A TRACER APPLICATION: DETECTING DAMAGE TO OIL INDUSTRY PIPING

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The problem to be attacked

• Massive investments by the oil industry are directed to maintenance and inspection.

• Annual cost of corrosion to the oil and gas industry in the United States alone estimated to be $27 billion, leading to an estimate of the global annual cost of maintenance as exceeding $60 billion
Main aims of maintenance

• Avoid breaches in the production process.
• Maximum advantage of time, personnel and tool resources obtained during planned pauses for maintenance.
• Avoid large negative impacts on economic achievement.
To comply with this:

• Equipment inspection procedures on a continuing basis emerge as crucial.

• The search for new inspection techniques turned into a differential in the oil industry.
Hence, some conjectures:

- Could tracers also be of value in detecting internal damage to closed pipes subject to aggressive environments such as oil processing plants?

- Could they be added to the present roll of nondestructive inspection techniques?
Corrosion and Scaling

• Two of the most deleterious damages to the structural properties of equipment components in oil refineries.

• Requiring unpostponable intervention and production stoppage.
Corrosion and Scaling

• Despite progresses have been achieved in the scientific knowledge of these processes, problems persist.

• They may even become more severe, due to the heavier, and therefore more acidic, crude oils being introduced in the refining processes.
Pit corrosion
Pit corrosion

• Internal aspect:
Pit corrosion

(50 X)
Scaling

• Iron hydroxide scales:
Scaling

- Scaling at a cooling water pipe
Methodology: Tracer impulse response

- Residence time distribution: \( E(t) = \frac{C(t)}{\int_0^T C(t)\,dt} \)
- Mean residence time: \( \bar{t} = \int_0^T t \cdot E(t)\,dt = \frac{V}{Q} \)
Simulacra pieces
Simulacra pieces
Assembly for Radiotracer test
Assembly for Dye Tracer test
GGUN-FL Fluorometer
DTS-Pro Software

• Convolution of entrance and exit pulses

\[ y(t) = \int_{0}^{t} E(t') \cdot x(t - t') \, dt' \]
DTS-Pro Software
Test flowrates

<table>
<thead>
<tr>
<th>Identification</th>
<th>Flowrate (mL.s(^{-1}))</th>
<th>Reynolds Number</th>
<th>Flow regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>28</td>
<td>880</td>
<td>laminar</td>
</tr>
<tr>
<td>Q2</td>
<td>111</td>
<td>3519</td>
<td>turbulent</td>
</tr>
<tr>
<td>Q3</td>
<td>249</td>
<td>7918</td>
<td>turbulent</td>
</tr>
</tbody>
</table>
Results from dye tracer tests
Results from radiotracer tests
Entrance Probe

28 mL/s (laminar)

111 mL/s (turbulent)

249 mL/s (turbulent)

SP A – clean
SP B – pit
SP C – scale
Results from radiotracer tests
Middle Probe

28 mL/s (laminar)

111 mL/s (turbulent)

249 mL/s (turbulent)

SP A – clean
SP B – pit
SP C – scale
Results from radiotracer tests
End Probe

28 mL/s
(laminar)

111 mL/s
(turbulent)

249 mL/s
(turbulent)

SP A – clean
SP B – pit
SP C – scale
Dispersion coefficients
## Flow parameters calculated by DTS Pro

<table>
<thead>
<tr>
<th>SP</th>
<th>Flowrate (mL/s)</th>
<th>$\bar{t}$ (s)</th>
<th>V (cm/s)</th>
<th>D (cm²/s)</th>
<th>Pe</th>
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<td>1,76 x 10⁵</td>
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CFD Simulation - Geometry
## CFD Simulation – Boundary conditions

<table>
<thead>
<tr>
<th>Material</th>
<th>Mass flowrate (kg/s)</th>
<th>Reynolds Number</th>
<th>Feed pressure (atm)</th>
<th>Domain</th>
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<tbody>
<tr>
<td>Pure water (constant properties)</td>
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<td>0.111</td>
<td>3519,757</td>
<td>1.000</td>
<td>Insode tube volume</td>
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</table>
CFD Simulation – 3D Grid
CFD Simulation Results – Streamlines

SP A

Q1

Q2

Q3
Velocities along the centre of the tubes

- Recirculation causes acceleration near the entrance and subsequent deceleration.
- The effect is stronger at higher flowrates.
Conclusions

• Dye tracers are not as effective as radiotracers due to the need of sampling and the lesser frequency of measurements.

• Qualitative differences could be noticed in the tracer response patterns of normal and damaged pipes.

• Scaling was more sensitive to the reduction in the time of transit
Conclusions

- Recirculation at the entrance increases with flowrate.
- Changes in the patterns of the RTD curve were due to discontinuities in the internal surface.
- Tracer dispersion consistently increased as flowrate increases, and the effect is more sensitive for scaling than for pit corrosion.
Conclusions

- Tracers, especially radiotracers, have a potential to detect damages that can introduce a discontinuity in the inner surface of pipes, namely pit corrosion and scaling.
THANK YOU FOR YOUR ATTENTION!