ESP Technology Challenges for Ultra-Deepwater in Gulf of Mexico

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Agenda

- Lower Tertiary Trend Overview
- Reservoir Characteristics
- Objectives & Methodology
- Results Analysis
- ESP Completion Options
- Summary
The Value Proposition - Lower Tertiary Trend GOM

- Lower Tertiary is thought to contain 15 billion barrels of oil in reserves
- Current known extent is approx. 80 mi wide and 400 mi long
- LT consists of older geological period, more compact sediments
- High density crude with low GOR and bubble point
- Highly fractured reservoirs – rapid pressure depletion
- Reservoir pressure to 20,000 psi, Temperature to 300º F
Regional Discontinuity

Major depth shift across discontinuity

Graph courtesy MMS
Objectives

- Model anticipated Lower Tertiary reservoir to evaluate production potential
- Compare the production expectations to understand the economic viability of ESP completion design options
- Evaluate ESP challenges to meet the completion needs of Lower Tertiary wells
Methodology

- Nodal Analysis - Petroleum Experts Prosper® Software
- ESP Production Modeling - Baker Hughes’ AutographPC®
- Compare various reservoir performance characteristics
Natural Flow Scenario

- No Subsea Boosting
- No In-Well ESP
- 250 psi Separator Pressure
- Step out 14 Miles
- Water depth 8,000 ft
- Flowline ID 6”
- Productivity Index (PI) of 1.0 to 3.0 bpd/psi
Subsea Booster Pump Scenario

- Subsea Boosting
- No In-Well ESP
- 1,250 psi Min. Subsea Tree Pressure
- PI = 1.0 to 3.0 bpd/psi
Combined Artificial Lift Scenario

- Near-Reservoir ESP, maximizing reservoir drawdown
- Subsea Boosting
- 1,250 psi Min. Subsea Tree Pressure
- 1,250 psi minimum Pump Intake Pressure
- PI of 1.0 to 3.0 bpd/psi
# Reservoir Characteristics

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Value</th>
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<tbody>
<tr>
<td>Water Depth</td>
<td>ft</td>
<td>8,000</td>
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<tr>
<td>Reservoir Depth (TVD)</td>
<td>ft</td>
<td>28,000</td>
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<tr>
<td>Reservoir Temperature</td>
<td>°F</td>
<td>275</td>
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<tr>
<td>Initial Reservoir Pressure</td>
<td>psi</td>
<td>20,000</td>
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<tr>
<td>Water cut</td>
<td>%</td>
<td>30</td>
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<tr>
<td>Permeability</td>
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<tr>
<td>Productivity Index</td>
<td>bpd/psi</td>
<td>1.0 - 3.0</td>
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<tr>
<td>Oil Viscosity</td>
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<td>Oil API gravity</td>
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<tr>
<td>Bubble point Pressure</td>
<td>psi</td>
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<tr>
<td>Gas Oil ratio (GOR)</td>
<td>scft/sbbl</td>
<td>250</td>
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</table>
Production Profile  PI=3 bpd/psi

Drawdown limited to 5,000 psi

5,200 bpd @ 6,000 psi

Reservoir Pressure (psi)

ESP to SSB  SSB  Nat Flow
Production Profile  PI=2 bpd/psi

Drawdown limited to 5,000 psi

Reservoir Pressure (psi)

Production Rate (bpd)

ESP to SSB  SSB  Nat Flow

3,500 bpd @ 6,000 psi
Production Profile  \( \text{PI}=1 \ \text{bpd/psi} \)

- **Natural Flow**
- **Subsea Booster Pump**
- **In-Well ESP**

Drawdown limited to 5,000 psi

- 0 bpd
- 1,800 bpd @ 6,000 psi

Reservoir Pressure (psi)

- ESP to SSB
- SSB
- Nat Flow

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ESP Pump Performance

![Graph showing ESP Pump Performance with Intake Flow Rate (bpd) vs. TDH (ft). The graph includes data points for PI 2 bpd/psi and PI 1 bpd/psi.]
ESP Completion Options

- **Deployment Multiple ESP Systems to Maximize Time Between Interventions**
  - Design Completion to avoid interventions for at least 8 to 10 years
  - Use Conventional Drilling Rig Intervention with a Riser

- **Coiled Tubing Deployed ESP System to Minimize Time and Cost for an Intervention**
  - Design Completion to keep Intervention Time at 30 Days or less
  - Use Emerging Medium Intervention Vessel Technology
Deployment Multiple ESP Systems
Challenges

- Production casing larger than standard GOM
- ESP CAN/Pod must be large
- Tubing hanger design
- Subsea Tree ESP power penetrator design
- CAN/Pod hanger design for high pressure
- ESP CAN power penetrator design
- Automatic diverter valve design for high volume
- ESP pump design for widest production range
- ESP qualification for extremely high pressure
- High pressure completion components:
  - Safety Valve
  - Reservoir isolation Barrier valve
  - Chemical Injection system
Coiled Tubing Deployed ESP System Challenges

- Coiled Tubing Hanger design
- Production Tubing Hanger design
- SubseaTree ESP power penetrator
- CT with Power Cable technology limits to 10,000 ft
- CT collapse pressure limitations
- ESP pump design for widest production range
- ESP qualification for extremely high pressure
- Length and weight of the ESP system
- Coiled tubing size
- Bypass Valve Design
- High pressure completion components:
  - Deepset Safety Valve
  - Reservoir isolation Barrier valve
  - Chemical Injection system
Summary

- Available reserves will keep the GoM as one of the world’s premier oil and gas basins for the oil industry.
- Sensitivity analyses for LTT shows that potential oil increase per well would be more than 50% over the life of the field by adding an ESP along with the SSB system.
- Deployment of multiple ESP systems is the conventional approach which has previous and successful run history. The current technology should be adapted to this application.
- CT deployed ESP systems in subsea and deepwater applications would be challenging and development of the components would require extensive engineering time, testing and qualification.
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Questions

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