Application of High Thermal Conductivity Graphite Sheet on Thermal Management of PEM Fuel Cells

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ABSTRACT

Thermal management of a proton exchange membrane fuel cell includes removing waste heat within it in order to avoid non-uniform temperature distribution and utilizing effectively the waste heat. The water and thermal management of a PEMFC stack becomes more complex and important than just a single cell. In the design of thermal management of a PEMFC stack, the cooling methods include internal water or air circulation and fluid evaporation in present applications. However, there are several subjects to be taken into account, e.g., cost of making cooling channels, sealing and additional volume of the fuel cell stack. In the present study, “ high thermal conductivity graphite sheet ” is used for cooling in a fuel cell for the first time. It is combined with the metal flow channel plate in the cathode and the graphite sheet protrudes the fuel cell as a fin to remove waste heat. The relationship of water production and temperature distribution is also studied. If too much water in the diffusive layer of cathode is produced, the flow channel will be flooded, and blocked from conducting the oxidant. On the other hand, if the temperature in a fuel cell is too high, membrane dehydration is occurred, In the study, the thermocouples are used for measuring temperature inside of a single PEMFC. Water production is visualized by a DV. It is shown the PGS can remove waste heat efficiently and improve the performance of the PEMFC. It provides a promising tool for the thermal management of a PEMFC.

Keywords : PEMFC, Thermal Management, High Thermal Conductivity Graphite Sheet

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REFERENCES

[1] S. Miachon and P. Aldebert, “ Internal Hydration H2/O2 100 cm2 Polymer Electrolyte Membrane Fuel Cell, ” J. Power Sources, Vol. 56, pp. 31-36, 1995 [2] J.H. Lee, T.R. Lalk and A.J. Appleby, “ Modeling Electrochemical Performance in Large Scale Proton Exchange Membrane Fuel Cell Stacks, ” J. Power Sources, Vol. 70. pp. 258-268, 1998 [3] 顏宇欣, “ 3C 用燃料電池介紹 ”, 工業材料雜誌, 169 期, pp 142-145. , 2001 [4] 衣寶廉, “ 燃料電池原理與應用 ”, 五南出版社, 2005 [5] V.A. Paganin, E. A. Ticianelli and E. R. Gonzalez, “ Development of Small Polymer Electrolyte Fuel Cell Stacks, ” J. Power Sources, Vol. 70, No. 1, pp.55-58, 1998 [6] D. Chu and R. Jiang, “ Comparative Studies of Polymer Electrolyte Membrane Fuel Cell Stack and Single Cell, ” J. Power Sources, Vol. 80, pp.226-234, 1999 [7] R. Jiang and D. Chu, “ Stack Design and Performance of Polymer Electrolyte Membrane Fuel Cell, ” J. Power Sources, Vol. 93, pp.25-31, 2001 [8] T. Susai, A. Kawakami, A. Hamada, Y. Miyake and Y. Azegami, “ Development of a 1 kW Polymer Electrolyte Fuel Cell Power Source, ” J. Power Sources, Vol. 92, pp.131-138,2001 [9] X. Ren and S. Gottesfeld, “ Electro-osmotic Drag of Water in poly (perfluorosulfonic) Membranes, ” J. Electrochemical Society, Vol. 148(1), A87-A93, 2001 [10] D.L. Wood, III, J.S. Yi, and T.V. Nguyen, “ Effect of Direct Liquid Water Injection and Interdigitated Flow Field on the Performance of Proton Exchange Membrane Fuel Cells ” Electrochemical Acta, Vol. 43, pp. 3795-3809. [11] K. Tuber., D. Pocza, and Christopher , “ Visualization of water buildup in the cathode of a transparent PEM fuel cell, ” J. Power Sources, Vol.124 pp.403 – 414, 2003 [12] A. Hakenjos, H. Muenter, U. Wittstadt, and C. Hebling, “ A PEM Fuel Cell for Combined Measurement of Current and Temperature Distribution, and Flow Field Flooding, ” Journal of Power Sources, Vol.131 pp.213 – 216, 2004 [13] M. Wang, H. Guo

and C. Ma, “ Temperature distribution on the MEA surface of a PEMFC with serpentine channel flow flow bed, ” Journal of Power Sources, Vol.157 pp.181 – 187, 2006 [14] D.M. Bernardi and M.W. Verbrugge, “ Mathematical Model of Gas Diffusion Electrode Bonded to a Polymer Electrolyte, ” AICHE Journal, Vol. 37, No. 8, pp. 1151-1163, 1991 [15] T.V. Nguyen and R.E. White, “ A Water and Heat Management Model for Proton Exchange Membrane Fuel Cells, ” J. Electrochemical Society, Vol. 140, No. 8, pp. 2178-2186, 1993 [16] J. S. Yi and T.V. Nguyen, “ An Along-the-Channel Model for Proton Exchange Membrane Fuel Cells, ” J. Electrochemical Society, Vol. 145, pp. 1149-1159, 1998. [17] T.F. Fuller and J.J. Newman, “ Water and Thermal Management in Solid-Polymer- Electrolyte Fuel Cells, ” J. Electrochemical Society, Vol. 140, No. 5, pp. 1218-1225, 1993 [18] R. Mosdale and S. Srinivasan, “ Analysis of Performance and of Water and Thermal Management in Proton Exchange Membrane Fuel Cells, ” Electrochimica Acta, Vol. 40, No. 4, pp. 413-421, 1995 [19] C. Marr and X. Li, “ An Engineering Model of Proton Exchange Membrane Fuel Cells Performance, ” ARI, pp. 190-200, 1998 [20] C. Marr and X. Li, “ Composition and Performance Modeling of Catalyst Layer in a Proton Exchange Membrane Fuel Cells, ” J. Power Sources, Vol. 77, Issue 1, pp.17-27, 1999 [21] V. Gurau, “ Two-Dimensional Model for Proton Exchange Membrane Fuel Cells, ” AICHE Journal, Vol. 44, No. 11, pp. 2410-2422, 1998 [22] T. Okada, X. Gang, and M. Meeg, “ Simulation for Water Management in Membranes for Polymer electrolyte Fuel Cells, ” Electrochimica Acta, V01. 43, No. 14-15, pp. 2141-2155, 1998 [23] T. Okada, “ Theory for Water Management in Membranes for Polymer Electrolyte Fuel Cells-Part 1 The Effect of Impurity Ions at the Anode Side on the Membrane Performances, ” J. Electroanal. Chem., 465, pp. 1-17, 1999 [24] T. Okada, “ Theory for Water Management in Membranes for Polymer Electrolyte Fuel Cells-Part 2 The Effect of Impurity Ions at the Anode Side on the Membrane Performances, ” J. Electroanal. Chem., 465, pp. 18-29, 1999 [25] P. Argyroupoulos, K. Scott, and W.M. Taama, “ One-Dimensional Thermal Model for Direct Methanol Fuel Cell Stacks Part.1 Model Development, ” J. Power Sources, 79, pp. 169-183, 1999 [26] P. Argyroupoulos, K. Scott, and W.M. Taama, “ One-Dimensional Thermal Model for Direct Methanol Fuel Cell Stacks Part.2 Model based parametric analysis and predicted temperature profiles ” J. Power Sources, 79, pp. 184-198, 1999 [27] 葛善海、衣寶廉、徐洪峰, “ 質子交換膜燃料電池水傳遞模 型 , Journal of Chemical Engineering, 第五十卷, 第一期, 1999 [28] J. Baschuk and X. Li, “ Modeling of Polymer Electrolyte Membrane Fuel Cells with Variable Degree of Water Flooding, ” J. Power Sources, Vol. 86, pp.181-196, 2000 [29] A. Rowe and X. Li, “ Mathematical Modeling of Proton Exchange Membrane Fuel Cells, ” J. Power Sources, pp. 82-96, 2001 [30] K. Dannenberg, P. Ekdunge and G. Lindbergh, “ Mathematical Model of the PEMFC, ” J. Applied Electrochemistry, Vol. 30, pp. 1377-1387, 2000 [31] L. R. Jordan, A. K. Shukla, T. Behrsing, N. R. Avery, B. C. Muddle and M. Forsyth, “ Diffusion Layer Parameters Influencing Optimal Fuel Cell Performance, ” J. Power Sources, Vol. 86, Issue 1/2, pp.250-254, 2000 [32] P. Costamagna, “ Transport phenomena in polymeric membrane fuel cells, ” Chem Eng Sci, 56(2):323, 2001 [33] T. Berning, D. M. Lu and N. Djilali, “ Three-Dimensional Computational Analysis of Transport Phenomena in a PEM Fuel Cell, ” J. Power Sources, pp.284-294, 2002 [34] 顏維謀、陳發林、宋齊有等, “ Analysis of thermal and water management with temperature-dependent diffusion effects in membrane of proton exchange membrane fuel cells, ” J. Power Sources, Vol.129, pp.127-137, 2004 [35] Y. Shan, Song-Yul Choe, “ A high dynamic PEM fuel cell model with temperature effects, ” J. Power Sources, 145, pp.30-39, 2005 [36] V. Gurau, H-T. Liu, and S. Kalac, “ Two-Dimensional Model for Proton Exchange Membrane Fuel Cells, ” AIChE Juornal, Vol.44, No.11 pp. 2410-2422, 1998 [37] J.S. Yi and T.V. Ng, “ Multicomponent Transport in Porous Electrodes of Proton Exchange Membrane Fuel Cell Using the Interdigitated Gas Distributors ”, J. Electrocemical Society, Vol. 146, No. 1, pp. 38-45.
[38] H. Naseri-Neshat, S. Shimpalee, S. Dutta, W-K. Lee, and J.W. Zee, “ Predicting the Effect of Gas-Flow Channel Spacing On Current Density in PEM Fuel Cells, ” AES-Vol.39, Proceedings of the ASME, Advanced Energy System Division, 1999 [39] S. Shimpalee, S. Dutta, W-K. Lee, and J.W. Zee, “ Effect of Humidity on PEM Fuel Cell Performance Part II – Numerical Simulation, ” HTD-Vol.364-1, Proceedings of the ASME, Heat Transfer Division, 1999 [40] http://www.beamassociate.com/ [41] Philip L., Hentall J., Barry Lakeman Gary O. Mepsted, et al. “ New materials for PEM fuel cell current collectors, ” J. Power Sources, 80 · 235. , 1999 [42] http://www.ucl.itri.org.tw/research/tech/9/index.html# [43] http://industrial.panasonic.com/ [44] http://www.fuelcelltestingsystem.com/Products/FCTS.htm [45] 溫志湧、蔡秉蒼, 黃國瑋, “ 質子交換膜燃料電池水氣生成 觀測暨組裝界面壓力對性能之影響, 中國機械工程學會第二 十二屆全國學術研討會論文集, 熱傳與能源工程, A8-020, 2005