Characterization of Transport Properties in Gas Diffusion Layers for PEMFCs

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In order to meet performance targets for PEMFCs, E-TEK creates Gas Diffusion Layer (GDL) structures with varying properties[1] such as porosity, permeability and hydrophobicity. Such varying properties are meant to improve the reactant and liquid water transport in the GDL as well as to insure a better electrical contact with the catalyst layer.

The convective transport of gas reactants in a porous GDL is characterized by the permeability coefficient, while the capillary transport of the liquid water is determined by the contact angle of water to the material and by the surface energy of the GDL material.

Since GDL materials are highly anisotropic, different permeability coefficients describe the fluid transport ‘in plane’ (x, y directions), versus ‘through plane’ (z direction). A method to determine separately the permeability coefficients in (x, y) and z directions respectively, by controlling the direction of the gas flow through the porous sample is employed at Case Western Reserve University. This method is applied initially to the macro-porous substrate of the GDL alone and subsequently to the macro-porous substrate with different micro-porous layers applied on it. The permeability of the micro-porous layer is calculated from the two measurements.

The internal contact angle of water to the fibers of a GDL is determined both by the material and by the pore structure of the GDL. The methods used to determine the contact angle of water by measuring the meniscus formed when the GDL is immersed in water[2] accounts only for the GDL material effect. At Case Western Reserve University we use a Krüss Processor Tensiometer along with the Owens-Wendt calculation method[3] to determine the internal contact angle of water to the fibers of the GDL and the surface tension of the GDL fibers. The method is applied separately to the macro-porous substrate carbon fibers and the micro-porous constituent components.

The methods for determining the permeability in (x, y) and z directions of GDL materials and the method for determining the internal contact angle of water to GDL materials along with results will be presented.

[1] B. Mueller, T. Zawodzinski, J. Bauman, F. Uribe, S. Gottesfeld, E. De Castro, M. De Marinis: “*Carbon Cloth Gas Diffusion Backings for High Performance PEFC Cathodes*” in Proton Conducting Membrane Fuel Cells II, PV 98-27, p. 1, The Electrochemical Society Proceedings Series, Pennington, NJ (1998)

[2] C. Lim, C.Y. Wang: “*Effects of Wetting Properties of Gas Diffusion Layer on PEM Fuel CellPerformance*” Electrochemical Society Meeting, October 20-25, 2002, Salt Lake City, UT

[3] D. K. Owens and R. C. Wendt, *J. Appl. Polym. Sci.* **13**, 1791 (1969)

Figures 1 and 2 show the apparatus for determining the permeability ‘through-plane’ (z-direction) of GDL materials and the apparatus used to determining the internal contact angle of water; Tables 1 and 2 present the results measured for four E-TEK GDL samples.

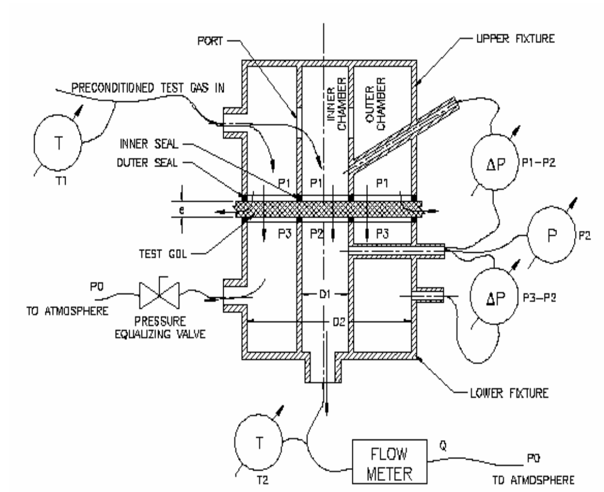

Figure 1
Apparatus for ‘through-plane’ (z-direction) permeability measurements

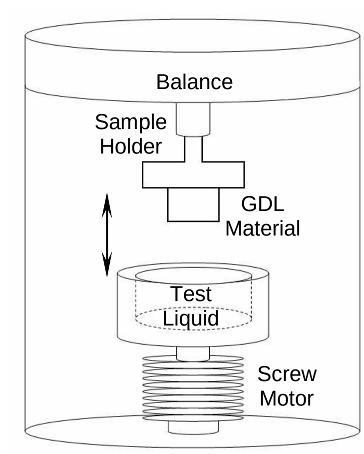

Figure 2
Apparatus for wettability measurements

Table 1
Measured ‘through-plane’ viscous permeability K_V and inertial permeability K_I for four E-TEK GDL samples

Sample	Lot #	Thick *[mm]*	K_V *[m²]*	K_I *[m]*
30% PTFE, type 1	3	0.383	9.58E-13	4.64E-8
30% PTFE, type 2	1	0.444	5.77E-13	9.95E-7
70% PTFE, type 1	4	0.455	8.12E-12	1.92E-7
70% PTFE, type 2	2	0.456	7.42E-12	1.02E-7

Table 2
Measured internal contact angle to water, GDL surface energy g_s, and its dispersive and polar components g_s^d and g_s^p

Sample	Lot #	Contact angle	g_s	g_s^d	g_s^p
30% PTFE, type 1	3	80^0	24.6	7.5	17.1
30% PTFE, type 2	1	84^0	22.2	7.8	14.4
70% PTFE, type 1	4	100^0	14.3	9.4	4.9
70% PTFE, type 2	2	94^0	17.1	9.5	7.6