Reaming/Cleaning

- Predrilled Hole
- Reamed Hole
- Hole Guide
- High Pressure Jets
- Predrilled Hole
Casing

High Pressure Jets

Under Reaming
CT Cement Cleanout Rates

ROP (ft/hr)

Low Pressure 10,000 psi

1000

60
Phase III -- Plans
Phase III SOW

- Assemble HP-CT system
- NEPA
- Upgrade CT software
- Shallow field test (Catoosa)
- Modify tools
- Deep field test
- Horizontal well applications
- Commercialization plan
NEPA

- Determine data needed
- Develop reporting form
- Supply Catoosa data
Upgrade CT Life

- Develop new algorithms to calculate stresses due to HP
- Determine effect of HP on fatigue
- Incorporate new algorithms
- Incorporate new CT materials
Shallow Field Test

- **Visit Catoosa**
  - Cohen
  - BJ services (Kelly Falk &/or Jay Albrecht)
- **Write engineered work plan**
  - Drill Depth 2000 ft
- **File NEPA documents**
- **Test drilling & slotting system**
Deep Field Test

- Modify tools
- NEPA
- Engineered work plan
- Test to minimum depth 8,500 to 10,000 ft
- Commercialization plan
  - Market survey
The End

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