On the Effect of Clamping Pressure and Methods on the Current Distribution of a Proton Exchange Membrane Water Electrolyzer

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On the Effect of Clamping Pressure and Methods on the Current Distribution of a Proton Exchange Membrane Water Electrolyzer

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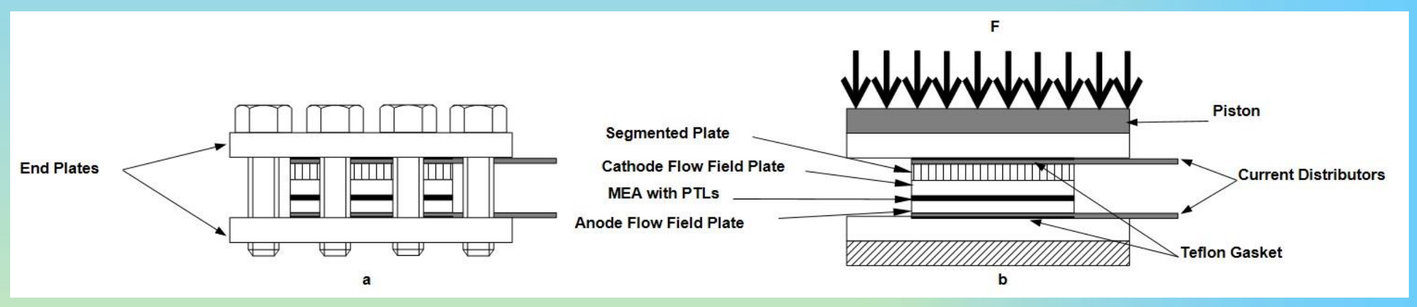
- Producing hydrogen using renewable energy sources :
  - Reduces the CO_2 footprint , and
  - Improves energy security.
- PEMWE is considered a good candidate to produce hydrogen from renewable energy sources.
- Technical challenges such as cost, reliability, and durability slowing down the widespread of PEMWE commercialization.
- Thus, a better understanding of the PEMWE electrochemical reaction degradation is required.
- The local current distribution (LCD) measurements is one of an operando and in-situ experimental characterization technique that can help for a better understanding for electro chemical reaction degradation at the coated catalyst layer of the PEM.
- In this work, LCD is measured at the cathode side of 50 cm^2 PEMWE cell at different clamping pressures and methods:
  - Bolting the cell with 8 bolts around the active area, and
  - Compressing the overall area of the end plate using pneumatic

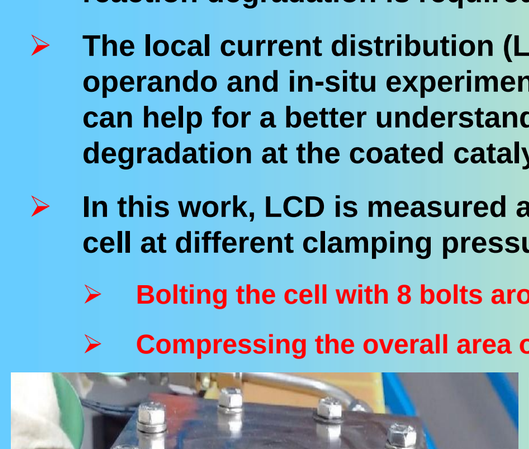


Front view of the PEMWE single cell clamped by: a) symmetrical 8 bolts around the active area, and b) uniform compression pressure on the whole area of the end plate (drawings are out of scale).

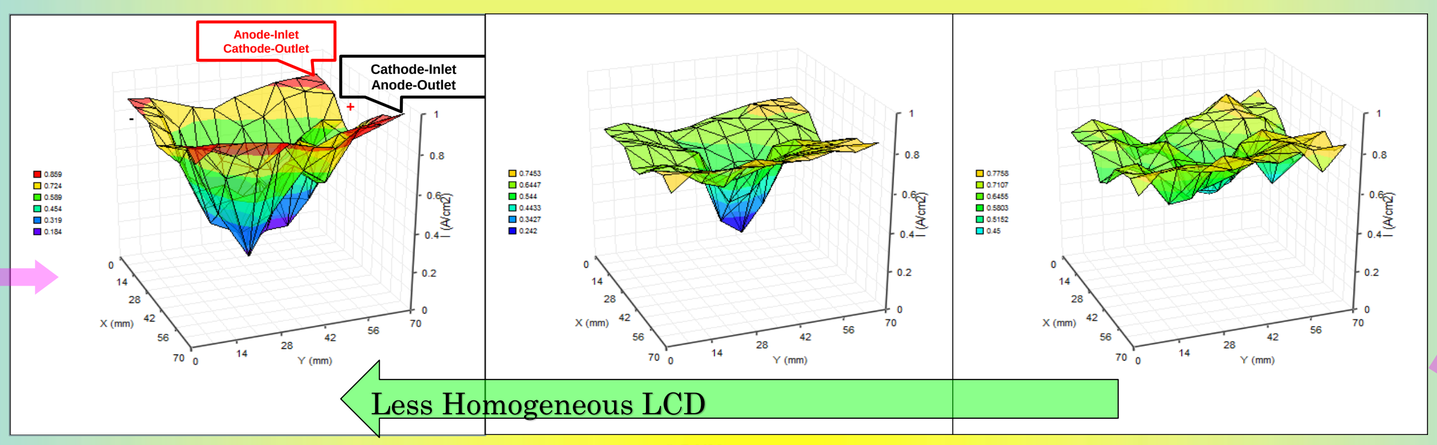
$$F_c = \frac{N \times \tau}{C \times D} \qquad P_c = \frac{F_c}{A_c}$$

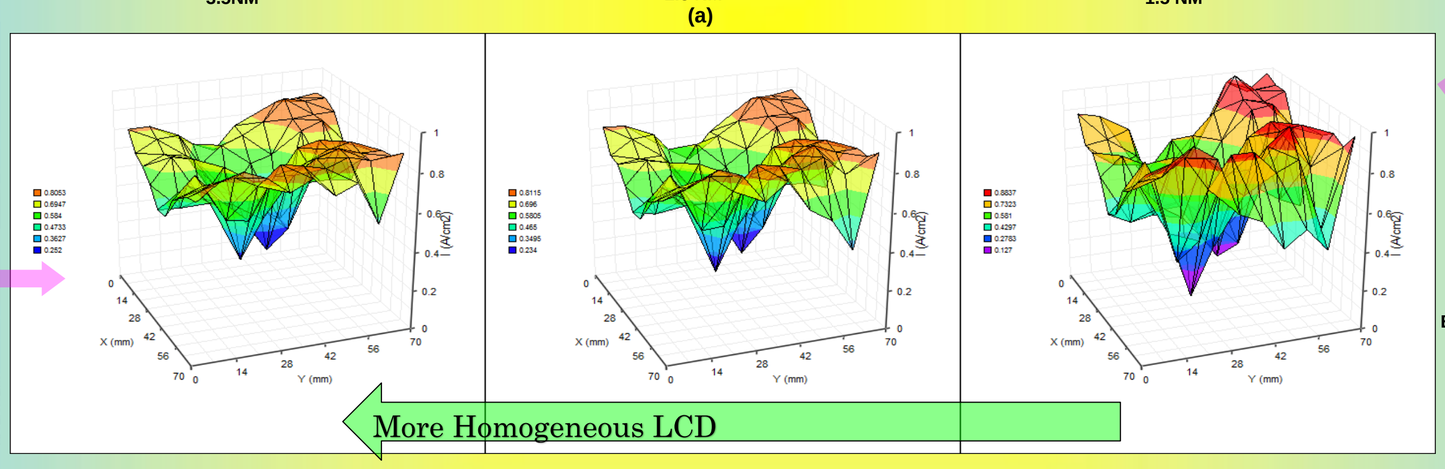
F_c is clamping force,
A_c is active area,
N is the number of bolts,
τ is the applied torque (inch-pounds),
C is the friction coefficient (0.2 for steel bolts),
D is the nominal bolt diameter (inch).

Bolted PEMWE Cell



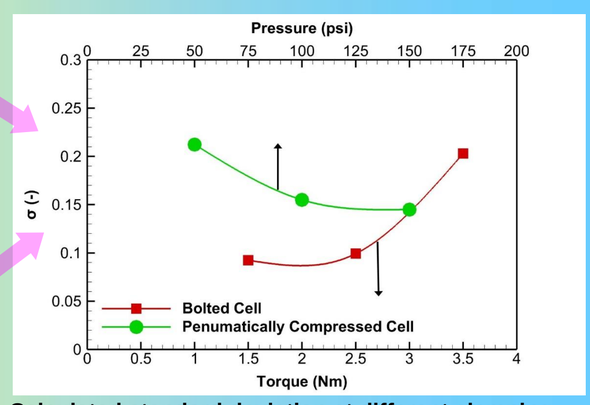
Pneumatically Compressed PEMWE Cell





Measured LCD of PEMWE cell a) bolted with 1.5, 2.5, and 3.5 Nm and b) pneumatically compressed with 50, 100, and 150 psi, at 70 ° C, 70 A, and atmospheric pressure.

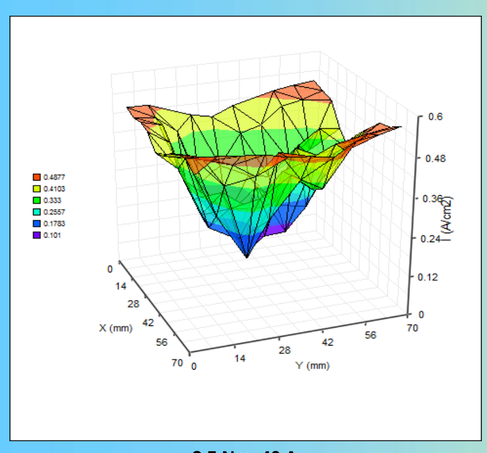
- A single-square PEMWE cell with 50 cm^2 active area was built in house.
- Similar titanium porous transport layers were used on both sides of the MEA.
- S++® Current Scan Lin was used to measure the LCD at the cathode side.



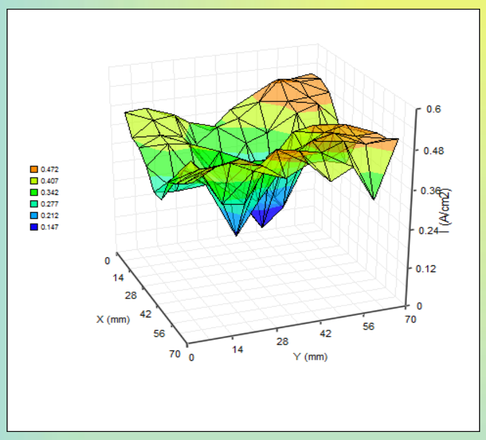
Calculated standard deviation at different clamping pressure and methods and 70 °C.

Experimental Conditions for Measuring the Polarization Curve and LCD.

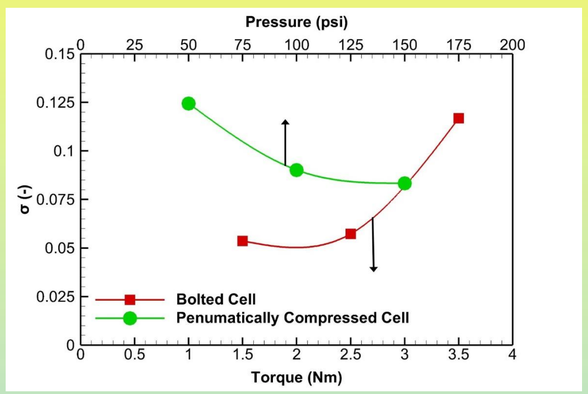
Description	Value
DI-Water inlet temperature for Anode and Cathode, T(°C)	70
Working Pressure (atm)	1
DI-Water flow rate (mlpm)	200
Clamping Pressure (psi)	50, 100,150
Clamping Torque (Nm)	1.5,2.5,3.5
PEMWE cell temperature T(°C)	70
I,V measuring frequency (Hz)	0.5
Steady state time (min)	20
LCD Measurement Time for 100 Segments (s)	0.5



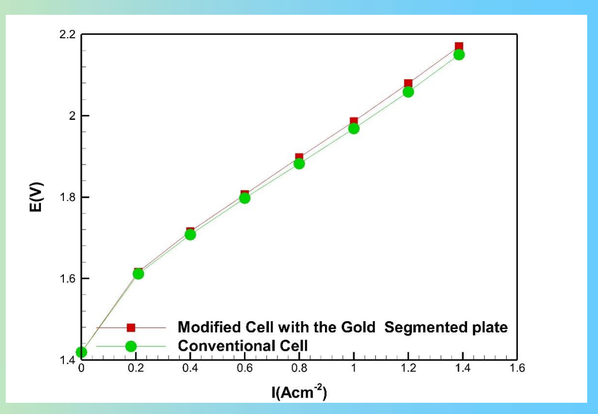
3.5 Nm, 40 A



150 psi, 40 A

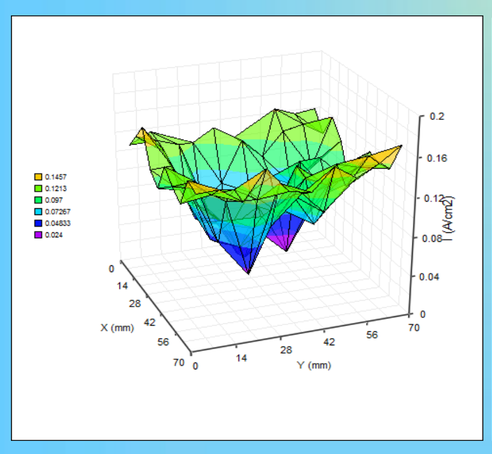


40 A

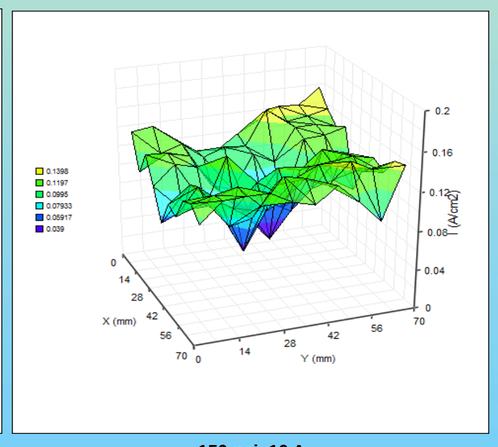


Measured IV curve with and without the S++® gold plated segmented plate at 70 ° C, atmospheric pressure, and 3.5 Nm compression torque

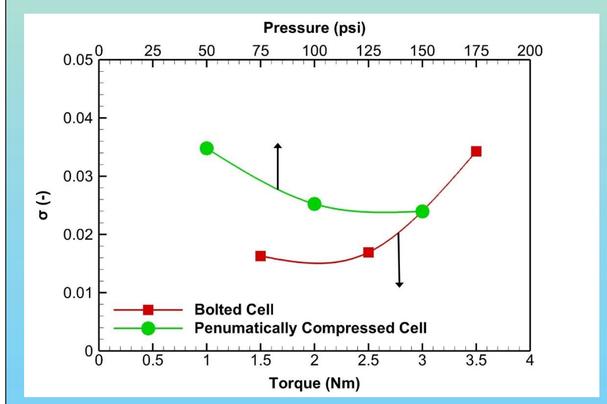
Measured LCD and calculated standard deviation at 40 A for the bolted cell at 3.5 Nm and for the pneumatically compressed cell at 150 psi.



3.5 Nm, 10 A



150 psi, 10 A



10 A

Measured LCD and calculated standard deviation at 10 A for the bolted cell at 3.5 Nm and for the pneumatically compressed cell at 150 psi.

- In this work, the effect of the amount of clamping pressure and methods on local current distribution (LCD) of the square single 50 cm2 PEMWE cell has been in-situ and operando experimentally demonstrated at different current densities.
- The bolted cell has shown more heterogeneous LCD and the heterogeneity increases with increasing the clamping torque.
- Meanwhile, more homogeneous LCD for the pneumatically compressed cell and the homogeneity of LCD increases with increasing the clamping pressure.
- The bolted cell has shown lower LCD values in the middle and higher values on the perimeter of the cell. Meanwhile, the more homogeneous LCD in the pneumatically compressed cell.
- Despite the fact that, the bolted cell has higher performance at the highest torque. The degradation rate of the electrochemical reaction might be higher due to heterogeneous LCD. On the other hand, the pneumatically compressed cell has shown more homogenous LCD at the highest applied pressure. Thus, highest performance with the lower electrochemical degradation rate can be obtained.