SCHAEFFLER

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Helmholtz Institute
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Optimization of PTL structure to enhance water and gas transport properties

MASTER THESIS EXPOSÉ

by

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Contents

Todo list

Acronyms

CCM	Catalyst Coated Membrane
PEM	proton exchange membrane
PEMWE	proton exchange membrane water electrolysis
PTL	porous transport layer

1 Motivation

PEM water electrolysis PEMWE is regarded as one of the most promising technologies in the fields of energy generation, distribution, use, and coupling of different sectors. Due to the possible „green“ generation of hydrogen, CO2 emissions can be avoided. For chemical processing, hydrogen is needed in large amounts. New drivetrain concepts rely on hydrogen as fuel or synthetic fuels, made out of hydrogen and a carbon source. Not only for energy conversion and use but also for integrating renewable energy sources into our electric energy system, hydrogen is assigned a mandatory role. Storing and releasing it can buffer natural energy oversupply into wind and solar energy deficiency.

Although PEMWE is widely researched and shows a well-understood state-of-the-art, some knowledge gaps can be identified. Industrialization and mass production-related knowledge is still lacking, often combined with gaps in scientific research. Regarding that, related topics like assembly-friendly design, quality assurance, normative or industrial standardization, and legislative treatment are mandatory to understand.

A further topic, not mainly driven in the context of industrialization, are performance issues. These can be linked to kinetic or activation energy losses, ohmic resistances in and between the cell components, and poor mass transport through the cell or respectively towards the CCM. The porous transport layer (PTL) is an important component and responsible for the transport of process media towards and away from the CCM. The focus of the company Schaeffler as a stack supplier and industrializer about this component, is the understanding and optimal choice of base materials and possible surface modifications.

Which of them are relevant for us as R&D, laying down examples

2 State of the art

Do the literature research.

Questions towards current knowledge (state-of-the-art in the thesis) as basic understanding:

Are there more topics, which smaller the knowledge gap?

- Are there ideas, on how an ideal and optimized PTL1 layer has to look like? (Regards to structural appearance, ...)
- Are there ideal material characteristics for PTL1 layers defined in literature? (Regarding specified characteristic values; what must the PTL1 be able to do?)
- Is there an understanding of
- How can the dominating mass transport effects be manipulated? Pore size distribution, surface modifications, pore shapes, operating characteristics, ...? (Standards and understanding in literature)

Which approaches have already been done in scientific research? What is already common knowledge?

Do I need to know more?

- Optimizations of PTLs for mass transport
- Approaches of optimization strategies
- Predicting goal values for material characteristics?

Research topics/start-off points for further development:

Do I need to know more?

- Are there optimum material characteristics for fine-graded porous transport layers?
- How does mass transport work in the finer porous transport materials?
- Which effects dominate the water and gas transportation in porous materials (pore size of PTL1)?
- How can the dominating mass transport effects be manipulated? Pore size distribution, surface modifications, pore shapes, operating characteristics, ...?

Approaches after [1]–[4].

3 Research outline

3.1 Assignment

Here is a task description of the assignment with restrictions/limitations, musts, wishes, and proposed methodology.

Describe the assignment.

3.2 Objectives

More specifically there are a few research questions derived, which further illustrate the goals and current research gaps. Rather than just naming them, background information is given to understand the interest behind and around the thesis, and to better interpret the results later on. A statement about continuing research is possible with that.

Find reasonable objectives, add background knowledge and information.

Research objective 1

Which production methods can be used to produce a composite structure between active components in a cell, including bipolar plates, porous transport layers, and if possible, catalyst coatings or catalyst-coated membranes? Is there a need for treatment before or after for the single components?

Here are some details about objective 1, why, and what linkage to the others.

Research objective 2

How can a composite structure between active components, such as bipolar plates and porous transport layers, improve the performance of a PEM electrolyzer stack and/or cell, with special regard to interface resistances and stability over the lifetime?

Here are some details about objective 2, why, and what linkage to the others.

3.3 Proceeding and working packages

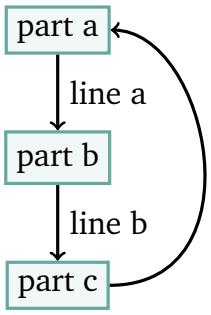

Figure 3.1: Schematic, respectively logical linking between planned tasks and working packages

3.4 Preliminary structure

With the presented motivation, state-of-the-art, approaches, methods and further information, the preliminary structure for the actual master thesis can be set. Concerning the limited possible content of the thesis, the following structure is proposed. The parts with cursive typeset are seen as obligatory and included when the process of the thesis is advancing.

Illustrate (simple) and describe (complete) methods, proceeding and resulting working packages.

Define resulting and projected structure.

1 Introduction and Motivation

2 State of the Art

- 2.1 Mass Transport Assessment and Models
- 2.2 Contact Welding
- 2.3 Materials and surface treatments of Porous Transport Layers

3 Design and Optimization of the setup

4 Experimental Methods

- 4.1 Production of the Specimens
- 4.2 Functional Testing
- 4.3 Ageing Tests

5 Results and Discussion

- 5.1 Production of the Specimens
- 5.2 Functional Testing

4 Suggested timeline

A full list of the estimated work packages and their time placement during the thesis is given in the appendix. Smaller time blocks for getting involved with the general topic, software or basic literature are considered, due to the already ongoing employment relationship with Schaeffler. In combination with the bigger preparation of the thesis assignment, rough methods are already chosen and a basic state-of-the-art outline is present (see chapter 2). Focus in the assumed planning is time for methods, interpretation, and writing.

Estimate a rough timeline.

Bibliography

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[3] T. Seip, N. Shaigan, M. Dinu, K. Fatih, and A. Bazylak, "Correlating nanostructure features to transport properties of polymer electrolyte membrane electrolyzer anode catalyst layers," *Journal of Power Sources*, vol. 559, p. 232 654, Mar. 2023, ISSN: 0378-7753. DOI: 10.1016/j.jpowsour.2023.232654. (visited on 04/03/2023).

[4] S. Bhaskaran, D. Pandey, V. K. Surasani, E. Tsotsas, T. Vidakovic-Koch, and N. Vorhauer-Huget, "LBM studies at pore scale for graded anodic porous transport layer (PTL) of PEM water electrolyzer," *International Journal of Hydrogen Energy*, GCGW-21 - Global Warming Reduction by Hydrogen, vol. 47, no. 74, pp. 31 551–31 565, Aug. 2022, ISSN: 0360-3199. DOI: 10.1016/j.ijhydene.2022.07.079. (visited on 09/18/2023).

Details on working packages and timeline

	May					Jun				Jul					Aug				Sep				Oct				
working package	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
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