Application of Flow Modelling to a Risk-based Approach to Well Decommissioning

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Risk-based approach to Well P&A Design

- UK well P&A expenditure forecast over the next decade: £ 7.5 billion*
- Urgent business need for a risk-based approach → fit for purpose, well specific design.
- P&A system long-term performance modelling required to assess risk and support cost-saving decision making process

*2018 Decommissioning Insight, Oil & Gas UK
**Possible Modelling Techniques**

<table>
<thead>
<tr>
<th></th>
<th>Upscaled Steady State</th>
<th>Transient Wellbore Modelling</th>
<th>Numerical Grid-Based Simulation</th>
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<tbody>
<tr>
<td><strong>Key Adv.</strong></td>
<td>Simple to implement</td>
<td>Captures (early) transient</td>
<td>Accurate flow through cement</td>
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<td></td>
<td></td>
<td>effects</td>
<td>(i.e. porous medium)</td>
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<td><strong>Key Disadv.</strong></td>
<td>No time dependence</td>
<td>Approximation: cement</td>
<td>Performance over time ( 1000s</td>
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<td></td>
<td></td>
<td>modelled as chokes</td>
<td>of years)</td>
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<td>Unsuitable flow correlations</td>
<td>Approximation: annular spaces</td>
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<td></td>
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<td>Computationally expensive</td>
<td>modelled as very high perm &amp;</td>
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<td>porosity medium.</td>
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\[ Q = \left( \frac{KA}{\mu L} \right) (\Delta P - \rho g L \cos \theta) \]

Developed Grid-Based Framework – Sample Application

Using:
- In-house pre/post processor
- Commercial simulator as back-end engine.

Scenario:
- Open hole completion
- Reservoir: Gas, Constant $P = 5000$ psia
- Wellbore: Water-saturated, intact cement $k = 1 \mu D$

Results consistent with expected trends
Validation of absolute flowrates using physical experiments would be ideal
Key parameter: effective permeability \((k_{\text{eff}})\)

**Effective Permeability**

\[ k_{\text{eff}} = k \cdot k_r \] (\(k = \text{absolute permeability}, k_r = \text{relative permeability}\))

**Multiphase flow in porous medium**

- **Model application:** identify most important input parameters.
Conclusions

- Numerical grid-based finite difference modelling works!
- The key input: $k_{\text{eff}}$ of cement, driven primarily by the absolute $k$.
- To improve reliability (especially for probabilistic analysis)
  - more data and a deeper understanding of flow properties of cement with different degrees of isolation required.
- All P&A scenarios can be modelled using our developed framework,
  - including through-tubing P&A, which is of particular interest from a cost-saving perspective.

More data required for reliable probabilistic analysis
Acknowledgements

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