Predicting Sessile Microorganism Populations in Oil and Gas Gathering and Transmission Facilities - Preliminary Results -

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I. Planktonic VS Sessile MO

- Planktonic microorganisms are ubiquitous in most oil and gas gathering and transmission facilities.

- MIC is caused by sessile microorganisms, which are part of a biofilm consortium attached to the metal surface.

Biofilm on metallic surface [1]
### I. Cont’d

#### Table 1: Comparison of planktonic VS sessile bacteria

<table>
<thead>
<tr>
<th></th>
<th>Planktonic bacteria</th>
<th>Sessile bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disposition</strong></td>
<td>Single cell or small aggregates</td>
<td>Aggregated form</td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>Free floating with the fluid flow</td>
<td>Attached to the surface</td>
</tr>
<tr>
<td><strong>Detection/numeration</strong></td>
<td>Relatively easy (fluid sample)</td>
<td>Expensive and time consuming</td>
</tr>
<tr>
<td><strong>Link to the MIC</strong></td>
<td>No direct link (species and location)</td>
<td>Direct link</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>Liquid samples from sampling points</td>
<td>Coupons or swab sampling</td>
</tr>
<tr>
<td><strong>Exposition to the biocides</strong></td>
<td>High exposition</td>
<td>Low exposition</td>
</tr>
</tbody>
</table>
II. Research Question

- As field data and research work revealed, there is no direct link between planktonic and sessile population count and locations [3].

- How can we mimic the transfer of planktonic-sessile and sessile-planktonic inside a pipeline?

MIC inside a pipeline [2]
III. Proposed Solution

Figure 1: Lifecycle of sessile bacteria
III. Cont’d

• The solution should mimic the following phenomenon:

1. Deposition
2. Attachment
3. Detachment
4. Growth
5. Desegregation
6. Reattachment

Computational Fluid Dynamics (CFD)
III. Cont’d

About CFD

• Computational fluid dynamics (CFD) is a science that, with the help of digital computers, produces quantitative predictions of fluid-flow phenomena based on the conservation laws (conservation of mass, momentum, and energy) governing fluid motion [4].
IV. Case Study Application

Figure 2: Produced water pipeline (case study)
IV. Cont’d

Inputs: Fluid Specifications

- **Fluid**: Produced water from offshore installation
- **Fluid flow**: Eulerian
- **Fluid phase**: Multiphase

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Oil</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume fraction</td>
<td>94%</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>Density (Kg/m³)</td>
<td>998.2</td>
<td>870</td>
<td>1098</td>
</tr>
<tr>
<td>Mass flow rate (Kg/s)</td>
<td>48.6</td>
<td>2.35</td>
<td>2.9</td>
</tr>
</tbody>
</table>
IV. Cont’d

Figure 3: Volume fraction of Bacteria
IV. Cont’d

Figure 4: Plot of the volume fraction of Bacteria

- Sessile bacteria count = \textbf{4.47\%} of the planktonic count
V. Next steps

Figure 1: Lifecycle of sessile bacteria
V. Next steps

VI. Key Challenges

Key challenges:

- Challenges in simulating fluid dynamics where volume fraction of bacteria is very low.
- Growth rate of sessile bacteria
- Others…
VII. Conclusion

- The CFD model aim to predict the count of sessile bacteria (each bacterial species separately).
- At this stage, further calibration by experimental data and field data is required.
- Once fully established, this model will provide an optimized and effective way to estimate the sessile microorganisms count given chemical, physical and microbiological data from the system.
References


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