An alternative approach to reservoir stimulation

Joannes Okkerman
22 Feb 2024
SPE Aberdeen Geothermal
How the reservoir stimulation is done – short summary

• Deploy lower completion string fitted with fishbone subs in open hole well bore to TD and anchor the completion string in the reservoir interval
• Start the pumping job to activate the fishbones system
• Acid is pumped for the jetted system and filtered drilling mud is pumped for drilled system
• Continue pumping (2-6 hours job) to simultaneously extend long hollow Titanium needles fitted with a drill bit or jetting nozzle at the tip out of the fishbone subs and into the formation to create all the laterals
• 3 needles/sub with the drilling system and 4 needles/sub with the jetting system
• Laterals are each 10-12m long, with a $\frac{1}{2}$” (drilled) to a 1-2 “ (jetted) diameter
• In a single reservoir stimulation operation creates a very large number (10’s to 100’s) laterals ~perpendicular to main well bore, spaced out all along the reservoir interval
Product Portfolio

dimensions:
- 4-1/2” liner for 6-1/4” - 6.5” open holes
- 5-1/2” liner for 8.5” open holes

specifications:
- Available in all materials/threads to match liner specifications
What we do

Applications to-date worldwide (onshore & offshore)

<table>
<thead>
<tr>
<th>Formations stimulated</th>
<th>Well types</th>
<th>Combinations with other well construction methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fractured and layered carbonates and sandstones</td>
<td>• Oil and gas producers</td>
<td>• Multi-lateral wells</td>
</tr>
<tr>
<td>• Heterolithic clastic sequences</td>
<td>• Water injectors</td>
<td>• Sand screens &amp; ICDs</td>
</tr>
<tr>
<td>• Conglomerates</td>
<td>• Vert. / Dev. / Horiz. Wells</td>
<td>• Swellable packers</td>
</tr>
<tr>
<td>• Fractured basement rock</td>
<td>• Max temp. 200° C</td>
<td>• Frac sleeves</td>
</tr>
<tr>
<td>• Chalk</td>
<td></td>
<td>• Perforations</td>
</tr>
</tbody>
</table>

- Logistically simple – fishbones completion system is delivered to wellsite ready to deploy
- Fast and operationally straight forward deployment as open hole liner system.
- Small spatial and environmental stimulation footprint

Started in geothermal market in mid 2023
Case Study: North Sea Fishbones Drilling

10 times increased productivity in conglomerate formation (2021)

**Challenge**
- Basement infill project
- New well in fractured conglomerate formation
- Sand control requirement
- Risk for losses

**Solution**
- 5 ½” Fishbones Drilling system with 53 subs / 159 laterals
- Fishbones in combination with standalone ICD screens
- Swell packers run to isolate loss zones

**Results**
- Excellent production results
- 10x better productivity than original prognosis.
- SPE-209953-MS
- 2nd well 2022 with 183 laterals
- 3rd well 2023 with 180 laterals

1100 meter 8.5” open hole
The value of Fishbones stimulation technology

- Bypass damaged zone
- Increase reservoir exposure
- Connect layered reservoirs
- Connect to open natural fractures
- Connect with sweet spots and lenses
- Accurately stimulate zones
- Reduced drawdown and lower injection pressure
- Improve distribution of injection & production flow
- Rapid and operationally robust stimulation
- Reduced HSE exposure
Thank You

www.fishbones.as
Follow us on LinkedIn

jos.okkerman@fishbones.as (Geothermal Business Development manager)
LinkedIn: Jos Okkerman