Six Years of Continuous Success With Progressing Cavity Pumps in Boscán Oil Field – Keys For Success And Lessons Learned

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OUTLINE

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– Reasons for Using PCPs
– Past Experience with PCPs in Boscán
– New Approach for PCPs
– Results of PCP Conversion Project
– Performance to Date
– Lessons Learned
– Best Practices
– Remaining Challenges
– Future of PCPs in Boscán
– Conclusions
BOSCÁN BACKGROUND (Cont’d.)

- Discovered: 1947
- Area: 255 miles\(^2\)
- Depths: 4500’ - 9500’
- Oil Cum: 1.31 Billion STBO
- Reservoirs: Upper and Lower Boscán (Misoa Formation)
- API Gravity: 10.5º
- Viscosity: 150 – 350 cps
- Reservoir Pressure: 1100 – 3000 psi
- Active Wells: 518 producers
- Well Production: 20 - 1300 BOPD
- Water Cut: 0 - 90% Avg: 40%
- Artificial Lift Methods: Rod Pumps (40%), PCPs (34%) and ESPs (26%)
REASONS FOR USING PCPs

– Most SR PUs (pumping units) reached end of operational life
– More suitable AL method for North Boscán conditions
– Reduction in CAPEX, power consumption and maintenance cost
– Safer and more reliable than gas driven SR PUs
– Smaller surface equipment
PAST EXPERIENCE WITH PCPs IN BOSCÁN (2000 - 2001)

- 25 wells converted from SR to PCP
- 3 different vendors used
- Averaging 27 failures / year
- Average run life ~ 90 days
- Program perceived as unsuccessful and recycled in 2001 for re-evaluation

![Map of Boscán area with various markers indicating well locations and pressures levels.]

![Pie chart showing the percentage of well issues by category: Pump Change (34%), Rods (11%), Wellhead (5%), Other (50%).]
Past Experience With PCPs in Boscán (2000 - 2001) (Cont’d.)

• Root Cause Analysis:
  – 85% of failures were pump related
  – Inadequate design, installation and / or maintenance
  – Most elastomers not compatible with Boscán crude
  – Lack of Company and Contractor experience with equipment and inability to anticipate, diagnose and solve problems
  – Absence of contractor presence in daily operations
  – 3 different contractors for small number of PCP wells

Tear downs indicated elastomer incompatibility with Boscan crude oil
Corrective Actions:

- Immediate review initiated both internally and with vendors
- Boscán crude elastomer compatibility tests conducted on all potential vendor’s elastomers by 3rd party lab
- Based on results, a Sole Source Alliance was awarded to one vendor
- Pump efficiency tests conducted locally on all PCP pumps before installation
- PCP project re-started in Feb 2002
RESULTS OF PCP CONVERSION PROJECT

- **Phase I and II:** 14 of 25 wells re-completed with new PCP equipment, which fully met all new goals ($\geq 1$ yr. run life and $\leq 0.70$ well interventions / yr.)
  - Current avg. run life of 913 days (1 PCP still running at 260 RPM w/ >2000 days run life)
  - Much higher reliability compared to gas driven SR PUs
  - 33% increase in production
  - Only 1 PCP lasted < 1 yr. (casing collapse)
  - Encouraging results led to expansion of PCP project

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**PCP Pilot Program**

<table>
<thead>
<tr>
<th></th>
<th>Avg. RL</th>
<th>1 Year</th>
<th>2 Years</th>
<th>3 Years</th>
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<td>2076</td>
<td>1400</td>
<td>1200</td>
<td>1050</td>
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<tr>
<td>Total</td>
<td>14</td>
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<td>1466</td>
<td>1386</td>
<td>1270</td>
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**Downtime Comparison**

- Gas driven SR PU
- Electric driven SR PU
- ESP
- PCP

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RESULTS OF PCP CONVERSION PROJECT (Cont’d.)

Conversion Project:

- More aggressive program initiated resulting in:
  - 126 wells converted in 2003 – 2008
  - 98 BOPD avg. gain / well
  - Improved reliability & efficiency by replacing inefficient gas driven SR PUs
  - Reduction in capital expenditure
  - PCPs became most used AL in North Boscán and 2nd most in entire field

<table>
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<th>Year</th>
<th># Conversions</th>
<th>Avg. Gain (BOPD)</th>
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<td>31</td>
<td>102</td>
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<tr>
<td>2004</td>
<td>54</td>
<td>114</td>
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<tr>
<td>2005</td>
<td>30</td>
<td>73</td>
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<tr>
<td>2006</td>
<td>8</td>
<td>63</td>
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<tr>
<td>2007</td>
<td>2</td>
<td>170</td>
</tr>
<tr>
<td>2008</td>
<td>2</td>
<td>TBD</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>98</td>
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PERFORMANCE TO DATE

– 187 PCP installations
– Since mid-2004 PCPs have replaced SRs as AL choice for new drilled wells (33 installations)
– Current avg. run life for active wells is ~ 513 days, and 360 days for all failures
– 334 failures in 2002 – 2008 (57% old age, 18% sand & 7% gas)
– 0.57 PCP well interventions/year vs. 0.74 for SRs
– Deepest Known Successful PCP - at 8611’, with an initial 1st failure of 923 days and 2nd current run life of 60 days (240 BOPD @ 150 rpm)
LESSONS LEARNED

PCP Filters:
- Earlier completions had no filters
- Elastomer separating from stator plugs downhole equipment and/or wellbore, resulting in lower production and expensive clean out jobs
- Since mid-2004, 2-⅞” x 4’ filters (w/welded bull plugs) used but were small and difficult to clean/reuse
- Since late-2006, a new 4-½” filter design used w/threaded bull plug for easier cleaning/re-assembly
- Currently ~70% of PCP completions have new filter design, and plan to install with all PCPs
LESSONS LEARNED (Cont’d.)

Transport and Lifting Devices:

- Due to Boscán depths, large head capacity requires long PCP pumps (~55 ft.) that are more difficult to transport / lift.
- Some pump models are longer than truck bed, resulting in damage due to equipment bouncing / bending up and down during transportation.
- When lifting rotor onto rig floor, excessive bending and permanent damage can occur.
- To resolve these situations 2 devices were designed, built and implemented.

**Lifting Device**

![Diagram of Lifting Device]

**Transport Device**

![Diagram of Transport Device]
BEST PRACTICES

Downhole Gauges and Automation:

– A key reason for PCP project success

– 158 of 188 wells have downhole sensors

– Sensor allows better monitoring, adjustment and diagnosis

– Downhole data and surface parameters are continuously available and recorded in SCADA system

– Various SCADA alarms are set, allowing operators to be notified and respond quicker
PCP Back Spin Controller:

- **Original Situation:**
  - 25% reduction in well production (up to 6000 BOPD & 1100 BOPD annual avg.)
  - Rod strings can unscrew
  - Uncontrolled back spin is safety hazard, and can also damage equipment

- **Solution:**
  - Proprietary software & hardware uses energy from falling fluid to quickly / safely brake the back spin, allowing control system to restart well after electrical power is restored
BEST PRACTICES (Cont’d.)

Back Spin Controller (Cont’d):

- **Results:**
  - Back spin reduced from ±2 - 6 hours, to only 1 - 1.5 minutes
  - Back spin control systems now installed in all PCP wells

Back Spin Control in Progressive Cavity Pump For Oil Well
Higher GOR Wells:

- Free gas reduces pump efficiency
- In low pressure areas with higher GOR (>500 SCF/STB), frequent PCP elastomer failures occur
- Run life only ±180 days
- Several potential solutions evaluated / tried, including gas and tandem separators, gas anchors, check valves and tubing tails
- To date, no clear results to show which is more effective but continuing trials

Tear Downs Showed Severe Blistering
Deviated Wells:

- In late-2005 / early-2006 two new deviated wells completed with poly rod guides and experienced high torque.
- Production loss from both wells ~220 BOPD.
- In late-2006 rod guides from both wells replaced with newer model Spin-thru rod guides.
- Able to optimize 1 well for short period (150 BOPD gain), but overall results did not fully meet expectations.

Results:

- Two other similar, new deviated wells were completed with ESPs.
- For now, future new deviated wells will be completed with ESPs.
- Currently planning a 2 well ESPCP trial.
Insert Pumps:

- Until late-2005 only used tubing pumps
- Special challenges due to depth and sand production
- Currently 10 running, with comparable performance to tubing pumps
- Savings of ±56 hours service rig time (~$21,000 / well) by not pulling tubing during pump changes
- Includes 2 early-2008 installations, with plans to install 7 more this year
- To date, only 3 pulled and replaced, but results encouraging. Flush-by capability not yet tested.
- If insert PCPs continue to perform well, plan to significantly expand use in Boscán where applicable (i.e., lower sand production)
**FUTURE OF PCPs IN BOSCÁN**

- Most locations in South Boscán have already been drilled.
- Future drilling activities will be mainly focused in North Boscán.
- More than 300 infill locations in North and Central Boscán, with most expected to be PCP completions.
- By early-2010, PCPs will be the most used AL method in the entire field.
- Total PCP population in next 5 years (2013) will likely increase to > 280 wells.
CONCLUSIONS

– When applied and monitored properly, PCPs have proven to be a reliable AL method in Boscán at depths ≤ 8600 ft.

– PCP conversion project (126 wells to date) very successful by increasing production and reducing capital expenditure, power consumption and operating costs.

– Downhole gauges and automation are keys for PCP success.

– Continuous improvements made allowing increase in PCP run life and reliability.

– Higher GOR and deviated wells are remaining challenges for Boscán PCP applications.

– As the northern part of Boscán continues to be developed, PCPs will soon become the most used AL method.
Throughout these 6 years of the Boscán PCP project, there have been many people actively involved to make it successful.

We want to thank everyone involved, but especially:

- Joe Wright  (former Western Ven. General Mgr.)
- Chuck Rubins  (former Reservoir Mgt. Manager)
- Artie Rodriguez  (former Prod. Eng. Supervisor)
- Gabriel Díaz  (former Prod. Eng. Supervisor)
QUESTIONS?