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Proposal for Capstone Design Projects at UBC Mech

AVL Fuel Cell Canada Inc.

Development of a method for measuring the Shear Modulus of Gas Diffusion Layers for PEM fuel cells

Proposal for UBC Mechanical Engineering Capstone Design Course
by AVL Fuel Cell Canada

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Proposal Information (1/2)

1 - Introduction

Proton-exchange fuel cells (PEMFC) fueled by hydrogen are energy conversion devices that are currently attracting attention as sustainable emission-free power sources for larger electric vehicles (e.g. buses and heavy-duty trucks), for which the use of batteries is not yet a practical solution due to the low energy-density and the slow charging-times of the current battery technology.

The design of a PEMFC stack involves a detailed understanding of the processes occurring in each subcomponent, while the optimization of cost and efficiency requires the accurate identification and quantification of the sources of performance and durability losses. Specifically, model-based design of PEMFC stacks and components relies on inputs such as material properties and also effective properties of the components. Some of these properties are difficult to measure directly, and standard measurement methods and tools are not yet available. Among these, the shear modulus of the gas-diffusion layer (GDL) is challenging to measure. The GDL is a porous structure typically made by pressing carbon fibers together into a carbon paper. GDLs come with a Micro Porous layer (MPL) that provides a smooth layer with good contact with the electrodes. The typical thickness of GDL varies between 100 and 250 um. There is not standard methods for directly measuring GDL shear modulus and the indirect ways that are used by some are cumbersome and not sufficiently accurate.

The goal for the proposed project is to define a novel method for measuring the shear modulus, in the thickness direction, of GDLs. The method should eventually give results that are sufficiently accurate for use as inputs in a FEA model of the PEMFC unit cell, which, in turn, should serve as a reliable optimization tool.

We recommend to approach this problem in a progressive fashion, for instance using first a thin film of a homogeneous material with known shear modulus for method validation. To carry out the experimental validation of the devised method, the team should have access to a lab equipped for the measurement of mechanical and electrical properties. The team will likely need to design and prototype ad-hoc sample holders or to modify existing jigs.

Proposal Information (2/2)

2 - Brief Project Description

The goal for the proposed project is to define a novel method for measuring the shear modulus of GDLs.

The GDL shear modulus is used as input to FEA modelling in order to determine the compression of the GDL to the CCM at the center of a channel of the bipolar plate. Ideally, one would like to directly measure the GDL to CCM compression at the center of the channel, but a mature tool or method does not exist. The project can expand to include the development of a tool to measure the center channel compression, which may help with the validation for the method of measuring shear modulus.

The new method should give a more direct measure, should be cost and time effective, and should provide a more accurate measure of the GDL shear modulus than the existing methods.

3 - Expected Outcomes

The team is expected to define the new method and provide a preliminary demonstration of the solution proposed. We recommend the following milestones: 1) review of methods to measure shear modules on thin films (100-200 um); 2) down selection (on theoretical basis) of methods that are applicable to thin composite films such as GDL; 3) report on experimental verification.

Given the circumstances with COVID-19, we recognize physical prototyping by the students may be limited. If this ends up being the case, we would expect a final design from the students and we would continue with fabrication and testing.

4 - Resources Available from the Customer

AVL Fuel Cell Canada Inc. will provide supervisory support and in-kind support with materials and equipment that will be made available to the team. We are located in North Burnaby near the Production Way skytrain station, and may be able to organize a workspace for the students to perform physical prototyping depending on COVID-19 and any other relevant safety considerations.

Budgeted resources: up to 2,000 CAD for materials; TBD for equipment and parts .

5 - Customer Requirements

Accuracy within ± 10 % (must have); Easy to implement (must have); Quick measurement time (nice to have)

References

- [Characterisation of mechanical behaviour and coupled electrical properties of polymer electrolyte membrane fuel cell gas diffusion layers](); Journal of Power Sources Volume 190, Issue 1, 1 May 2009, Pages 92-102.

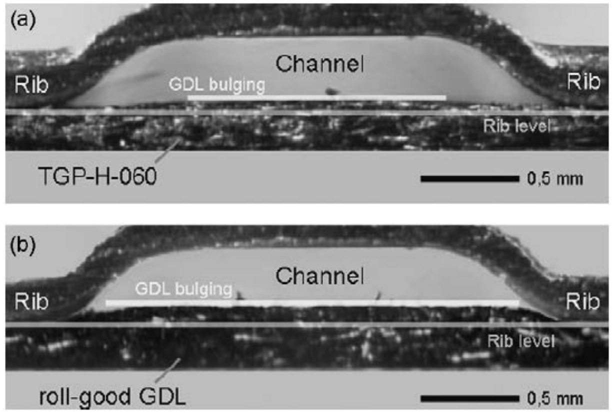

Fig. 2. GDL compression distribution mapped in a compressed microscopic flow-field cross-section setup for TGP-H060 (a) and a commercial roll-good GDL (b). The roll-good GDL is hardly compressed under the channel.

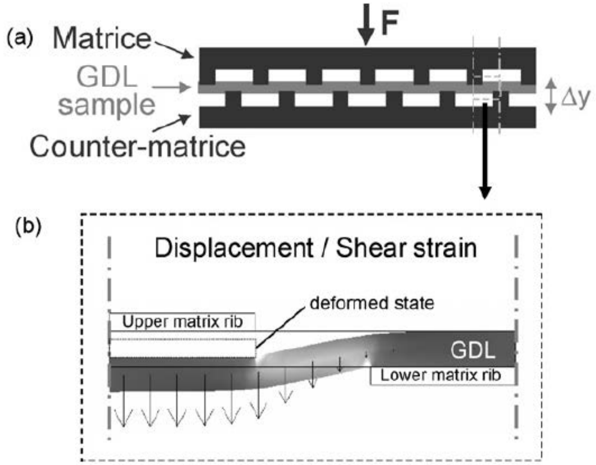

Fig. 6. (a) Multipoint short-beam bending setup for determination of through-plane shear modulus G_{xy}. Bending span was optimized for a maximum shear influence on the result, but still material compression and bending have an impact of around 50% on the measured deflection. (b) Structural FEM-simulation of one bending segment was used to find correction factors for determination of real GDL through-plane shear modulus G_{xy} with known compression E_y and bending properties E_x.

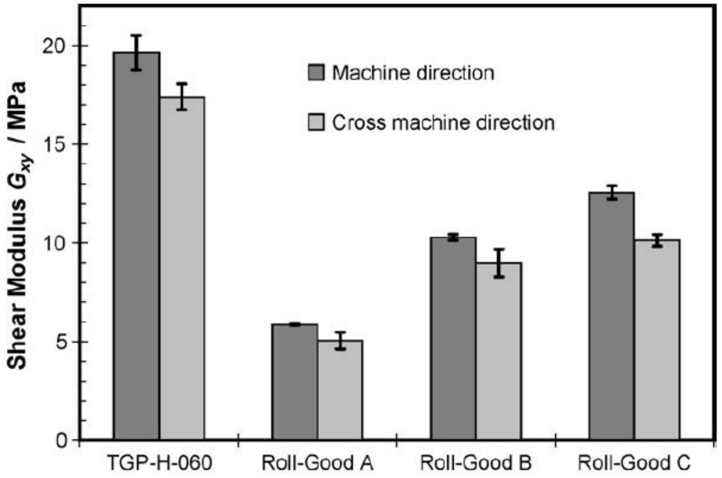

Fig. 7. FEM-corrected shear modulus results G_{xy} for the different GDL types.

References

- Channel intrusion of gas diffusion media and the effect on fuel cell performance; Journal of Power Sources Volume 184, Issue 1, 15 September 2008, Pages 120-128
- Uneven gas diffusion layer intrusion in gas channel arrays of proton exchange membrane fuel cell and its effects on flow distribution; Journal of Power Sources Volume 194, Issue 1, 20 October 2009, Pages 328-337
- Effect of GDL deformation on the pressure drop of polymer electrolyte fuel cell separator channel; Journal of Power Sources Volume 202, 15 March 2012, Pages 100-107

Vielen Dank

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