Technology

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Performance Modeling and Flow Rate Optimization of Vanadium Redox Flow Batteries

Master's Thesis

GRIN

Bibliographic information published by the German National Library:

The German National Library lists this publication in the National Bibliography; detailed bibliographic data are available on the Internet at http://dnb.dnb.de .

Imprint:

Copyright © 2020 GRIN Verlag
ISBN: 9783346228321

This book at GRIN:

https://www.grin.com/document/914611

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STAGE-II (EN594) THESIS

Submitted in partial fulfilment of the requirements

of the degree of

Bachelor and Master of Technology

By

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(2020)

Abstract

There is a drastic capacity increase in the ocean, solar, and wind power based energy generation in recent years. Moreover, a larger increase is predicted in future years. Hence, we need a reliable, efficient, and cost-effective energy storage system to match up with the intermittent nature of renewable energy sources. Vanadium redox flow batteries are a promising option and are fast approaching commercialization owing to their unique characteristics like including independent scaling of power and energy density. However, there are various losses associated with the membrane, electrodes, and also due to mass transfer which limit its performance and further decrease battery capacity and efficiency. The first part of this study focusses on membrane thickness, mass transfer coefficients, electrode morphology, and current density to analyze the performance of the battery. The latter part describes the effect of flow rate on concentration over-potential, pressure losses, and pumping power to come up with an optimal variable flow rate strategy to maximize the battery capacity and system efficiency.

Keywords: Electrochemical Energy Storage, Vanadium Redox Flow Batteries, Flow Rate optimization, Performance Modeling, Polarization Curves, Over-potential, Hydraulic Model, Variable flow rate, system efficiency, mass transfer, membrane thickness, current density, limiting current density, tortuosity, porosity, electrode compression, catalysis, specific surface area

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