Simulation and Study of a Hydrogen and Fuel Cell Power Generation System

張祐齊、王啟聖 ; 陳木松

E-mail: 9806472@mail.dyu.edu.tw

ABSTRACT

The hydrogen and fuel cell technologies belong to the field of new clean energy. In general, it is well-known that they are suitable for vehicles or stationary power generation systems. Future more, they can replace gasoline and diesel combustion engines, and coal-fired power generation at the present time for a cleaner environment.

The major research of this thesis is to utilize hydrogen and fuel cell technologies to produce electricity. By using Argonne National Laboratory ' s(ANL ' s) simulation software, GCtool, a simulation model of the electrical power generation system is built and established; they include gas turbine electrical power system, 1-kWe combine hydrogen production and fuel cell power system, and hybrid of fuel cell and gas turbine power system. In the meantime, a simple 1-kWe fuel cell power system is built and installed. The simulation parameters and result are validated by the experimental data. This would validate our proof-of-concepts and gain our learning experience from GCtool operations, model simulation, H2/Fuel Cell characteristics.

The results of this research that utilizes GCtool models generally have a good agreement with experiment data. Thus, the models from the research could be used as a scale-up tool and theoretical basis for building a large power plant in the future.

Keywords : Hydrogen、Fuel Cell、Power Generation System、Thermal Plasma Hydrogen Production、Scale-up tool

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REFERENCES

1.P. Ridge,“ Hydrogen manufacture by electrolysis, thermal decomposition and unusual techniques, ” Noyes Data corporation, New Jersey, M. S. Casper (1978).2.H.K. Geyer, R.K. Ahluwalia, GCTool for Fuel Cell Systems Design and Analysis:User Documentation, Argonne National Laboratory, Report ANL-98/8.3.東亞產氫資訊網，2008年10月23日下載， http://idic.tier.org.tw。4.Beneman, J. (1996) Hydrogen biotechnology-progress and prospect.Nature biotechnol., 14, 1101.5.施宏杰，“ 火花放電之電漿反應對於甲烷產出氫氣之特性研究 ” 碩士?文，崑山科技大學機械工程系，民國 93 ?。6.鍾??，“ 脈衝式燃?電漿轉換器之設計??影響研究 ” 碩士?文，崑山科技大學機械工程系，民國 94 ?。7.黃曉鳳，“ 微波電漿應用於甲烷重組之研究 ”，碩士?文，中原大學化學工程系，民國 90 ?。8.施伯勳，“ 微波電漿應用於甲烷重組之研究 ”，碩士?文，中原大學化學工程系，民國 93 ?。9.B. Pietruszka, K. Anklam, M. Heintze,“ Plasma-assisted partial oxidation of methance to synthesis, ” Applied catalysis A: General, Vol. 261, 2004, pp. 19-24.10.M. Heintze, B. Pietruszka,“ Plasma catalytic conversion of methane into syngas : the combined effect of discharge activation and catalysis, ” Catalysis Today ,Vol. 89, 2004, pp. 21-25.11.B. Pietruszka, M. Heintze,“ Methane conversion at low temperature: the combined application of catalysis and non-equilibrium plasma, ” Catalysis Today, Vol. 90, 2004, pp. 151-158.12.L. Bromberg, D.R. Cohn, A. Rabinovich and N. Alexeev,“ Plasma catalytic reforming of methane, ” Int. J. Hydrogen Energy, Vol. 24, 1999, pp. 1131-1137.13.王啟聖，電漿重組器，台灣專利號碼270849，公告日期 2005 年7月21日。14.C. S. Wang and H. S. Huang, Fuel-Flexible H2-Reformer Using Advanced Thermoelectric Technology, presented at 2003 Fuel Cell Seminar, Abstracts, Miami Beach, Florida, November 3-7, 2003, pp. 637-640.15.C. S. Wang, Y. C. Chang, S. S. Hong, H. B. Lee, N. H. Kuo, H. L. Tsai, K. I. Chang, and C. H. Kuo,“ Optimal design of a 1kWe thermal plasma reformer, ” ECS Transactions, doi: 10.1149/1.2729051, Vol. 5, No.1, March 2007. pp. 699-706.16.Huan-Liang Tsai and Chi-Sheng Wang,“ Thermodynamic equilibrium prediction for natural gas dry reforming in thermal plasma reformer, ” Journal of the Chinese Institute of Engineers, Vol. 31, No. 5, July 2008, pp.891-896. (NSC96-2815-C-212-003-E) (SCI)17.Huan-Liang Tsai, Chi-Sheng Wang, and Chien-Hsiung Lee,“ Hydrogen production in a thermal plasma hydrogen reformer using ethanol steam reforming, ” Journal of the Chinese Institute of Engineers, Vol. 31, No. 3, May 2008, pp. 417-425. (SCI)18.翁頂清、Pham Minh Duc、蔡渙良、王啟聖，“ 以植物油為燃料運用熱電漿水蒸氣重組器的熱動力平衡預測 ”，2007年再生能源科技與應用研討會，2007年3月30日，彰化台灣， pp.67-73。19.K. Karl and S. Gunter,“ Fuel Cell and Their Applications ”, Wenheim. New York. Basel. Cambridge. Tokyo, pp.9~12. (1996)。20.黃鎮江，“ 燃?電池，第二版 ”，全華科技圖書股份有限公司, 第3-11頁。21.A. Kumar and R. G. Reddy,“ Effect of channel dimensions and shape in the flow-field distributor on the performance of polymer electrolyte membrane fuel cells ”, Journal of Power Sources, Vol. 113, pp.11-18, 2003.22.衣寶廉，“ 燃料電池—原理與應用，第三版 ”，五南圖書出版公司，第63~505頁。23.smart 化學專題報告主題一 <氫電池>，2009年6月3日下載 http://www.mingdao.edu.tw/physics/pdf_page/Lesson_5.pdf。24.楊志忠、林頌恩、韋文誠(2003) 。「燃料電池的發展現況」《科學發展》。367 期，30～33 頁。25.R.K. Ahluwalia,“ Sodium alanate hydrogen storage system for automotive fuel cells ”, International Journal of Hydrogen Energy 32 (2007) 1251 – 1261.26.R.K. Ahluwalia, E.D. Doss, R. Kumar,“ Performance of high-temperature polymer electrolyte fuel cell systems ”, Journal of Power Sources 117 (2003) 45 – 60.27.Daisie D. Boettner,

Michael J. Moran, ” Proton exchange membrane (PEM) fuel cell-powered vehicle performance using direct-hydrogen fueling and on-board methanol reforming ”, Energy 29 (2004) 2317 – 2330.28.Rajesh K. Ahluwalia, X. Wang, “ Direct hydrogen fuel cell systems for hybrid vehicles ”, Journal of Power Sources 139 (2005) 152 – 164.29.J.O. Schumacher, P. Gemmar, M. Denneb,1, M. Zedd, M. Stueber, “ Control of miniature proton exchange membrane fuel cells based on fuzzy logic ”, Journal of Power Sources 129 (2004) 143 – 151.30.H. Adachi, S. Ahmed, S.H.D. Lee, D. Papadias, R.K. Ahluwalia ,J.C. Bendert, S.A. Kanner, Y., “ A natural-gas fuel processor for a residential fuel cell system ”, Journal of Power Sources 188 (2009) 244 – 255.31.Tsang-Dong Chung, Wen-Tang Hong, Yau-Pin Chyou, Dong-Di Yu, Kin-Fu Lin, Chien-Hsiung Lee, “ Efficiency analyses of solid oxide fuel cell power plant systems ”, Applied Thermal Engineering 28 (2008) 933 – 941.32.Tsang-Dong Chung, Yau-Pin Chyou, Wen-Tang Hong, Yung-Neng Cheng, and Kin-Fu Lin, ” Influence of Energy Recuperation on the Efficiency of a Solid OxideFuel Cell Power System ”, Energy & Fuels 21(2007) 314-321.33.何明析, ”獨?運轉固態氧化物燃?電池/微渦?機混成發電系統之概?設計 ”, 碩士論文, 國立清華大學工程與系統科學研究所, 民國95年。34.Incropera DeWitt著, 侯順雄, 林松浩, 張仲卿譯, “ Fundamentals of Heat and Mass Transfer 5/e, 熱傳遞 ”, 高立圖書有限公司, 第600~607頁。35.A.F. Mills, “ Heat Transfer ”, 2rd, Prentic Hall, Inc., (1999).36.K. Nishida, T. Takage, S. Kinoshita, T. Tsuji, “ Performance evaluation of multi-stage SOFC and gas turbine combined systems ”, Proceeding of ASME TURBO EXPO 2002, Amsterdam, The Netherlands, June 3-6 (2002).