A New Approach to Flowline Active Heating

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A New Approach to Flowline Active Heating

• Flow Assurance Issues:
  – Flow should arrive at temperature above:
    • Cloud point / wax appearance temperature
    • Pour point
    • Hydrate formation temperature
    • Scale formation conditions
  – Cold start-up after unplanned shutdown
    • Avoid hydrate blockages
    • Avoid high viscosity blockages
  – Unplanned shut down
    • Maximize ‘no-touch time’
Sub-sea Tie-back Typical Design

- **Looped Pipeline Design**
  - Pig launching and receiving facilities on the host
  - Chemical injection facilities via a hydraulic / electrical umbilical system
  - Pipeline pigging pumps on the host facility
  - Insulated flowlines
  - PLET with multiple or single wells
Sub-sea Tie-back Designs

- Dual steel looped pipelines
  - Pipeline carries production fluids
  - High performance insulation coating
  - Heat is lost to the surrounding environment
Sub-sea Tie-back Designs

• Dual steel pipe in pipe
  – Inner pipe carries production fluids
  – The outer pipe (annulus) carries the heating fluid (may be 8” inner with 12” carrier pipe)
  – Hot water one way in annulus then dump
  – Heat is lost to the surrounding environment
  – PIP flow area restricted / limited by centralization members / supports
  – Low heating fluid velocity
    • Biological material accumulation in annulus
    • Scale accumulation in annulus
  – Long term inspection issues for annulus (outer pipe)
Sub-sea Tie-back New Active Heating

- Active heating fluid & system inside the production pipe
- We believe this will enable:
  - Reduced insulation requirements
  - Reduced fabrication materials requirement
  - Reduced installation costs
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• Layout options
  – Open circuit where the fluid from trace heating pipe commingles with production flow
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• Layout options
  – Closed circuit where fluid from trace heating pipe exits to sea

Note #1: Clean water only
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Modelled Production System Parameters

<table>
<thead>
<tr>
<th>Production System</th>
<th>Units</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline Size</td>
<td>inch</td>
<td>8</td>
</tr>
<tr>
<td>Insulation</td>
<td>Type</td>
<td>None#1</td>
</tr>
<tr>
<td>Pipeline Length</td>
<td>km</td>
<td>8</td>
</tr>
<tr>
<td>Water Depth (inlet)</td>
<td>m</td>
<td>-350</td>
</tr>
<tr>
<td>Inlet from</td>
<td></td>
<td>Wellhead</td>
</tr>
<tr>
<td>Seabed Temperature</td>
<td>Deg C</td>
<td>4</td>
</tr>
<tr>
<td>Water Depth (outlet)</td>
<td>m</td>
<td>40</td>
</tr>
<tr>
<td>Outlet to</td>
<td></td>
<td>Production facility</td>
</tr>
<tr>
<td>Production Flow Rate</td>
<td>bpd</td>
<td>5000</td>
</tr>
<tr>
<td>GOR</td>
<td>scf/bbl</td>
<td>420</td>
</tr>
<tr>
<td>Water Cut</td>
<td>%</td>
<td>20</td>
</tr>
<tr>
<td>Pipeline inlet pressure</td>
<td>bar</td>
<td>47</td>
</tr>
<tr>
<td>Pipeline Inlet temperature</td>
<td>Deg C</td>
<td>50</td>
</tr>
<tr>
<td>Wax appearance temperature</td>
<td>Deg C</td>
<td>24</td>
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</table>

Note: The focus of the modelling was paraffin wax
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Active Heating System Parameters

<table>
<thead>
<tr>
<th>Active Heating Tube#1</th>
<th>Units</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside diameter</td>
<td>inch</td>
<td>2.375</td>
</tr>
<tr>
<td>Internal diameter</td>
<td>inch</td>
<td>2</td>
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<tr>
<td>Tube length</td>
<td>km</td>
<td>7.997</td>
</tr>
<tr>
<td>Heating fluid flow rate</td>
<td>bpd</td>
<td>5000</td>
</tr>
<tr>
<td>Heating fluid type</td>
<td></td>
<td>Water</td>
</tr>
<tr>
<td>Inlet temperature</td>
<td>Deg C</td>
<td>120</td>
</tr>
<tr>
<td>Inlet pressure</td>
<td>bar</td>
<td>332</td>
</tr>
</tbody>
</table>

#1 The active heating tube has been based on using a composite material.
Field Layout

- Field schematic

8,000m
-350m

+40m

Host

WH
Field Layout

- Field schematic with production flow temperature profile overlay (no Insulation)
Production Fluid Temperature Profile

Case 1: No insulation and No active heating

Data generated by OLGA
Production Fluid Temperature Profile

Case 1: No insulation and No active heating
Case 2: 35mm of insulation, No active heating

Data generated by OLGA
Production Fluid Temperature Profile

Case 2: 35mm of insulation, No active heating
Case 3: Active heating installed and injecting 5k bbl / day of fluid at 120C

Production fluids arrive at ≈80°C, it may be possible remove the requirement for process heaters resulting in a smaller footprint on facilities.

Data generated by OLGA based on Open Circuit Condition
Production Fluid Temperature Profile

Case 3: Active heating installed and injecting 5k bbl / day of fluid at 120°C
Case 4: As case 3 but insulation reduced to 14mm

Data generated by OLGA based on Open Circuit Condition
Production Fluid Temperature Profile

Case 5: Active heating installed 20mm of insulation and injecting 5k bbl / day of fluid at:
120C, 100C, 80C, 60C and 40C

Data generated by OLGA based on Open Circuit Condition
Production Fluid Temperature Profile

Case 6: Active heating installed 20mm of insulation and injecting the fluid at 120°C:
- 5000, 4000, 3000, and 2000 bbl / day

Data generated by OLGA based on Open Circuit Condition
Comparison between:
New active heating system 5000 bbl / day at 120C, 20mm of insulation
Pipe in Pipe (8” in 10”) 5000 bbl / day at 120C, 20mm of insulation

Efficiency improvement may result in:-
Lower operating costs or
Lower CAPEX costs or
A combination of the two

Data generated by OLGA based on Closed Circuit Condition used as both PIP and New System discharge to sea
Pipeline ‘Warm-up Time’

The time required for the temperature at the discharge point of the active heating tube to reach equilibrium.

Pipeline has 20mm of insulation

- Base case 5000 bbl / Day at 120 C at injection point
- 4000 bbl / Day at 120 C at injection point
- 3000 bbl / Day at 120 C at injection point
- 2000 bbl / Day at 120 C at injection point
- 1000 bbl / Day at 120 C at injection point
## Tie-back Comparison (Theoretical)

<table>
<thead>
<tr>
<th>Traditional Pipe in Pipe Active Heating</th>
<th>New Active Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual steel 8” x 10”</td>
<td>Single steel 8” x composite 2.375”</td>
</tr>
<tr>
<td>Hot water one way in annulus then dump</td>
<td>Circulate hot fluid in 2.375” tube#1</td>
</tr>
<tr>
<td></td>
<td>Lower power requirement</td>
</tr>
<tr>
<td></td>
<td>Quicker warm up</td>
</tr>
<tr>
<td></td>
<td>Efficient heat transfer</td>
</tr>
<tr>
<td>Percentage of heat lost to surroundings</td>
<td>Application of production chemistry#2</td>
</tr>
<tr>
<td></td>
<td>Treatment of emulsions</td>
</tr>
<tr>
<td></td>
<td>Minimal reduction in flow area</td>
</tr>
<tr>
<td></td>
<td>Enabling technology for ‘stranded oil’</td>
</tr>
<tr>
<td></td>
<td>New concept needs testing</td>
</tr>
</tbody>
</table>
Comparison of Closed and Open Circuit

- **Open circuit**
  - Can be retrofitted
  - Can apply production chemistry
  - Fluid types can be changed
  - Good thermal performance
  - Possible to move the active heating tube
  - May be possible to pig the pipeline
  - May reduce the chemical injection lines in umbilical
  - Composite material removes possibility of galvanic corrosion

- **Closed circuit**
  - Challenge to retrofit
  - Can only use clean water
  - Can not vary fluid types
  - Best thermal performance
  - Difficult to move the tube once installed
  - Can not pig the pipeline
  - Probably will not change umbilical design
  - Composite material removes possibility of galvanic corrosion
Opportunities

• Topside footprint reduced due to ‘process heater’ located in the pipeline
• Reduction in produced fluid viscosity by converting oil external emulsions to water external emulsions
• Reduce power requirements (OPEX) for heating produced fluids
• Reduce the insulation requirements on pipeline systems
• Reduce complexity (cost) of umbilical
• Potential application with heavy oil
Technology Gaps

• How to pig the pipeline?
  – Operational pigging may not be required
  – Inspection pigging

• Flowline / Pipeline Design
  – Eliminate 5D bends
Potential Field Development CAPEX Savings

Calculations and cost estimates are from a hypothetical project

- 8 km tie-back in 350m of water
- Costs are based on:
  - Looped 8 inch development#1
  - Single 8 inch with insulation reduced by 30%
- Potential Project Savings >$11.8 million US (>33%)

Note #1: Not a Pipe in Pipe system
Conclusions based on modelling data

- Pipeline flow assurance and operational costs can benefit from a new design of active heating system.
- The concept of the active heating tube in the production pipeline is feasible.
- The efficiency of the active heating system is superior to a pipe in pipe design and more cost effective than a looped non heated pipeline design.
- If production chemistry is applied through the active heating tube it may be possible to remove this requirement from the umbilical.
- Reduced CAPEX and OPEX costs may enable the production of hydrocarbons from ‘stranded oil’ or remote / marginal fields.
- This is a new concept and needs further modelling, testing and ultimately qualification.
Questions & Open Forum

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For further details refer to US6,772,840