Multiphysics Modelling of Spring-Supported Thrust Bearings for Hydropower Applications

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Thrust bearings are commonly used in hydroelectric power plants. These bearings are required to support the shafts of the turbines.
1.2) HOW does it work

The relative motion between the collar and the pads generates a pressure distribution.

\[
\frac{d}{dx} \left( \frac{\rho \cdot h^3 \, dp}{12 \cdot \eta \, dx} \right) - \frac{U}{2} \frac{d}{dx} (\rho \cdot h) = 0
\]

GAP GEOMETRY

- Tilting
- Elastic Deformation
- Thermal Expansion

Fluid Velocity Field \( U \)

Pressure distribution \( p \)

Gap Height \( h \)

External Load

COLLAR

PAD SUPPORT
1.3) Spring-Supported

The pad is supported by a spring mattress.

There is not a defined pivot point.
2) Model

A.) PAD

B.) COLLAR

C.) FLUID
2.1) Physics Applied

- **Lubricant Shell**
  \[ \nabla \left( \frac{\rho \cdot h^3}{12 \cdot \eta} \cdot \nabla \rho \right) = \nabla \left( \frac{U_x}{U_y} \right) \cdot \rho \cdot h \nabla \]

- **Solid Mechanics**
  \[ \sigma = E \cdot \varepsilon \quad \frac{\Delta L}{L} = \alpha_L \cdot \Delta T \]

- **Heat Transfer in Fluids**
  \[ \rho \cdot C_p \cdot \left( u_T \cdot \frac{\partial T}{\partial x} + v_T \cdot \frac{\partial T}{\partial y} \right) - k \cdot \frac{\partial^2 T}{\partial z^2} = \]
  \[ = \eta \cdot \left[ \left( \frac{\partial u}{\partial x} \right)^2 + \left( \frac{\partial v}{\partial y} \right)^2 \right] - \frac{1}{\rho} \cdot \frac{\partial}{\partial t} \left( U_T \cdot \frac{\partial T}{\partial x} + v_T \cdot \frac{\partial T}{\partial y} \right) \]

- **Heat Transfer in Solids**
  \[ \rho \cdot C_p \cdot U_{trans} \cdot \nabla T = \nabla \cdot \left( k \cdot \nabla T \right) + Q \]

- **Moving Mesh**
  (mesh deformation)
2.2) Model Coupling

- **COLLAR**
  - 1

- **FLUID**
  - 2

- **PAD**
  - 3

Symbols and Equations:
- \( u, v, z \)
- \( T \)
- \( h_{\text{channel}} \)
- \( h_{\text{wall}} \)
- \( pf \)
3) RESULTS: Global Scheme

**INPUTS**
- Shaft Angular Velocity
- External Load Applied
- Bath Temperature
- Geometry Parameters
- Material Properties
- Springs Pattern Characteristics

**OUTPUTS**

<table>
<thead>
<tr>
<th>PAD</th>
<th>Deformation</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLLAR</td>
<td>Deformation</td>
<td>Temperature</td>
</tr>
<tr>
<td>FLUID</td>
<td>Film Thickness</td>
<td>Temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Losses</td>
</tr>
</tbody>
</table>
3.1) Results

- Pressure on the Gap
- Pad Temperature
- Fluid Velocity Field
- Collar Displacement
- Fluid Film Thickness
3.2) Applications of the Model

• Varying operating conditions:
  a) Load
  b) Angular Velocity
  c) Bath Temperature
  d) Springs Patterns

• Test different kinds of lubricants.
• Test different compounds materials.
• Test shape improvements.
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