WELL PERFORMANCE DIAGNOSTICS USING SMART PLUNGER TECHNOLOGY

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**BACKGROUND**

- **What is plunger lift?**
  - "An artificial-lift method principally used in gas wells to unload relatively small volumes of liquid..." -SLB Oilfield Glossary-

- **How does plunger lift work?**
  - “When the well is shut-in, a plunger is dropped down the production string. When the control system opens the well for production, the plunger and a column of fluid are carried up the tubing string...” -SLB Oilfield Glossary-

- **How is plunger lift managed?**
  - “An automated system mounted on the wellhead controls the well on an intermittent flow regime...” -SLB Oilfield Glossary-
VALIDATE TRAVELING SMART PUNGER TECHNOLOGY AS A FEASIBLE SOLUTION TO THE ISSUE OF OPTIMIZING NEGLECTED OR STRUGGLING PLUNGER LIFT INSTALLATIONS TO THE POINT OF “MAXIMUM EFFICIENCY”, i.e.

*the achievement of a balanced relation between the plunger lift system’s ability to keep the tubing free of liquid load and the maximum amount of after-flow time allowable in a single day without the plunger running “hot” (no fluid column above the plunger).”*
Highlight alternative applications of Smart Plunger Technology to aid in "PERFORMANCE OPTIMIZATION" of a particular well and/or network of wells, i.e.

recent developments in automation technology have given rise to the collective plunger lift system - an integrated network of all plunger lift controllers in a particular area that can be managed and optimized from a remote master system.
“So what is the difference between a Standard Plunger and a Smart Plunger?”

- The Smart Plunger is designed to internally accommodate a TEMPERATURE AND PRESSURE DATA LOGGER.

- The Data Logger housed within the Smart plunger will sample temperature and pressure at a given time interval until its power supply is disconnected.

- Temperature and Pressure Data from the Data Logger can then be transferred to an application called “CalWIN” and the plunger lift installations performance can be evaluated.
SMART PLUNGER EQUIPMENT - I

“Smart Plunger Kit” Contents

- 1 to 3 traveling plungers: bar stock, brush and pad
- Temperature and Pressure Data Logger
- Maintenance and analysis tools
- Battery
- Training and data review

NOTE: Cost/rental fee for an entire Smart Plunger kit is $500 per day (2007 quote).
Also included in a “Smart Plunger Kit...”

“DOWNHOLE” Flow-Through Smart Plunger

Drop-Off Plunger

Retrieval Plunger

Thermal Actuator
PLPP MISSION

- Apply the contents in a Smart Plunger Kit to 3 candidate wells for a period of 30 days.

- Determine what effect the technology has on the performance efficiency of each well.

- Provide findings on the economic feasibility of the technology.
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**INITIAL DIAGNOSTICS**

**WELL #1**

Max. Pressure: 654.327  Max. Temperature: 197.607

If Plunger Had Reached Bottom Temperature Plot Would have Leveled out…

No Liquid Signature/ Slope Change (Dog Leg)

Tight Spot in Tubing

Fall Time Added, Slope Change Evident, Plunger Reaches Bottom Plunger Run Optimized…

Bottom of Well (End of Tubing)

Top of Well (Lubricator)

- **Pressure**
- **Temperature**

**DELTA TIME (HOURS)**

Plunger Does Not Reach Bottom After 1:17:30 Fall Time

- **WELL #1**
- **INITIAL DIAGNOSTICS**
- **WELL #1**

- **Pressure**
- **Temperature**

**DELTA TIME (HOURS)**
**INITIAL DIAGNOSTICS**

**WELL #2**

- **Plunger Reaches Bottom After 1:30:30 Min of Fall Time**
- **Slope Change**
- **Slope Change**
- **Plunger on Bottom**
- **43 Min Not quite on top (verified on site)…**
- **A LOT OF LIQUID!!!**

*Top of Well (Lubricator)*

*Bottom of Well (End of Tubing)*

Max. Pressure: 1075.397  Max. Temperature: 204.926
INITIAL DIAGNOSTICS

WELL #3

Top of Well (Lubricator)

Bottom of Well (End of Tubing)

DELTA TIME (HOURS)

PRESSURE

TEMPERATURE

1 TRIP

2 TRIPS

? ? ?

Plunger Not Reaching Surface

Plunger Not Reaching Surface

INITIAL DIAGNOSTICS
Initial Un-loading of Well

Installed PCS By-pass With Plugs... Better Critical Rate Option

MCFD

80 MCFD

Began Smart Plunger Operations

Began Installation Period

Installed Weatherford Padded Rapid-Flow...

Initial Un-loading of Well

WELL #1: Post-SMART PLPP Production Rate vs. Time

Incr Net Sales = 80 MCFD X 30 days/mo X 75% NRI X $6.50/MCF = $11,700 / mo

Incr LOE = $500/day ÷ 3 wells X 30 days/mo + $1,000 Installation Cost = $6,000/ mo

Incremental Net Revenue = $5,700 / month
WELL #2: Post-SMART PLPP
Production Rate vs. Time

Incr Net Sales = 80 MCFD X 30 days/mo X 75% NRI X $6.50/MCF = $11,700 / mo
Incr LOE = $500/day ÷ 3 wells X 30 days/mo + $4,000 Installation Cost = $9,000/ mo
Incremental Net Revenue = $2,700 / month
WELL #3: Post-SMART PLPP
Production Rate vs. Time

Incr Net Sales = 90 MCFD X 30 days/mo X 75% NRI X $6.50/MCF = $13,162 / mo
Incr LOE = $500/day ÷ 3 wells X 30 days/mo + 1,000 Installation Cost = $6,000 / mo
Incremental Net Revenue = $7,162/ month
ECONOMIC ANALYSIS RESULTS
SMART PLPP

Well #1

- Incremental Net Sales
- Incremental LOE
- Incremental Net Revenue

Well #2

- Incremental Net Sales
- Incremental LOE
- Incremental Net Revenue

Well #3

- Incremental Net Sales
- Incremental LOE
- Incremental Net Revenue

After 30 Days....

- $15,562 of Incremental Net Revenue Between 3 Wells.

- Net revenue interests, technology rental costs and additional installation costs for all 3 wells Included.
Having performed 20+ individual Smart Plunger tests as a plunger operator...

- Smart Plunger technology is dependable – both operationally and mechanically.
- The processed data is clear, concise and interpretable.

Processed data was used to help increase the performance efficiency and enhance the economic viability of marginal wells...

- Efficiency increases ranged from 80-90+ mcfpd per well.
- Lease Operating Expenses were minimally impacted by the implementation of the technology (reference PLPP).
PURPOSE: LOCATE TUBING HOLES!!!

As the plunger travels the length of the tubing string the data logger takes temperature readings at a maximum rate of three per second.

If the plunger travels across a tubing hole the data logger will record a decrease in temperature.

The temperature on the backside is less than the temperature in the tubing string.
BECOME SUSPICIOUS!

Max. Pressure: 1093.420  Max. Temperature: 173.674

- Why can’t my plunger make it back to surface?
- Why does the temperature and pressure data so closely mimic one another?
"Additional Applications of Smart Plunger Technology"

TUBING HOLE TEST CASE

Csg and Tbg Pressures Have Equalized After 15 minutes of Shut-in

ECHOMETER/TOTAL WELL MANAGEMENT
DEPTH ESTIMATION

1762.38’
FIRST TUBING HOLES EVER LOCATED IN 2 1/16” TUBING USING SMART PLUNGER TECHNOLOGY!

#1 = 1783.45’

#2 = 1836.45’

- Depth = 10,500 ft
- Fall Time = 66 min
- Sample Rate = 3 Samples/sec
- Plunger Fall Rate = 159 ft/min
- 3,960 Seconds
- 11,880 Samples
- 1 Sample Every 2.65 ft

TUBING WAS PULLED AND HOLES WERE VALIDATED
For wells equipped with 2 1/16” tubing, only Barstock Smart Plungers can be utilized because a 2 1/16” Padded Smart Plunger can’t accommodate the data logger diameter.

Barstock plungers have faster fall velocities then padded plungers...

As a result, it was accepted practice that the temperature data logger could not sample fast enough in order to pick up tubing hole signatures in a Barstock Smart Plunger.

It is believed that the efforts herein presented are the first undertaken at implementing Smart Plunger Technology to successfully pinpoint tubing holes in wells equipped with 2 1/16” tubing.
Downhole Flow-Through Smart Plunger Test Case

Max. Pressure: 650.177  Max. Temperature: 186.615

Flow Against Sales Line Pressure

Installed Compressor… Several Start-up Problems

More Start-up Problems

Drawdown can be Evaluated for Reservoir Characteristics

"Additional Applications of Smart Plunger Technology"

COMPRESSON OPTIMIZATION
Compression drawdown test data from the Downhole Tool promoted a more thorough understanding of compressor/well performance...

High surface temperatures correlated to compressor issues.

Installing additional compressors would help effectively combat increasing line pressures at the reservoir level.

Abrupt Bumps in Line Pressure Seriously Inhibit plunger lift systems not programmed to run off critical rate.
CONCLUSIONS

- Traveling Smart Plunger technology can be introduced as an effective well performance diagnostic for field personnel.
- If processed data is interpreted correctly, installation costs will pay-out within 30 days with realistic gas price assumptions.
- Given sufficient lease maintenance, a well on plunger lift can maintain “MAXIMUM EFFICIENCY” and increased life until P&A.
- The Temperature Data Logger can effectively locate tubing holes, providing assurance and depth estimations before a costly workover procedure is performed to replace all or portions of a tubing string.
- Well performance diagnostics CAN be performed in wells with 2 1/16” tubing.
- The Downhole Tool is a readily available alternative to running temperature and pressure bombs in wells with tubing strings as it eliminates the logistics and costs associated with wireline outlets and provides interpretable well performance data that can be used for reservoir, well and facilities analysis.
Thank you for your attention!

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- - - QUESTIONS - - -
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