Modeling of Soluble lead-acid flow battery
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Introduction

✓ Need of clean energy
✓ Emphasis on RES
✓ Energy storage technology

Flow battery

Electrolyte:  \( CH_3SO_3H \Leftrightarrow CH_2SO_3 + H^+ \)

\( \text{Pb(CH}_3\text{SO}_3\text{)}_2 \Leftrightarrow \text{Pb}^++2\text{CH}_2\text{SO}_3^- \)

Cathode:  \( \text{Pb}^++2e^- \Leftrightarrow \text{Pb} \)

Anode:  \( \text{Pb}^++2H_2O \Leftrightarrow \text{PbO}_2 + 4H^++2e^- \)

Overall:  \( 2\text{Pb}^++2H_2O \Leftrightarrow \text{Pb}_n + \text{PbO}_2+4H^+ \)

Side Reaction:

\( \text{PbO}_2+2H^++2e^- \Leftrightarrow \text{PbO}_2+H_2O \)

Computational Methods

Physics Interfaces:

a. Laminar Flow  
b. Ternary Current Distribution-moving/ fixed grid  
c. Surface Reaction  
d. Global ODE

\[
\frac{dc_{in}^{in}}{dt} = \frac{Q}{V c_{in} - c_{in}^{in}} \\
J_{PbO_2} = nFk_{e^{PbO_2}} \left( \exp \left( \frac{2\alpha F}{RT} \eta \right) - \exp \left( \frac{-2\beta F}{RT} \eta \right) \right) \\
0 \quad \text{if} \quad C_{PbO_2} = 0 \\
J_{Pb} = nFk_{e^{Pb}} \left( \exp \left( \frac{2\alpha F}{RT} \eta \right) - \exp \left( \frac{-2\beta F}{RT} \eta \right) \right) \\
J_{PbO_2} = nFk_{e^{PbO_2}} \left( \exp \left( \frac{0.9 F}{RT} \eta \right) - nFk_{e^{Pb}} C_{PbO_2} \exp \left( \frac{-0.9 F}{RT} \eta \right) \right)
\]

\( p = 100 \text{kPa} \)

Results (Fixed geometry)

- Voltage versus time profile obtained
- Current density is not uniform
- Peak current at edge of reaction zone
- Changing geometry may have influence

Results (Moving grid, reduced domain)

Conclusions

References