Production Optimisation of Heavy Oil Wells using Autonomous Inflow Control Devices

Mojtaba Moradi

DEVEX 2019    7-8 May 2019
The Challenges

Heavy Oil Reservoirs
- Unfavourable mobility compared to water
- Rapid increase in water cut,
- Low recovery factor due to uneven sweep of hydrocarbon resulting from: viscous fingering, permeability channelling etc,
- Requirement to use artificial lift

Horizontal Wells
- Uneven inflow from the reservoir to the well
- Annular flow
- Cross-flow
Autonomous Inflow Control Devices (AICD) is a viscosity and density dependent device:

\[
\partial P = \left(\frac{\rho_{mix}^2}{\rho_{cal}}\right)\left(\frac{\mu_{cal}}{\mu_{mix}}\right)^y \times a_{AICD} \times q^x
\]

\[
\rho_{mix} = \alpha_{oil}\rho_{oil} + \alpha_{water}\rho_{water} + \alpha_{gas}\rho_{gas}
\]

\[
\mu_{mix} = \alpha_{oil}\mu_{oil} + \alpha_{water}\mu_{water} + \alpha_{gas}\mu_{gas}
\]

AICD = Design constant
x = constant
y = constant
\(a\) = fraction

\(P\) = Pressure
\(\rho\) = Density
\(\mu\) = Viscosity
\(q\) = Flowrate
RCP AICD Performance

- Disc not levitate
- Restrict at inlet

High Velocity
- Disc levitate
- Restrict between disc

Oil 27 cp

Oil 106 cp
Case Histories

<table>
<thead>
<tr>
<th>Type of wells</th>
<th>Oil Rate Increment</th>
<th>Reduction in Water Cut</th>
<th>Viscosity range (cP)</th>
<th>Reservoir Formation</th>
<th>Conventional Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Retrofit and new</td>
<td>28%</td>
<td>10%</td>
<td>20-30</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Canada</td>
<td>Retrofit and new</td>
<td>240%</td>
<td>Up to 40%</td>
<td>150-1500</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Africa</td>
<td>New</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>Sandstone</td>
</tr>
<tr>
<td>The Middle East</td>
<td>Retrofit and new</td>
<td>30%</td>
<td>Up to 40%</td>
<td>&gt; 300</td>
<td>Carbonate</td>
</tr>
</tbody>
</table>

➢ Tendeka RCP AICDs has been successfully installed in more than 26 wells in heavy oil formations worldwide and many more planned for the early future.
➢ The devices were used in new wells or to retrofits the current completion.
The pressure drop across the ICD and AICD increase as the water breakthrough. However,
1) the magnitude of increase in the pressure drop with water compared to oil is about 4 for the AICD while is almost 2 for the ICD.
2) the pressure drop across the AICD is monotonically increasing as the water cut increases while for the ICD after a certain water cut the pressure drop falls due to an overall reduction in the well productivity and increased back-pressure.

\[
\delta P = f(q^2, \rho)
\]

The pressure drop across both ICD and AICD completions when only oil flows are from 0.6 to 8.20 bars.
Thank you

Any Questions?

For details, please refer to **SPE 1973718**
“Production Optimisation of Heavy Oil Wells using Autonomous Inflow Control Devices”