ITERATIVE COUPLING OF SINGLE-PHASE RESERVOIR FLOW AND GEOMECHANICS
Simulation analysis

Explicit and iterative coupling

Simulation performance

Objective
INTRODUCTION

Depth of 1829 m
770 x 770 x 60 (m)
Single-phase water depletion
Displacement boundary conditions
INTRODUCTION

Radius 0.08 m
Rate 15,000 bbl/day
INTRODUCTION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal stresses</td>
<td>27.58 MPa</td>
</tr>
<tr>
<td>Vertical stress</td>
<td>41.37 MPa</td>
</tr>
<tr>
<td>Young modulus</td>
<td>68.94 MPa</td>
</tr>
<tr>
<td>Poisson ratio</td>
<td>0.30</td>
</tr>
</tbody>
</table>
1. Pore pressure in each block
2. Pore pressure in each gridpoint of blocks
3. Volumetric Strain by volumetric average
4. Update the porosity, permeability and compressibility
1. Model brick size.
2. Constitutive model.
3. Fix velocity in all gridpoints.
4. Apply initial stress conditions.
5. Apply reaction forces.
6. Free velocity in all gridpoints.
7. Apply constraints conditions.
8. First pore pressure of problem.
9. Apply zero initial displacement.
10. Apply next pore pressure.
11. Fish and Python commands.
12. Are the timesteps finished?
\[
\phi_{n+1} = \frac{\phi^n + \epsilon v^{n+1} - (1 - \phi^n) \alpha t (T^{n+1} - T^n)}{1 + \epsilon v^{n+1}}
\]
Tortike and Farouq Ali (1993)

\[
Cr = \frac{\epsilon v^{n+1} - \epsilon v^n}{\phi^n (P^{n+1} - P^n)}
\]
Inoue and Fontoura (2009)

\[
K^{n+1} = K^n \left(1 + \frac{\epsilon v^{n+1}}{\phi^n}\right)^3
\]
Tortike and Farouq Ali (1993)
**METHODOLOGY**

\[
\phi_{n+1} = \frac{\phi_{n+1} + \varepsilon \nu^{n+1}}{1 + \varepsilon \nu^{n+1}}
\]

Tortike and Farouq Ali (1993)

\[
Cr = \frac{\varepsilon \nu^{n+1} - \varepsilon \nu^n}{\phi^n (P_{n+1} - P_n)}
\]

Inoue and Fontoura (2009)

\[
K^{n+1} = K^n \left(1 + \frac{\varepsilon \nu^{n+1}}{\phi^n}\right)^3 \frac{1 + \varepsilon \nu^{n+1}}{1 + \varepsilon \nu^{n+1}}
\]

Tortike and Farouq Ali (1993)
RESULTS

- Mechanical ratio-average limit

Until 250 days.
RESULTS

- Displacement vectors and compression behavior
RESULTS

- Subsidence 3D view
RESULTS

- **Subsidence effect**

![Graph showing subsidence effect over time](image)
The explicit and iterative coupling proposed in this paper obtained similar results as the one proposed in Dean’s article.

However, the coupling developed in this work ensures better control of the properties and behavior of the simulation, due to the adjustment and analysis of geomechanical parameters behavior.

This work also shows how the reservoir behaves and how it deforms during exploitation, ensuring its safe monitoring, updating key reservoir parameters as porosity, permeability, and compressibility.
REFERENCES


MATLAB & Simulink for Building Simulation – State of the Art, MathWorks, Inc., 2018. MA, USA.


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