An ALS Solution to Low Pressure SAGD

ASME/API/ISO Gas-Lift Workshop

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Introduction

- SAGD Well Parameters
- Hydraulic Gas Pump (HGP) Introduction
- Lab Testing & Development
- HGP SAGD Field Trials
- Identified Issues & Solutions
- Continuing Development
- Reference
SAGD Parameters

• From an ALS perspective the well parameters are extreme:
  
  – 200 °C+ BHT
  
  – Variable capacity ~ 1000m³/day to 100m³/day
  
  – Multi-phase inflow
  
  – Low fluid shear and pressure drop
  
  – Low pump intake pressure (e.g. 300 KPa)
  
  – Wide range of fluid viscosity (1 – 2000cps)
  
  – Solids handling
Hydraulic Gas Pump (HGP)

- Improved and simple positive displacement pumping system suitable where gas operation is possible

- In a SAGD application, resident high pressure supply gas actuates the pump
  - **Note**: All of the gas is returned to generate steam
The HGP System

Bottom Hole Assembly
- Foot valve
- Standing valve
- Production chamber
- Control valve

Surface Components
- Modified wellhead
- Three control lines
- Hydraulic panel
- Electronic control panel
HGP Animation
Three Step Process

• Prototype design, manufacture and installation in test facility

• High temperature dynamic seal testing

• Field trials in operating SAGD wells
Test Well Installation Objectives

- Verify HGP operation
- Validate computer predictive performance modeling
- Prove the completion procedure
- Function test the down hole control valve and associated hydraulics
- Function test the electric control system and associated software operating the pump
- Test manual and automatic shutdown routines
Test Well Installation

- HGP landed at 185m MD and at 15.7° inclination
- 177.8 mm production chamber, 42.4 mm gas injection string, 73 mm production tubing
- Pumped drill mud S.G. 1.138
- Power gas from nitrogen tube truck
- Gas pressure was varied to alter pump performance
Schematic of Surface Hook-Up at Test Well
## Test Well Analysis

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<th>ON (SEC)</th>
<th>OFF (SEC)</th>
<th>PRESS (kPa)</th>
<th>BACK PRESS (kPa)</th>
<th>LEVEL (kPa)</th>
<th>LEVEL (m)</th>
<th>PUMP DIFF PRESS</th>
<th>ACTUAL DIFF PRESS</th>
<th>FLOW/ CYCLE (m³/d)</th>
<th>AVE FLOW (m³/d)</th>
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Test Well Installation Results

• HGP pumped fluid at expected flow rates (ranging from 60m$^3$/day to 300m$^3$/day) and operated as expected

• The computer modeling predicted results similar to the actual performance (Slight adjustments to valve coefficients)

• Dual completion installation and wellhead adaptation posed no problem

• Hydraulic, electric control panels and software worked as expected

• Shutdown procedure worked well

• Overall the HGP performance met or exceeded expectations
High Temperature Dynamic Seal Testing

- High temperature test apparatus
- Control valve subjected to 450,000 cycles at 205°C
  - Represents 10-12 months of operation
HGP SAGD Field Trial – 1

• CNRL Burnt Lake SAGD facility
  – 7” HGP installed April 29, 2005 (14CP# 10-2-67-3 W4M)
  – HGP replaced a reciprocating rod pump system and was installed at the same depth for a meaningful comparison
HGP SAGD Field Trial – 1 Application

- Gas pressure 5.45 MPa
- Flow line pressure – 600 KPa
- Pump landed at 60°, 528m MD, 476m TVD
- Fluid level 445m TVD
- Production from previous ALS – 125m³/day
- Flow line temperature 145°C
HGP SAGD Field Trial – 1 Performance

Total Production

week ending


system down for half day while installing modem

Burnt Lake experienced power failure. Lost 1/2 day of production

system down for half day while installing modem

Burnt Lake experienced power failure. Lost 1/2 day of production
HGP SAGD Field Trial – 1 Performance

• HGP utilized timers to inject and vent the gas.

• Maximum production reached was 262m³/day. Well inflow slowly declined to reach a steady state nearing 150m³/day. It is believed that the HGP is pumped off at 150m³/day.

• At 150m³/day the HGP system operation had an injection time of 30 seconds and venting of 50 seconds.

• The HGP outperformed the reciprocating rod pump.

• It is agreed that the HGP has performed as expected with no indication of mechanical or other operational problems.
HGP SAGD Field Trial – 2

- 7” HGP system installed and began operation on January 22, 2006
- It is landed at 80º inclination
- 10 ¾” Casing
- Depth is 470m MD, 350m TVD
- BHT temperatures varied from 52 Deg C to 150 Deg C
- System is performing as expected
Identified Issues

- Hydraulic control panel
  - Gas driven system freezes up in wet gas applications
  - Control fluid volume in control lines varies with ambient temperature & is difficult to equalize
- Identified large possible tubing movement between production and gas injection lines
- Potential for foreign debris in gas injection line to enter the control valve and prohibit proper operation
Solutions

• The hydraulic control panel updated – electric hydraulic pump with reservoir
  – Eliminates potential freezing of wet gas in system
  – Removes requirement to balance fluid volume in control lines
  – Onboard heating element insures smooth operation

• Developing expansion joint for gas injection line

• Addition of a screen or trap in gas injection line on surface to catch any potential debris
Summary

• The HGP system is a simple positive displacement pumping system which utilizes high pressure supply gas to displace the well fluid.

• No gas is consumed by the pump…all of the gas is returned to generate steam.

• The HGP has passed rigorous lab testing.
  – Including 205°C dynamic seal testing

• The HGP has performed as expected in two operating SAGD producing wells
Continuing Development

- High temperature HGP for CSS operations
- Wireline retrievable check valves – production chamber
- Upgrade electronic control panel (Touchscreen design - more user friendly)
- Pad configuration control
- Model capable of fluid production up to 1600m³/day
- Spreadsheet program for sizing new installations and fine tuning existing installations
- 1st Production unit scheduled for completion before end of Qtr 1 ’07.
- Field trials with R&D prototype units (both 7” and 9-5/8”) are encouraged
Reference

- SPE Paper# 97683
  An ALS Solution to Low Pressure to SAGD
  Darren J. Wiltse, SPE, Weatherford Completion & Production Systems

Previously Presented:

2005 SPE International Thermal Operations and Heavy Oil Symposium
Calgary, Alberta, Canada
1 – 3 November 2005
Questions?