TEMPERATURE DISTRIBUTION OF PNEUMATIC COOLED FUEL CELLS

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Abstract

Temperature distribution in a energy cell significantly affects the performance and effectiveness of the energy cell system. Particularly, in low temperature energy cells,enhancement of the system requires proper thermal operation, which indicates the need for developing accurate thermal models. In this study, a 3D numerical thermal model is presented to dissect the heat transfer and prognosticate the temperature distribution in air cooled proton exchange membrane energycells (PEMFC). In the modeled energy cell mound, forced air flux inventories oxidant aswell as cooling. Conservation equations of mass, instigation, and energy are answered in the oxidant channel, while energy equation isanswered in the entire sphere, including the gas prolixity layers and division plates, whichplay a significant part in heat transfer. Parametric studies are performed to probe the goods of colorful parcels and operating conditions on the maximum cell temperature.The present results are farther validated with trial. This model provides a theoreticalfoundation for thermal analysis of air- cooled PEMFC heaps, where temperature non- uniformity is high and thermal operation andmound cooling is a significant challenge.

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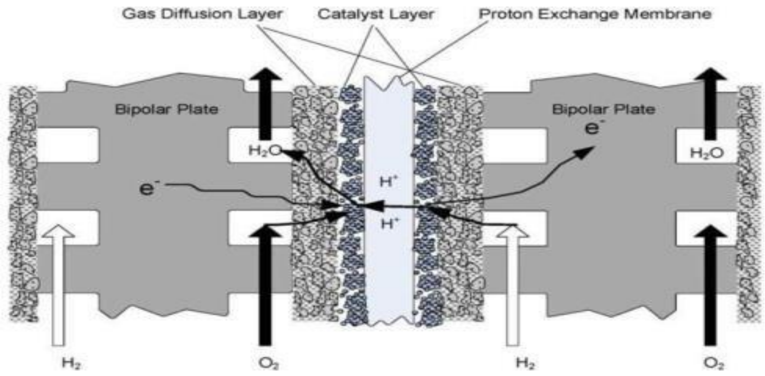
INTRODUCTION

Energy cells are bias that produce electricity through electrochemical responses. In a proton exchange membrane energy cell (PEMFC), a membrane separates oxidation and reduction half responses. schematically shows the introductory construction of a PEMFC. The energy is hydrogen gas and theoxidant is ambient air Pure oxygen. The onlyderivations of this response are heat and water. Considering their high energy conversion effectiveness zero emigration eventuality, low noise and implicit use of renewable energies, energy cells are considered as unborn bias for mobile, stationary, and movable power operations. still, PEMFC systems aren't presently bring effective adding their effectiveness for transportation and stationary operations can collaborate.



Basic construction of a typical PEM fuel cell

Operation of a PEMFC is a complex process and includes transport of mass, instigation, energy, species and charges that take place contemporaneously. Different corridor of a PEMFCare comprised of current collectors, anode and cathode inflow channels, gas prolixity layers GDLs),catalyst layers and the membrane. During the operation of a PEMFC, hydrogen motes are supplied at the anode and split into protons and electrons. The polymeric membrane conducts protons to the cathode while the electrons are pushed round an external circuit and a current is generated from anode side cathode side via electric cargo, Oxygen is consumed cathode side and reacts with the hydrogen ions, producing water and heat Fuel cells are still undergoing intense development, and the combination of new and optimized materials, improved product development, novel architectures, more efficient numerous reports indicating that significant emission reductions are transport processes, and design optimization and integration are expected to lead to major gains in performance, efficiency, reliability, manufacturability and cost effectiveness.

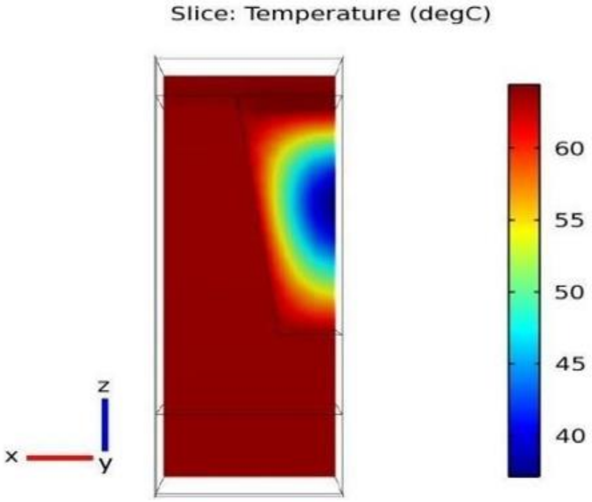
REVIEW OF PEMFC THERMAL MODELS

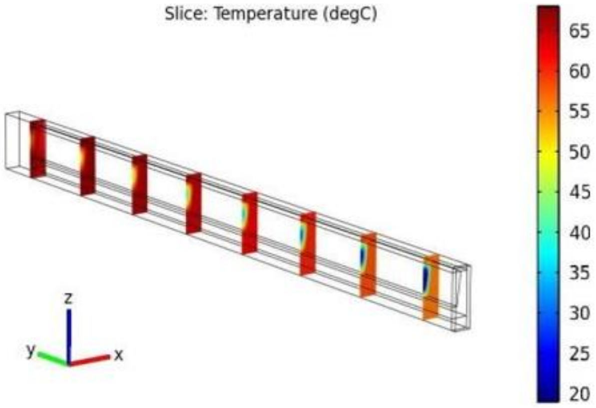
Analytical Model: system level: Due to the complexity of PEMFC systems, system- position models don't include temperature grade within the energy cell mound. utmost of the system- position thermal operation studies in the literature are moreover experimental or simplified logical models that consider isothermal condition for the energy cell mound.

CFD Based model : There also live several computational fluid dynamics(CFD) models of PEMFCs. A literature overview of models, ranging from one- dimensional, single- element to complete three- dimensional, large- scale setups, was presented by Siegel in with an emphasis onheat and mass transfer. His, review included modeling strategies and generally used simulation software for energy cell. a two- dimensional heat model and attained thermal distributions in a PEMFC in the normal to the cathode flux direction. In thiswork, only conductive heat transfer was considered. A three dimensional model was developed by Shimpalee and Dutta(17), which answered the energy equation to predict the temperature distribution inside astraight channel PEMFC. They analyzed the effect of heat produced by the electrochemical responses on the energy cell performance.

RESULT AND DISCUSSION

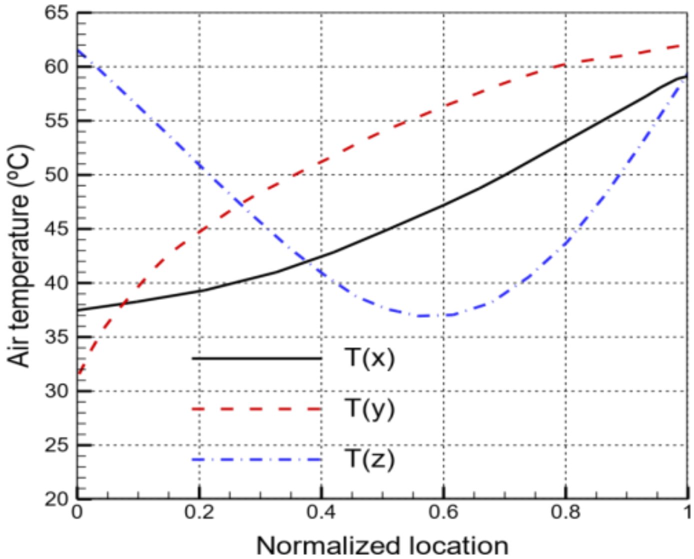
It shows the temperature silhouettes in the middle cross section of the channel. A invariant temperature distribution in the solid region is observed, whereas fairly high temperature grade exists in the inflow channel. Also in temperature silhouettes are shown in different sections along the channel. For better description of temperature distribution in the solid and fluid regions, their temperature variations along and directions are colluded in Figure 3-3 and Figure 3-4. The vertical axis shows the regularized position, where, Y max and Z max specifies boundaries of the domain x, y and z.





Temperature contours in the middle cross sectionTemperature contours in eight slices from inlet to outlet

As preliminarily mentioned, two major modes of heat transfer in this problem are forced convective heat transfer in cathode channels and conductive heat transfer in the entire sphere.



Temperature variation in different directions in bipolar plateTemperature variation in different directions in air

It represents the temperature distribution in the late attained from interpolation using 24 different temperature data measured by thermocouples in the central row of the mound. The experimental and numerical values for the plate temperature in the channel bay and outlet are compared for the central and lateral channels.

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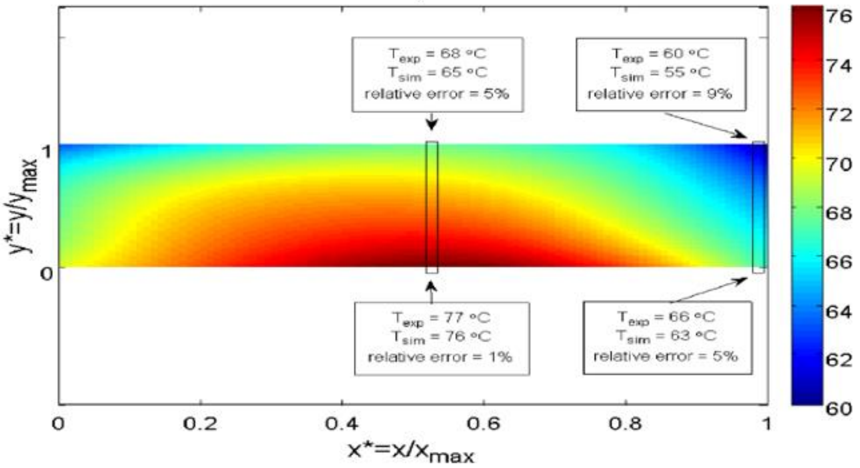
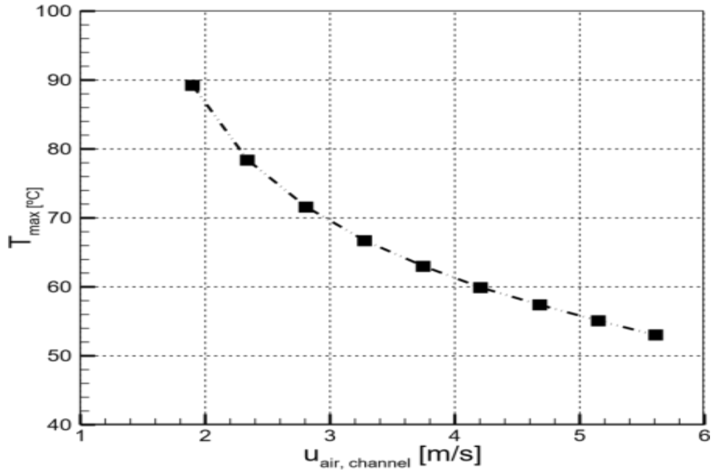
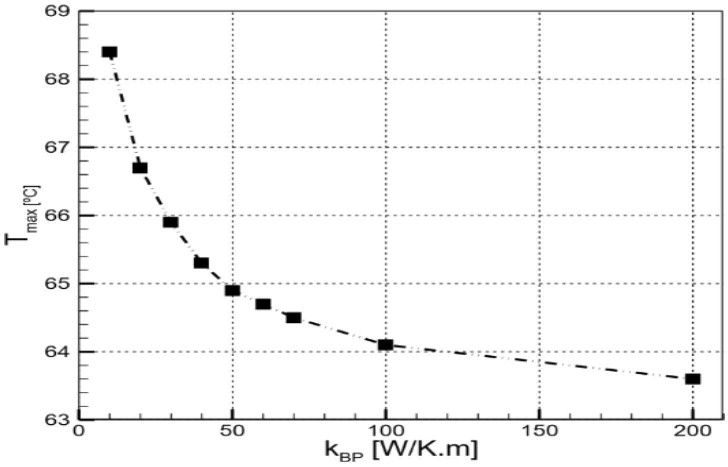


Temperature distribution in one plate, interpolatedusing experimental data points. The experimental and numerical values for the inlet and outlet are compared for the central andside channels

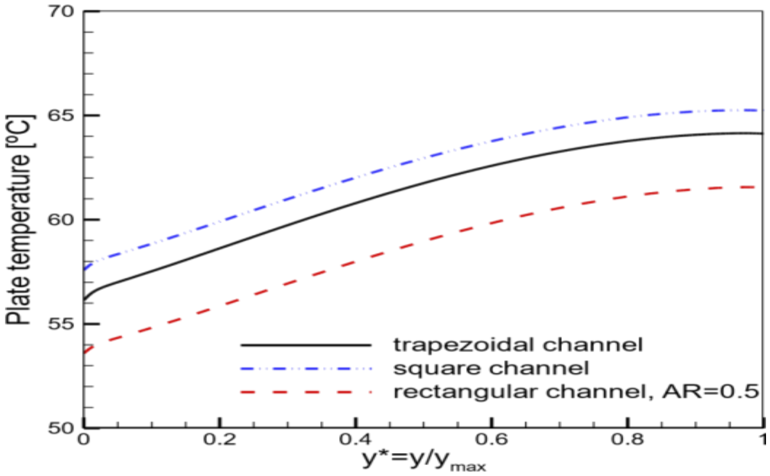
By adding the bay air haste, the maximum temperature drops vastly, as anticipated. adding the bipolar plate thermal conductivity also has a positive impact on reducing the temperature in the entire sphere. Notice that the range of studied air haste is a practical range of the operating condition. Also the thermalconductivity of graphite bipolar plate has a wide range from 15W/m.K to400W/mk



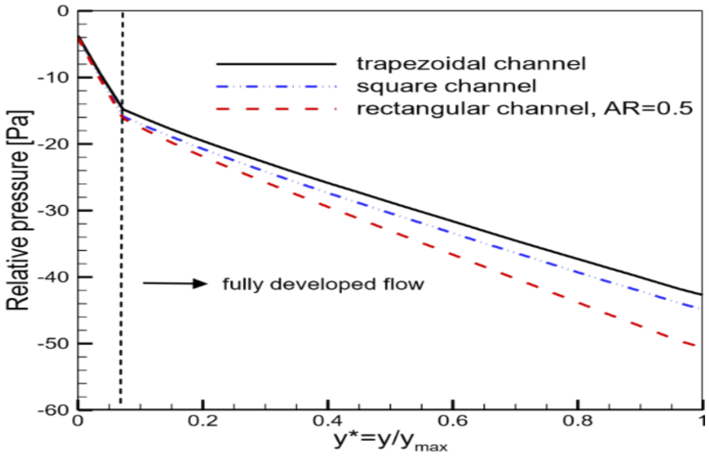


The results of GDL temperature distribution along the change to probe the effect of channel figure, all other parametersshould be kept constant. thus, in addition tothe constraint of constant channel cross-sectional area, constant cell area has to be considered. This means that the bipolar plate caricature consistence should vary consequently with the variation of channel figure.It compares the temperature distribution in different channel shapes, trapezoidal, square, and blockish cross-sections. This figure shows that under the conditions of constant oxidant inflow rate and cross-sectional face area, the plate temperature in blockish channel is lowerthan that of trapezoidal channel. Also below the same conditions, in a trapezoidal channel bipolar plate has a lower temperature than in a square channel. This is caused by the contact face area between air sluice and GDL. A blockish crosssectionwith aspect rate of0.5 in which the longer side is the top wall(GDL), provides a largercontact area between air and GDL compared to a square or a trapezoidal crosssection and thus, enhances heat transfer. also, in a trapezoidal channel, air has a larger contact face with GDL andfurther heat can be rejected by forced convection. nel are intrigued in Figure 4- 8 for a case neglecting TCR and the same caseincluding TCR. As it can be seen in this figure, including TCR results in a slightly advanced temperature distribution but the impact is negligible. That's a direct result ofthe convective- dominant thermal transfer in the channel. In other words, the TCR will only affect the conduction heat transfer from GDL to bipolar plate, which is much lower that the convection heat transfer fromGDL to the air flux.

The channel figure not only affects the temperature distribution, but also changes the pressure drop.
The oxidant relative pressure is colluded in which shows that trapezoidal channel has the smallest pressure drop among the considered shapes. The change in the trend of pressure drop in is due to the transition from hydrodynamically developing flow to fully developed flow.



Temperature variation in flow directionfor trapezoidal, square & rectangular cross section



Oxidant variation in pressure flow direction fortrapezoidal, square & rectangular cross section

CONCLUSION AND DISCUSSIONS

We have developed of channel figure on temperature distribution and pressure drop. Channels with trapezoid, square, and blockish cross sections with equal face areawere compared in terms of temperature distribution and pressure drop. The results show that the trapezoidal channel gives the minimal pressure drop among the considered shapes while the blockish channel gives the minimal temperature. thus, the selection of channel figure remainsto a trade off design analysis of operating temperature and pressure that can be considered as a unborn work.

It is also possible to integrate the present thermal model with a performance model inorder to probe the goods of parameters, similar as relative moisture, that influence the energy cell current and voltage and eventually change the quantum of heat generation in the mound. This three- dimensional model for single cells can form a theoretical foundation for thermal analysis of multi-cell heaps where thermal operation and mound cooling is a significant engineering challenge.

REFERENCES

1. Sadeghi E, Djilali N, Bahrami M (2011) Effective thermal conductivity and thermal contact resistance of gas diffusion layers in proton exchange membrane fuel cells. Part 1: Effect of compressive load. Journal of Power Sources 196: 246254
2. Shahsavari S, Kjeang E, Bahrami M (2010) Analytical velocity and temperature distributions for flow in microchannels of various cross-sectionsThe 8th International ASME Conference on Nanochannels, Microchannels, and Minichannels, Monreal, Canada.
3. Wen C-Y, Lin Y-S, Lu C-H, Luo T-W (2011) Thermal management of a proton exchange membrane fuel cell stack withpyrolytic graphite sheets and fans combined. International Journal of Hydrogen Energy 36: 6082-6089
4. Asghari S, Akhgar H, Imani BF (2011) Design of thermal management subsystemfor a 5 kW polymer electrolyte membranefuel cell system. Journal of Power Sources196: 3141-3148
5. Baek SM, Yu SH, Nam JH, Kim C-J(2011) A numerical study on uniform cooling of large-scale PEMFCs with different coolant flow field designs. Applied Thermal Engineering 31: 1427-1434
6. Kurnia JC, Sasmito AP, Mujumdar AS (2011) Numerical investigation of laminarheat transfer performance of various cooling channel designs. Applied Thermal Engineering 31: 1293-1304
7. Song T-W, Choi K-H, Kim J-R, Yi JS (2011) Pumpless thermal management ofwater- cooled high-temperature proton exchange membrane fuel cells. Journalof Power Sources 196: 4671-4679
8. Sasmito AP, Lum KW, Birgersson E, Mujumdar AS (2010) Computational study of forced air-convection in open-cathode polymer electrolyte fuel cell stacks. Journal of Power Sources 195: 5550-5563