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Modeling of Interfacial Resistance Effects on the Performance and Efficiency for Electrolyzer Energy Storage

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In this paper, a comprehensive model for quantifying the effects of physical parameters including liquid/gas diffusion layer (LGDL) thickness, proton exchange membrane (PEM) thickness, and interfacial resistance on the performance and efficiency of a PEM electrolyzer cell is developed. A new equivalent resistance module, which combines component resistances and interfacial resistances, is well established to model the ohmic loss in a single PEM electrolyzer cell. The numerical results indicate that changes in both PEM thickness and LGDL thickness have significant influences on the cell voltage and efficiency. Decreasing the PEM thickness and LGDL thickness can reduce the cell voltage and consequently improve the cell performance and efficiency. In addition, the cell voltage and efficiency is found to vary significantly with the interfacial resistance and current density. It can be calculated that the losses due to the interfacial resistances comprise around 28.3% of the total ohmic loss when the interfacial resistance is 30 mΩ·cm². Modeling results will provide very accurate information for the understanding and optimization of the performance and efficiency of a PEM electrolyzer cell.

Nomenclature

A	=	reaction area
α_i	=	charge transfer coefficient or species activity
$C_{H_2,m}$	=	hydrogen concentration at the interface of LGDL and CL
$C_{O_2,m}$	=	oxygen concentration at the interface of LGDL and CL
j	=	current density
j_0	=	exchange current density
K	=	permeability
k_r	=	relative permeability
M	=	molar mass
N	=	fluid mass flux
p	=	pressure
p_c	=	capillary pressure
p_{H_2O}	=	liquid water pressure
p_{O_2}	=	oxygen pressure
R_c	=	CL resistance
R_{in-cl}	=	Interfacial resistance of CL and PEM
R_{in-gc}	=	Interfacial resistance of LGDL and CL
R_{in-pg}	=	Interfacial resistance of plate and LGDL
R_g	=	LGDL resistance
R_m	=	PEM resistance

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R_p	= plate resistance
s	= liquid saturation
T	= temperature
V	= voltage or overpotential
V_0	= reversible voltage
V_{act}	= activation overpotential
V_{act}	= diffusion overpotential
V_{ohm}	= ohmic loss
n	= mole number of electrons
η	= cell efficiency
ε	= LGDL porosity
σ	= surface tension
θ	= contact angle

I. Introduction

Recently, in order to provide reliable, compact, and high-efficiency renewable energy for aerospace applications, a mature water electrolysis technology for hydrogen storage and production is needed, and synergy between hydrogen energy, oxygen production and power energy sources is particularly interesting. Among all types of electrolyzer cell systems, proton exchange membrane (PEM) electrolyzer cell technology, which has the similar working components as PEM fuel cells but operates in the opposite process, provides a sustainable solution for renewable energy storage, hydrogen and oxygen production due to its higher energy efficiency/density, faster charging/discharging, a more compact design and environmentally-friendly system [1-4]. Figure 1 shows a module schematic of a PEM electrolyzer cell for space application. In this simplified system, electrolyzer cell combines electrical energy from solar power and water to produce oxygen at the anode and hydrogen at the cathode. Hydrogen fuel can be used to provide energy for propulsion power systems when needed and the water product may be electrolyzed in the next cycle. In addition, water electrolysis can provide breathing oxygen for the crew in space. For these reasons, studies that enhance the performance and efficiency of a PEM electrolyzer cell are desired. Although good progress has been achieved in PEM electrolyzer [5-9], most of the researches are experimental, and improvements of mathematical modeling are still needed in many fundamental issues. This paper will pay attention to the issue related to the effect of interfacial resistance on the performance and efficiency of a PEM electrolyzer cell.

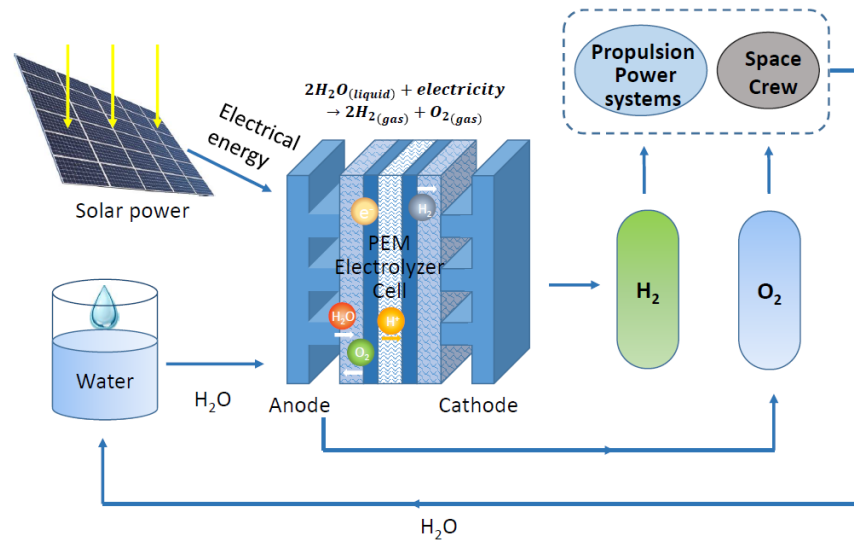


Figure 1. Schematic of a PEM electrolyzer cell for space application

Interfacial resistance, or contact resistance, which is from interfacial failure between different components due to assembly compression, physical interaction, mass transport and material corrosion, has been considered to be a

critical element for the performance and efficiency of regenerative fuel cell and electrolyzer systems. A single PEM electrolyzer cell consists of bipolar plates, liquid/gas diffusion layers (LGDLs), catalyst layers (CLs) and PEM, so its interfacial resistances should consist of three parts, including the interfacial resistance between plate and LGDL, the interfacial resistance between LGDL and CL and the interfacial resistance between CL and PEM, and each of which plays an important role in the cell performance and efficiency. According to the previous modeling results [10], the loss due to interfacial resistances between a CL and LGDL was found to comprise about 30% of the total ohmic loss in a PEM electrolyzer cell and the loss could be greater if other interfaces are considered. Therefore, it is necessary to develop a method for analyzing the effect of interfacial resistance and then optimize the electrolyzer structure to improve the cell performance.

Few experiments and numerical models [7, 10] were carried out to examine the interfacial effect of a PEM electrolyzer cell, but some work has been made in the interfacial resistances of PEM fuel cell, which will be useful for PEM electrolyzer cell issues. Zhang et al. [11] proposed two semi-empirical method to predict the interfacial resistance of plate and GDL in PEM fuel cell based on an interfacial resistance-pressure constitutive relationship obtained from experimental data. They reported that the interfacial resistance was highly affected by the assembly clamping pressure and the cell performance could be greatly improved by optimizing the assembly pressure. Pivovar and Kim et al. [12-14] conducted a series of experimental studies on the interfacial resistance between a membrane and porous electrode in a PEM fuel cell. They reported an experimental method for measuring the interfacial resistance of membrane and electrode, and the resistance values were found to range from $8m\Omega \cdot cm^2$ to $57m\Omega \cdot cm^2$. Kalidindi et al. [15] developed a two-dimensional model to investigate the interfacial effects of CL and microporous layer (MPL) and two-phase transport behaviors. Their modeling results show that interfacial morphology plays an important role in the cell performance under high current density. Other works have focused on the interfacial resistance of GDL and CL, and the interfacial morphology issues [16-18].

In this paper, a new equivalent resistance model with interfacial effect is developed to calculate the effects of component parameters including PEM thickness, LGDL thickness, and interfacial resistance on the cell performance and efficiency. The results will provide useful information for demonstrating technical feasibility of electrolyzer system in future space exploration missions. This paper is organized as follows: Section II presents the model development, Section III shows numerical results and discussion including model validation, PEM thickness effect, LGDL thickness effect, and interfacial effect, and Section IV gets the conclusion.

II. Model development

In order to model the interfacial effect and ohmic loss in a PEM electrolyzer cell, a new equivalent resistance model for a single cell is developed. As shown in Figure 2, a single PEM electrolyzer cell consists of two plates, two LGDLs, two CLs and a PEM. Interfacial resistance occurs at three interfaces inside the cell, including interface of plate and LGDL, interface of LGDL and CL, and interface of CL and PEM.

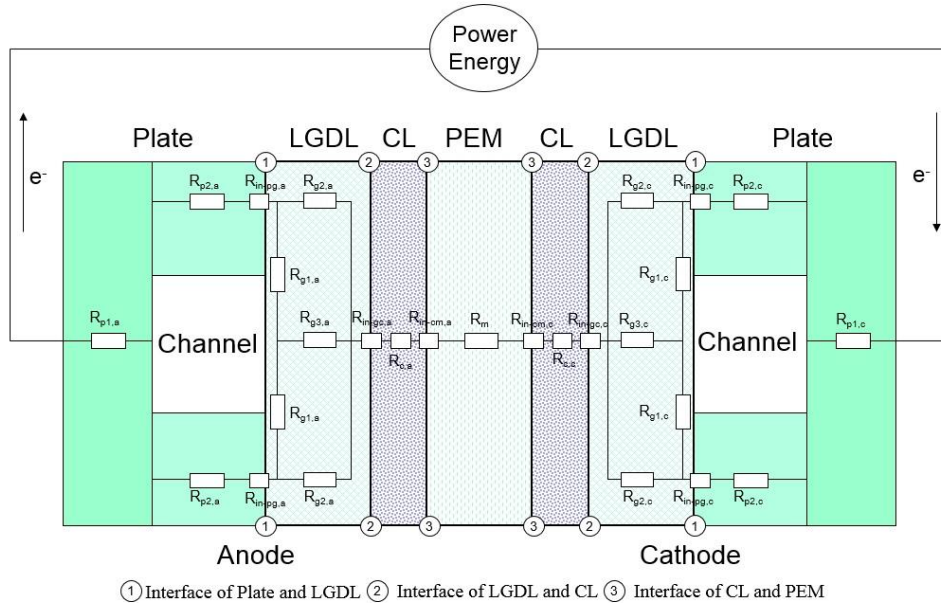


Figure 2. Equivalent resistance model for a single PEM electrolyzer cell

Based on the above resistance model, the total voltage or electrochemical performance of a single PEM electrolyzer cell can be obtained by calculating the sum of open circuit voltage, activation overpotential, diffusion overpotential and ohmic loss overpotential. In addition, gas/liquid two-phase transport process inside the LGDL is considered in the present model and its governing equations can be derived from classical porous flow theory, which consists of mass and momentum conservation equations. Key relationships of modeling electrolyzer cell performance and two-phase transport behaviors are shown in the following and more details can be found in the previous paper [10].

The open circuit voltage (OCV) [19] is mainly dependent on the reversible voltage, operating temperature and pressure. Generally, OCV can be calculated from the Nernst equation as

$$V_{ocv} = V_0 + \frac{RT}{nF} \ln \left(\frac{\alpha_{H_2} \alpha_{O_2}^{0.5}}{\alpha_{H_2O}} \right) \quad (1)$$

Where V_0 is the reversible voltage, T is the temperature, R is the gas constant, F is the Faraday constant, n is the electron mole number, α is species activity that is related to partial pressure.

The activation overpotential generated during electrolysis reaction and the diffusion overpotential due to mass transport can be calculated as follows:

$$V_{act} = \frac{RT_{an}}{\alpha_{an}F} \sinh^{-1} \left(\frac{j}{2sj_{0,an}} \right) + \frac{RT_{cat}}{\alpha_{cat}F} \sinh^{-1} \left(\frac{j}{2sj_{0,cat}} \right) \quad (2)$$

$$V_{diff} = \frac{RT_{an}}{n_{an}F} \ln \left(\frac{C_{O_2,m}}{C_{O_2,m0}} \right) + \frac{RT_{cat}}{n_{cat}F} \ln \left(\frac{C_{H_2,m}}{C_{H_2,m0}} \right) \quad (3)$$

Where α_{an} is the anode charge transfer coefficient, α_{cat} is the cathode charge transfer coefficient, j is the current density, s is the liquid saturation at the interface of anode LGDL and CL, $C_{O_2,m}$ is the oxygen concentration at the interface of anode LGDL and CL, $C_{H_2,m}$ is the hydrogen concentration at the interface of cathode LGDL and CL, j_0 is the exchange current density that is closely associated to operating conditions and catalyst materials. Since the exchange current density is difficult to quantify and its value ranges largely in different studies [6], the exchange current density is generally adjusted to better fit the numerical result to experimental data.

The ohmic loss, which is due to cell resistances, can be calculated by using the equivalent resistance model in Figure 2. As shown in Figure 2, the total resistance should consist of two plate resistances (R_p), two LGDL resistances (R_g), two CL resistances (R_c), one PEM resistance (R_m), and three interfacial resistances ($R_{in-pg}/R_{in-gc}/R_{in-cm}$), so the voltage due to the ohmic loss can be defined as:

$$V_{ohm} = (R_p + R_{in-pg} + R_g + R_{in-gc} + R_c + R_{in-cm} + R_m)jA \quad (4)$$

Where the relationship of material resistivity and component thickness is used to calculate the plate, LGDL, and CL resistances while PEM resistance can be calculated by an empirical formulas [9], the interfacial resistances are obtained from existing experimental data [12], A is the reaction area.

The total potential and efficiency of a PEM electrolyzer cell can be calculated as

$$\text{Potential: } V_{total} = V_{ocv} + V_{act} + V_{diff} + V_{ohm} \quad (5)$$

$$\text{Efficiency: } \eta = \frac{V_{ocv}}{V_{total}} \quad (6)$$

For gas/liquid transport modeling, two-phase transport governing equations are needed to obtain the liquid water distribution inside the LGDL. Based on the classical fluid mass and momentum equations in a porous media, a steady state gas/liquid two-phase transport model for anode LGDL of a PEM electrolyzer cell can be derived as follows.

A steady state conservation equation for gas phase or oxygen transport inside the LGDL can be expressed as

$$\nabla \cdot \left(-\frac{Kk_{O_2}}{\mu_{O_2}/\rho_{O_2}} \nabla p_{O_2} \right) = N_{O_2} \quad (7)$$

Similarly, a steady state conservation equation for liquid phase or liquid water transport inside the LGDL can be written as

$$\nabla \cdot \left(-\frac{Kk_{H_2O}}{\mu_{H_2O}/\rho_{H_2O}} \nabla p_{H_2O} \right) = N_{H_2O} \quad (8)$$

Here K is the permeability, k is the relative permeability, μ is the fluid dynamic viscosity, ρ is the fluid density, p is the fluid pressure, and N is the mass flux due to electrochemical reaction.

For the hydrophilic porous LGDL, the capillary pressure is equal to the difference of oxygen pressure and liquid water pressure, which can be written as

$$p_c = p_{O_2} - p_{H_2O} \quad (9)$$

In addition, the capillary pressure can also be defined as in detail, which is dependent on porous LGDL properties including porosity, permeability, surface tension, contact angle and liquid water saturation.

$$p_c = J(s) \left(\frac{\varepsilon}{K} \right)^{1/2} \sigma \cos \theta \quad (10)$$

Here ε is the LGDL porosity, σ is the surface tension, θ is the LGDL contact angle and $J(s)$ is the Leverett's function, which takes the following form

$$J(s) = \begin{cases} 1.417(1-s) - 2.120(1-s)^2 + 1.263(1-s)^3, & 0 < \theta < 90^\circ, \text{ hydrophilic} \\ 1.417s - 2.120s^2 + 1.263s^3, & 90^\circ < \theta < 180^\circ, \text{ hydrophobic} \end{cases} \quad (11)$$

III. Results and discussion

In this section, the modeling results obtained from the present model are first compared and validated with experimental data. Then the model is applied to calculate the performance and efficiency of a PEM electrolyzer cell. Initial geometrical parameters and electrode material properties for modeling PEM electrolyzer cell are respectively listed in Table 1 and Table 2.

Table 1: Geometry and physicochemical parameters for modeling a PEM electrolyzer cell

Description, symbol	Value, unit
MEA active area	5.0 cm ²
Flow channel thickness	0.5 mm
LGDL thickness	200 μ m
LGDL porosity	0.6
CL thickness	10 μ m
CL porosity	0.2
Operating pressure, P	1 atm
Operating temperature, T	80°C
Contact angle, θ	80°
Faraday constant, F	96487.0 C/mol
Water molar mass, M_{H_2O}	18 g/mol
Oxygen molar mass, M_{O_2}	32 g/mol
Liquid water dynamic viscosity, μ_{H_2O}	3.55×10^{-4} N s/m ²
Liquid water density, ρ_{H_2O}	1000 kg/m ³
Oxygen dynamic viscosity, μ_{O_2}	2.34×10^{-5} N s/m ²
Oxygen density, ρ_{O_2}	1.0 kg/m ³
Surface tension, σ	0.0625 N/m

Since the electrode is separately treated as LGDL and CL in the present model, there should be different structure parameters for modeling. As shown in Table 1, the LGDL and CL porosity is respectively set to 0.6 and 0.2 and the LGDL and the CL thickness is respectively set to 200 and 10 microns. Due to the corrosive condition at the anode side of a PEM electrolyzer cell, the electrode materials used in a PEM fuel cell cannot be directly applied to electrolyzer cell. In the present model, titanium is used as anode LGDL material and carbon paper is used as cathode LGDL material. For oxygen evolution reaction at the anode side, the most active material is ruthenium

oxide, but a mixed oxide of ruthenium and iridium is more stable than other catalysts. For hydrogen evolution reaction at the cathode side, the best catalyst is platinum supported on carbon. There are different electrical resistivity for these materials, as shown in Table 2.

Table 2: Electrical resistivity of LGDL and catalyst at the anode and cathode	
Material	Resistivity, Ω cm
Anode LGDL: Titanium	5.0×10^{-3} [20]
Cathode LGDL: Carbon paper	80.0×10^{-3} [21]
Anode catalyst: $\text{Ir}_x\text{Ru}_{1-x}\text{O}_2$	0.05 [8]
Cathode catalyst: Pt/C	1.4×10^{-3} [22]

A. Model validation

Based on the above calculation conditions, the performance and two-phase transport equations can be properly solved. The present computational program is written and performed in FORTRAN 90. Grid point number for numerical calculation is set to 200 in the LGDL thickness direction. Furthermore, to ensure that the numerical results are independent on the present grid number, a case that the grid number is adjusted to more than 200 is performed. It is found that the numerical results are almost identical with the grid number of 200. In the existing literature, Debe et al. [23] reported an experimental polarization curve of a PEM electrolyzer cell. In their experiment, electrolyzer cell was operated at a temperature of 80°C , an anode pressure of 1 atm, a cathode pressure of 13.6 atm and a PEM thickness of 178 microns. The cell voltage is around 1.9 V at a current density of 2.0 A/cm^2 , which represents the real voltage of a commercial electrolyzer cell. Therefore, the experimental data is used to validate the present model. As shown in Figure 3, it can be seen that the cell voltage increase very fast when the current density is in the range of 0 to 0.5 A/cm^2 , which is mainly controlled by the activation overpotential. With the current density increasing, the effects of diffusion overpotential and ohmic loss overpotential will become dominant role in the cell performance. The polarization curve from the present model shows a good agreement to the experimental data, thus the present developed model is validated. In the next sections, to understand and obtain the main factors and operating parameters contributing to the electrolyzer cell performance, the validated model is used to investigate the effects of different parameters including PEM thickness, LGDL thickness, and interfacial resistance on the cell performance and efficiency.

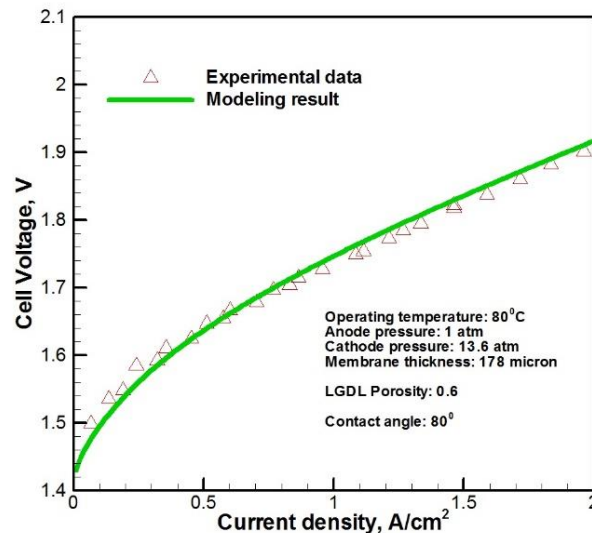


Figure 3. Comparison of numerical modeling results with experimental data

B. PEM thickness effect

PEM is the core component of a PEM electrolyzer cell, which is placed between two electrodes. There are some factors including conductivity, humidification, temperature, and thickness that may affect the behavior of PEM and consequently affect the performance of a PEM electrolyzer cell. Since PEM thickness is directly related to the ohmic

loss, it will be an important parameter determining the cell performance. In the following, the present model is applied to calculate the effects of PEM thickness on the cell resistance, performance, and efficiency. It is found that the cell performance and efficiency are sensitive to the change of PEM thickness, especially at high current density.

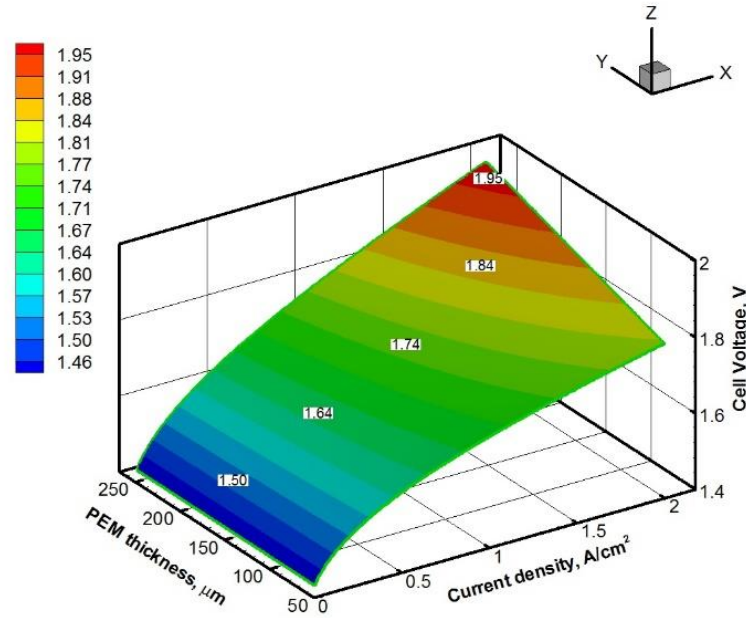


Figure 4. Cell voltage with PEM thickness and current density

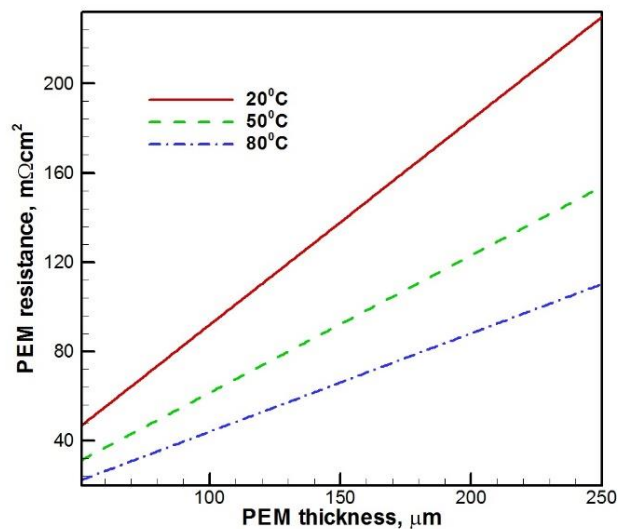


Figure 5. PEM resistance with PEM thickness and operating temperature

Figure 4 shows the relationship of cell voltage, PEM thickness, and current density. In this case, PEM thickness is set to be in the range of 50 to 250 microns while the current density ranges from 0 to 2.0 A/cm². It can be seen that at low current density, the cell voltage is insensitive to the change of PEM thickness. For example, when the current density is in the range of 0 to 0.5, the cell voltage is around 1.5 V and almost unchanged with PEM thickness. As the current density increases to 2.0 A/cm², the cell voltage will vary within a relatively large range with PEM thickness. At a PEM thickness of 250 microns and a current density of 2.0 A/cm², the cell voltage reaches the

maximum value that is equal to 1.98 V. This is because a thick PEM can significantly increase the ohmic resistance. As shown in Figure 5, the effect of PEM thickness on the PEM resistance is examined at three different temperature values. It can be observed that PEM resistance increases significantly along with its thickness increasing, especially at low operating temperature. For a PEM thickness of 100 microns, the PEM resistance is $44.1 \text{ m}\Omega\cdot\text{cm}^2$ at 80°C . As the operating temperature decreases to 50°C , the PEM resistance is $61.5 \text{ m}\Omega\cdot\text{cm}^2$. This is due to the fact that the PEM resistance is proportional with PEM thickness and inversely proportional to PEM conductivity that is dependent on the humidification and operating temperature.

To get a better understanding of the effect of PEM thickness on the cell performance and efficiency, the polarization curves and efficiency curves of a single PEM electrolyzer cell are presented at three certain PEM thicknesses of 50, 100, and 200 microns, as shown in Figure 6. It can be clearly observed that the polarization and efficiency curves are sensitive to the change of PEM thickness. For a current density of 1.5 A/cm^2 and a PEM thickness of 200 microns, the cell voltage is 1.85 V and the cell efficiency is 66%. When the PEM thickness is decreased to 50 microns, the cell voltage is 1.75 V and the cell efficiency is 69.6%. At smaller PEM thickness, the ohmic loss is smaller that can lead to lower cell voltage. Therefore, the cell performance and efficiency improves with decreasing the PEM thickness.

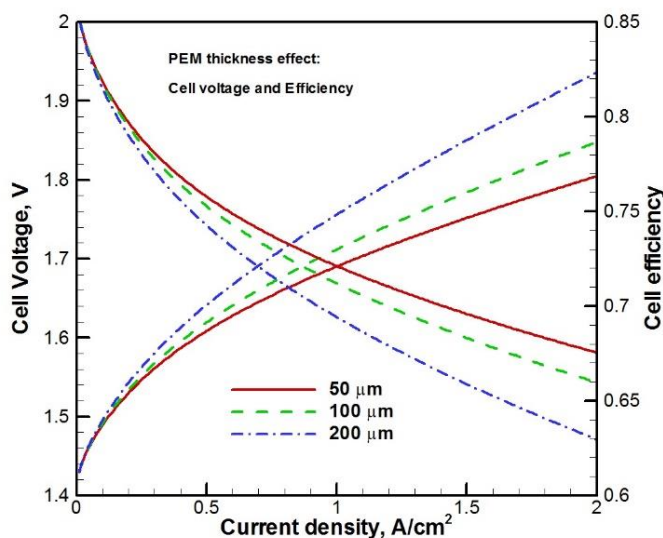


Figure 6. Effect of PEM thickness on the cell performance and efficiency

C. LGDL thickness effect

Based on the present model, the liquid saturation, diffusion overpotential, and ohmic loss is directly related to the LGDL thickness, so the changes in LGDL thickness will play an important role in the cell performance. In order to investigate the effects of different LGDL thicknesses on the cell performance, the LGDL thickness is set to be in the range of 100 to 600 microns and there is the same thickness for both anode and cathode LGDL. Figure 7 shows the cell voltage variations with the LGDL thickness and current density. It is found that as the LGDL thickness and current density increase, the cell voltage becomes large. When the current density is low, the cell voltage does not significantly change with the LGDL thickness, but as the current density increase to 2.0 A/cm^2 , the cell voltage have a significant correlation to the LGDL thickness. For instance, at a current density of 2.0 A/cm^2 , when the LGDL thickness ranges from 100 to 600 microns, the cell voltage increases by around 0.12 V. The maximum voltage that is equal to 2.01 V is reached at 600 microns LGDL thickness and 2.0 A/cm^2 . This means that LGDL thickness has a significant influence in the cell performance, especially at high current density. In Figure 8, the internal resistance (plate and electrode resistance) variations with LGDL thickness at three different porosity values of 0.35, 0.55 and 0.75 are shown. For a fixed LGDL thickness, the internal resistance increases with LGDL porosity increasing, this is due to the fact that large porosity will reduce the area of conductor cross section, leading to higher resistance. For instance, when the LGDL thickness is set to 300 microns, the internal resistance will increase by $10.8 \text{ m}\Omega\cdot\text{cm}^2$ as the porosity increases from 0.35 to 0.55. The resistance change due to the LGDL thickness and porosity will have a significant influence in the cell voltage and consequently affect the cell performance and efficiency.

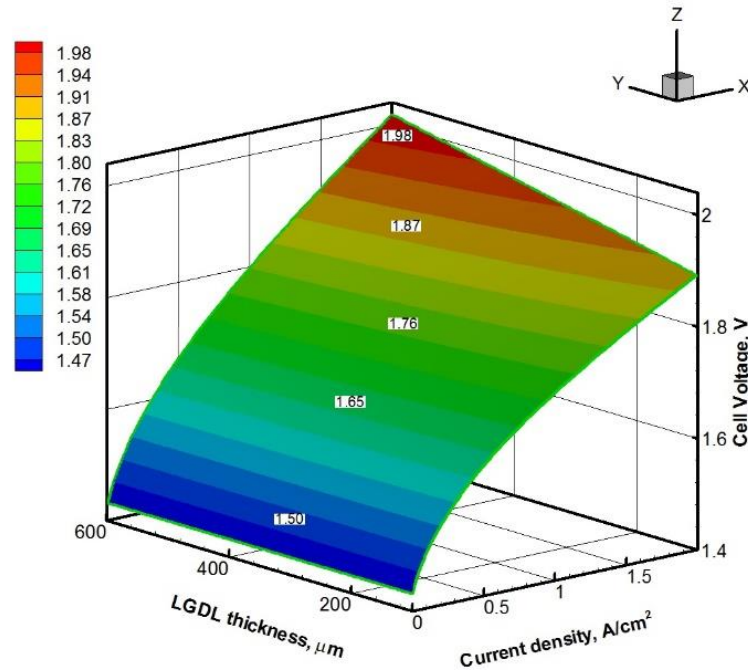


Figure 7. Cell voltage with LGDL thickness and current density

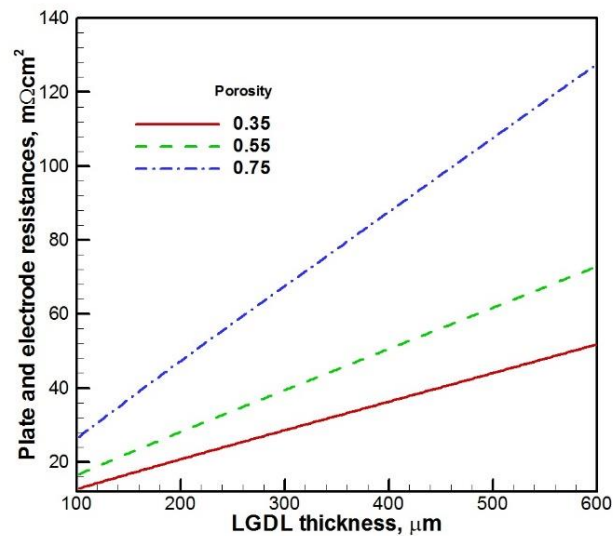


Figure 8. Plate and electrode (LGDL and CL) resistance with LGDL thickness and porosity

The polarization and efficiency curves under three different LGDL thickness of 100, 300, and 500 microns are shown in Figure 9. In this case, the average porosities for titanium and carbon paper LGDLs are assumed to be 0.6. Other calculation conditions can be found in Table 1 and Table 2. From the modeling results, it can be clearly found that a thicker LGDL will lead to worse cell performance and efficiency. This is because a thicker LGDL would lead to higher diffusion overpotential and ohmic loss overpotential. Actually, as the current density increases, compared with the low current density, the cell voltage and efficiency difference under different LGDL thickness will become more significant. As shown in Figure 9, at a current density of 0.5 A/cm², it can be calculated that the cell voltage will only increase by 0.03 V when the LGDL thickness increases from 100 to 500 microns. However, as the current

density increases to 2.0 A/cm^2 , the voltage difference between 100 and 500 microns is up to 0.1 V. Therefore, it is highly desired to develop a thin LGDL with high diffusion efficiency and low ohmic loss.

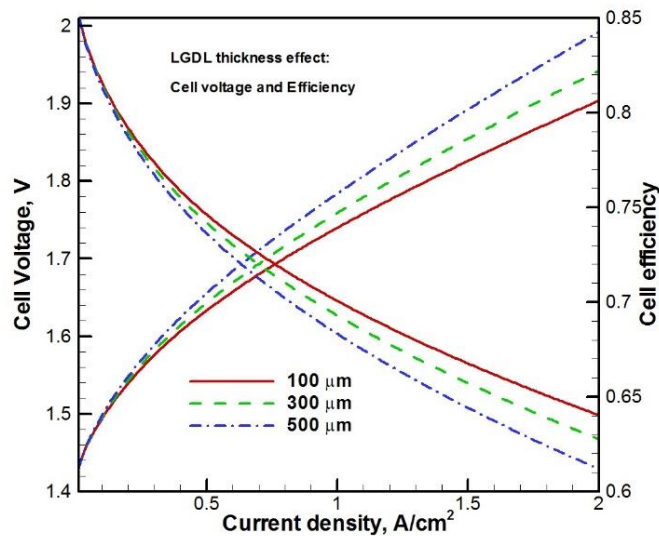


Figure 9. Effect of LGDL thickness on the cell performance and efficiency

D. Interfacial resistance effect

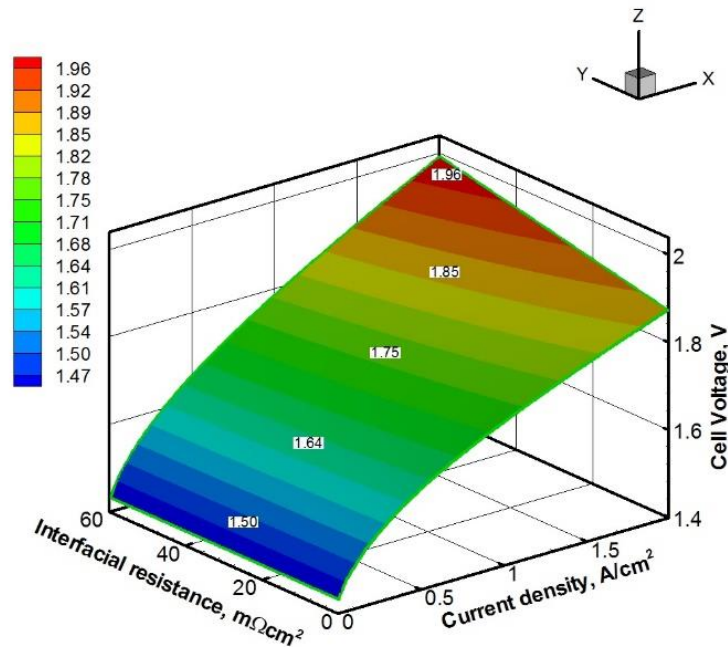


Figure 10. Cell voltage with interfacial resistance and current density

As shown in Figure 2, there are three contributions of interfacial resistances in a single PEM electrolyzer cell, including the interfacial resistance between the Plate and LGDL (PL), the interfacial resistance between the LGDL and CL (LC), and the interfacial resistance between the CL and PEM (CP). These interfaces are caused by various material properties, assembly ways and pressure, and mechanical conditions, which are difficult to quantify using a specific relationship. The following case incorporates three interfacial resistances as a total interfacial resistance and

the values are set to be in the range of 0 to 60 $\text{m}\Omega\cdot\text{cm}^2$ based on the experimental data [12]. Figure 10 shows the relationship of the cell voltage, interfacial resistance, and current density. It can be observed that at low current density (less than 0.5 A/cm^2), the cell voltage is insensitive to the variation of interfacial resistance, but at high current density (more than 1.0 A/cm^2), the interfacial resistance has a significant impact on the cell voltage. For example, when the current density is 0.2 A/cm^2 , all cell voltages are almost equal to around 1.53 V even though the interfacial resistance changes from 0 to 60 $\text{m}\Omega\cdot\text{cm}^2$. However, as the current density increases to 2.0 A/cm^2 , the cell voltage increases by around 0.12 V when the interfacial resistance ranges from 0 to 60 $\text{m}\Omega\cdot\text{cm}^2$. The maximum cell voltage is found to be 1.99 V.

In addition, to study the effect of the interfacial resistance on the cell performance and efficiency, three different resistance cases of 10, 30, and 60 $\text{m}\Omega\cdot\text{cm}^2$ are performed. The polarization and efficiency curves of a PEM electrolyzer cell is shown in Figure 11. Comparing the polarization and efficiency curves, it can be found that higher interfacial resistance will lead to more ohmic losses and consequently reduce the cell performance and efficiency. For instance, when the interfacial resistance is set to 10 $\text{m}\Omega\cdot\text{cm}^2$, the loss due to the interfacial resistance comprises 11% of the total ohmic loss. If the interfacial resistance is set to 30 $\text{m}\Omega\cdot\text{cm}^2$, the loss will comprise 28.3% of the total ohmic loss.

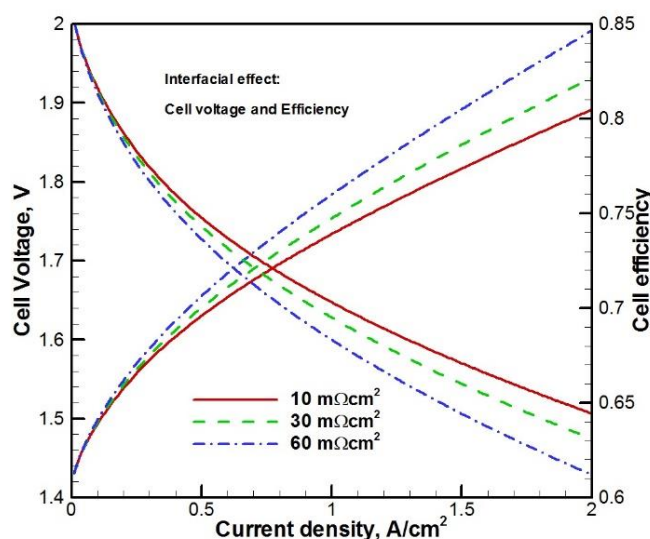


Figure 11. Effect of total interfacial resistance on the cell performance and efficiency

IV. Conclusion

In this paper, a new equivalent resistance model for a single PEM electrolyzer cell is developed and incorporated into the present two-phase transport model at NanoHELP group. The two-phase model is employed to calculate the effects of different physical parameters on the cell performance and efficiency, including PEM thickness, LGDL thickness, and interfacial resistance. The model is validated with the experimental data and shows a good agreement. The modeling results indicate that changes in both PEM thickness and LGDL thickness have significant influences on the cell voltage and efficiency. Decreasing the PEM thickness and LGDL thickness can reduce the cell voltage due to less ohmic losses and consequently improve the cell performance and efficiency, especially at high current density. In addition, interfacial resistance plays an important role in the cell performance at high current density. The cell voltage and efficiency is found to change significantly with the interfacial resistance and current density. It can be calculated that the loss due to the interfacial resistances comprise around 28.3% of the total ohmic loss when the interfacial resistance is set to 30 $\text{m}\Omega\cdot\text{cm}^2$. Modeling results may provide useful information for understanding and optimizing the performance and efficiency of a PEM electrolyzer cell.

Acknowledgments

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