

Development and Modelling of Large-scale Vanadium Flow Batteries

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Daisaku Taguchi, K. Fujikawa, T. Kanno, K. Yamanishi

Sumitomo Electric Industries, Ltd.

Introduction

■ Sumitomo Electric Industries (SEI) Overview

✓ Global electronics company specializing in power, communication, and control systems technologies and products

■ Recent Announcements

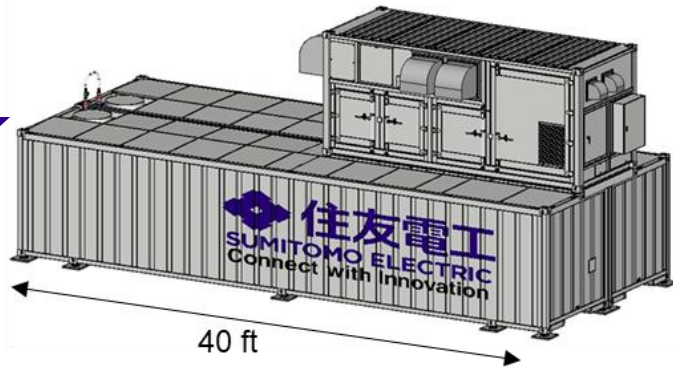
- Press release on the new advanced VFB systems in February 2025
- Goals:

✓ Achieve high energy density 15% up*

*Compared to previous models

✓ Reduce overall costs 30% off*

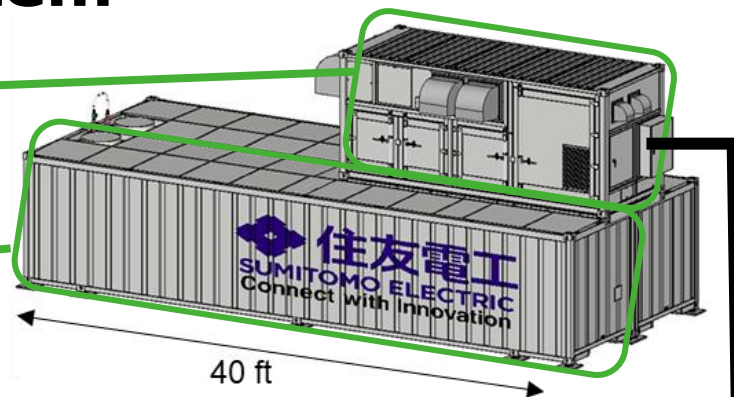
✓ Ensure long-term operation Up to 30 years



System Overview and Configuration

■ 300 kW/2400 kWh VFB System

- Two-tier configuration
 - ✓ Upper tier: Battery cells (**300 kW output**)
 - ✓ Lower tier: Electrolyte tanks (**2400 kWh capacity**)
- Connection to PCS
 - ✓ Charging/discharging controlled according to load demands



Charge/
Discharge

Power Conversion System
(PCS)

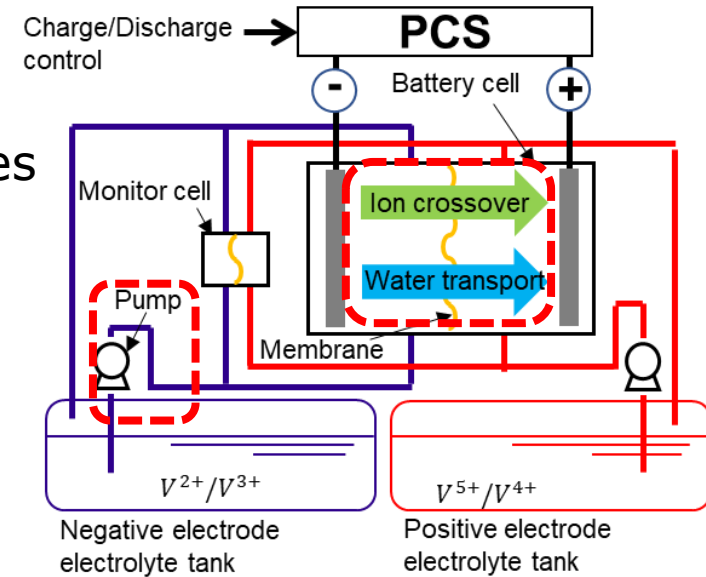
Unfavorable Phenomena and Optimization Challenges

■ Unfavorable Phenomena

- Ion crossover through the membrane
 - Leads to long-term capacity loss
- Pressure loss in battery cells and pipelines
 - Reduces system efficiency

■ Optimization Challenges

- Ion Crossover Suppression
 - ✓ Mixing techniques
 - ✓ Membrane technology
- Flow Rate Control
 - ✓ Minimizing pump losses
 - ✓ Maximizing SOC (State of Charge) range



Modeling Approach

■ Objective

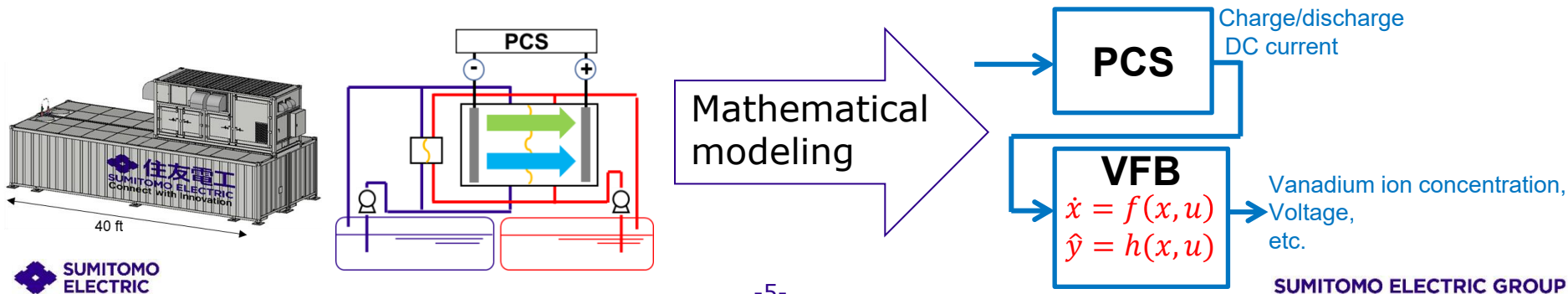
- ✓ Develop model for 300 kW/2400 kWh VFB system

■ Focus Areas

- ✓ Ion crossover
- ✓ Battery voltage dynamics

■ Approach

- Mathematical modeling
 - ✓ Use of detailed equations and simulations



Parameter Estimation

■ Model Construction

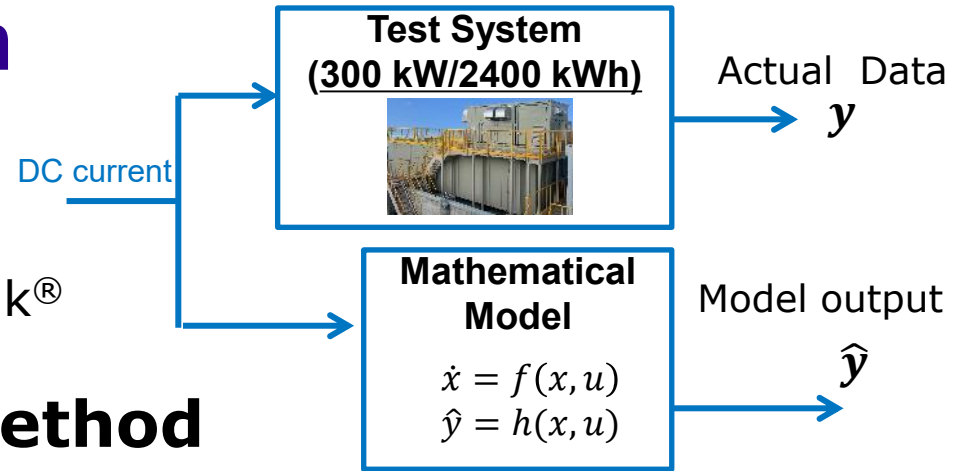
- Platform and Tools
 - ✓ Using MATLAB® and Simulink®

■ Parameter Estimation Method

- Least-Squares Method
 - ✓ For estimating unknown parameters(p)

$$\min_p \|\mathbf{y} - \hat{\mathbf{y}}\|^2$$

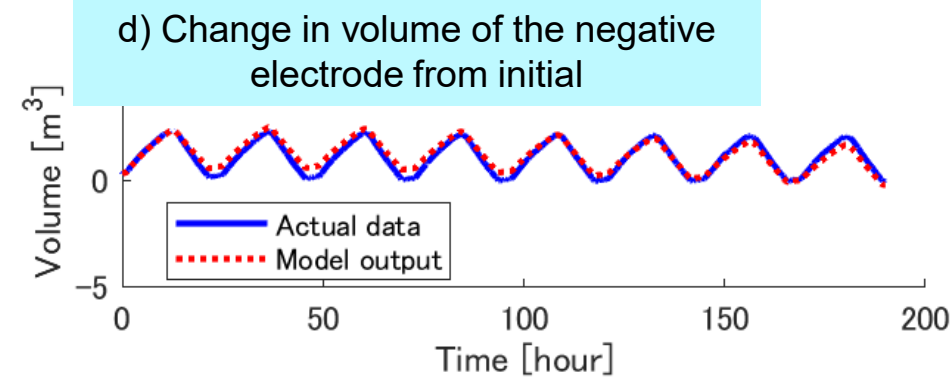
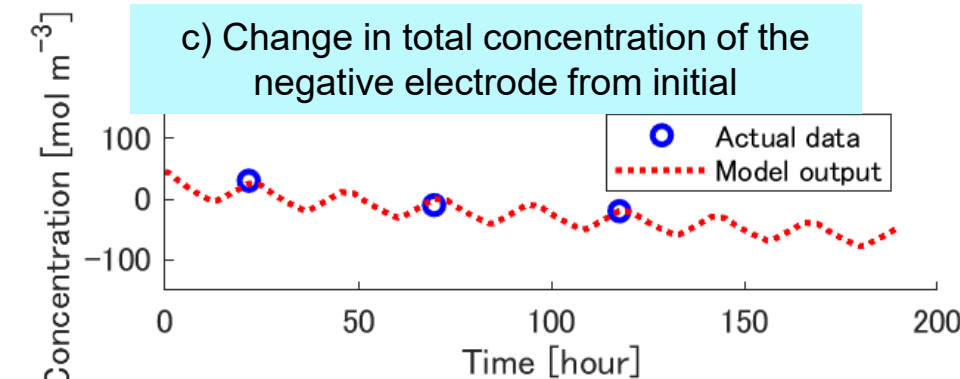
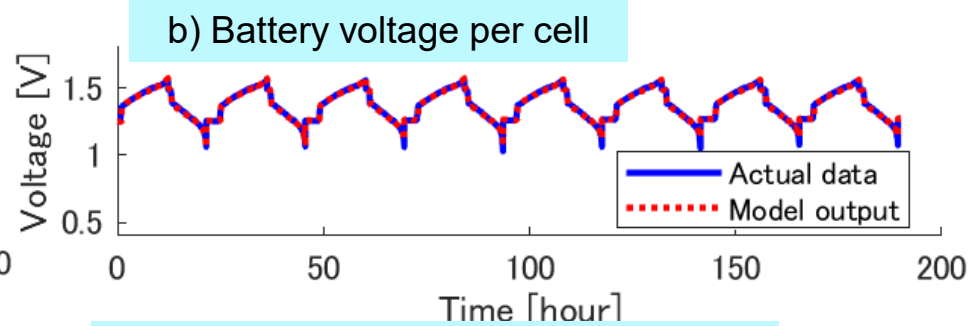
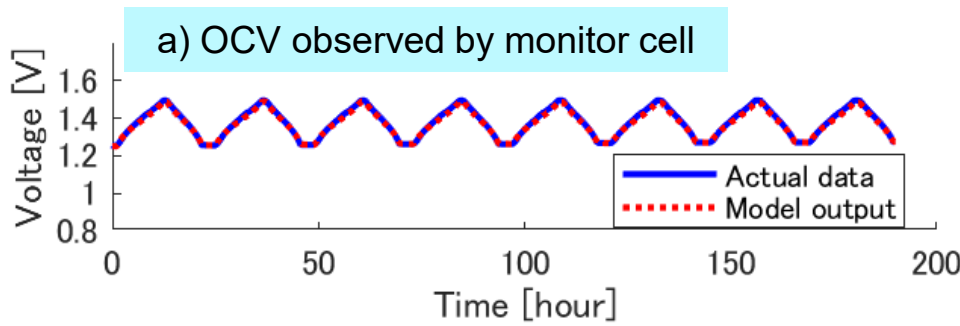
- Pattern Search Algorithm
 - ✓ MATLAB Global Optimization Toolbox



Model Outputs vs Actual Data

■ Validation Results

✓ Our model accurately matches actual data



Optimization

■ Using mathematical model

- ✓ Consider simple optimization using obtained model

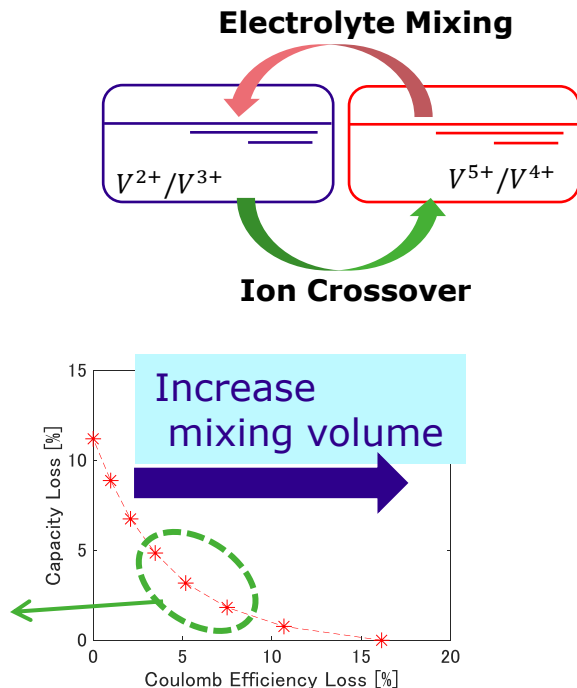
■ Examination

- Vanadium Imbalance Correction
 - ✓ Recover battery capacity loss through electrolyte mixing
- Trade-off: Increased mixing leads to self-discharge and decreased efficiency

■ Simulation Results

- ✓ Analyze efficiency vs capacity by varying the mixing volume

Optimal mixing conditions



Conclusion

■ Summary of Key Points

- ✓ Developed VFB Mathematical Model
- ✓ Validated the model using the new advanced 300kW/2400kWh VFB test system
- ✓ Demonstrated an example of design optimization using the model

■ Future Work

- ✓ Further Optimization
- ✓ Now on Demonstration

New VFB system



Pre-orders start FY2025

Thank you! Any Question?

taguchi-daisaku@sei.co.jp



Technology for a Better Tomorrow

We live in a world that grows ever more advanced thanks to technological innovation. In five business segments, the Sumitomo Electric Group is contributing to this trend:

- Safer, more comfortable, more eco-friendly cars
- Higher capacity infocommunication networks
- Electronic devices with greater functionality
- Stable supplies of electricity from renewable sources
- Advanced materials used in industries and households

Every day, we strive to develop technology that enriches society. This is our mission at the Sumitomo Electric Group.

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