REFORMING SYSTEMS FOR FUEL CELLS

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Contents

Summary

Though hydrogen production using renewable energy resources is widely expected in future, hydrogen production from hydrocarbon fuels is thought to be the most practical. The steam reforming process, which is commonly used in many practical fuel cell plants, is mainly discussed here. The basic chemical reaction formulae, equilibrium gas composition and chemical reactors required for the fuel processing system are explained.

1. Introduction

The actual fuel required by fuel cells is hydrogen. Hydrogen is widely regarded as being produced by electrolysis and thermochemical methods from our abundant water supply, using natural energy or recyclable energy sources. However, at the beginning of the twenty-first century, due to considerations of economics, including the existing infrastructure, as well as the ease of conversion of existing technologies, reforming methods are employed in which hydrogen is produced using hydrocarbon fuels such as natural gas (mainly methane), propane and butane gases, naphtha, kerosene, methanol and coal. Options for utilizing as-yet unused resources include the use of landfill gases, waste processing gases and other biogases. In particular, as awareness of environmental problems grow, the use of methane generated from digestive gas (or biologically generated gas from organic chemical substances) produced in breweries and sewage treatment plants is being considered. Also, utilization of by-product hydrogen in the chemical industry is conceivable.

At present, fossil fuels are widely used as the primary fuels for hydrogen production. However, different chemical processes are necessary for each type of fuel used. In essence, processes for hydrogen production are either steam reforming methods or partial-oxidation methods. As an example, the gasification of coal involves steaming coal in a reducing environment, so that partial oxidation results in a mixture gas of H_2, CO, CO_2 and H_2O. Natural gas and other gaseous fuels tend to be used as the primary

fuels for fuel cell power plant systems, and so the following explanation focuses mainly on steam reforming methods.

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Bibliography

Abaoud H. A, Ghouse M, Lowell K. V, Al-Motairy G. N. A hybrid technique for fabricating PEMFC's low platinum loading electrode. Int J hydrogen energyy 2005; 30(4): 385-341.

Alkine et al. editors. Advances in electrochemical science and engineering. Vol.5, Weinheim; Germany: Wiley-VCH; 1997.

Andersen J.R, Boudart M. editors. Catalysis science and technology. New York; Springer; 1984.

Appleby A. J. Characteristic of fuel cell systems. In: Blomen L, Mugerwa M. editors. Fuel cell systems, New York; Plenum Press; 1993. 157-99.

Babir F. PEM fuel cells, Theory and practice. Burlington, MA, Academic Press, 2005.

Barbir F, Broun J, Neutaler J. Properties of molded graphite bipolar plates for PEM fuel cell stocks. J new mates eelectrochem systems. 1999; 2: 197-200.

Bar-on I, Kirchain R, Roth R. Technical cost analysis for PEM fuel cells. J power sources 2002; 109: 71-5.

Biyikoglu A. Review of proton exchange membrane fuel cell models. Int J hydrogen energy 2005: 30(11): 1181-1212.

Blomen L.J, Mugeswa M.N. Fuel cell systems. New York; Plenum Press: 1993.

Bockris J'OM, Conway B.E, White R.E, editors, Modern aspects of electrochemistry Vol. 29. New York; Plenum Press, 1995.

Carette L, Friedrick K.A, Stimming U. Fuel cells-fundamentals and applications. fuel cells J 2001; 1: 5-39.

Chalk S. Energy efficiency and renewable energy: FY 2000 progress report for fuel cell power systems, U.S. Department of Energy, 2000.

Hayashi A, Kosugi T, Yoshida H. Evaliation of polymer electrolyte fuel cell application technology R & D by GERT analysis. Int J hydrogen energy 2005; 30(9): 931-941.

Huang Y, Dass R I, Xing Z, Goodenough J B. Science 2006; 312: 254-57.

Larminie J, Dicks A. Fuel cell systems explained. Mew York; Wiley-VCH; 2000.

Li X. Principles of fuel cells. New York; Taylor and Francis; 2005.

Minh N.Q, Takahashi T. Science and technology of ceramic fuel cells. Amsterdam; Elsevier; 1995.

Ota K, Kamiya H. Polymer electrolyte fuel cell. Electrochemical energy conversion 5 in: Sorrell C. C, Sigiura S, Nowworthy J. editors. Materials for energy conversion devices, New York CRC Press; 2005, p.123-239.

Pagain V. A, Ticiane II E.A, Gonzalez E.R. Development and electrochemical studies of gas diffusion electrodes for polymer electrolyte fuel cells. J appl electrochem 1996;26(3): 297-304.

Parsen Inc. Fuel cells: a hand book, business/technology books. Oxford; Elsevier;2000.

Saab A. P, Garzan F. H, Zawodzinski T. A. The effects of processing conditions and chemical composition on electronic and ionic resistivities of fuel cell electrode composites. J electrochem soc 2003; 150: A214-8.

Salgado T. R. C, Antolini E, Gonzalez E. R. Structure and activity of carbon-supported Pt-Co electrocatalysts for oxygen reduction. J. phys. chem. B 2004; 108: 1767-74.

Singhal S.C. Advances in Solid oxide fuel cell technology. Solid state ionics 2000; 135: 305-13.

Springer T. E, Rockward T, Zawodzinski T. A, Gottesfeld S. Model for polymer electrolyte fuel cell operation on reformate feed-effect of CO, H_2 diffusion, and high fuel utilization. J electrochem soc 2001; 146(1):A11-23.

Vielstich W, lamm A. Gasteiger H.A. Hand book of fuel cells fundamentals, technology, and application. Chichester; England: Wiley;2003.

Vogt H.Gas evolving electrodes. In: Comprehensive treatise of electrochemistry, Vol.6. New York; Plenum Press; 1983, 445.

Biographical Sketch

Akifusa Hagiwara was born in 1954, received his master's degree in mechanical engineering from Waseda University, Japan, in 1979. He joined the International Flame Research Foundation in the Netherlands in 1981, and engaged in the research projects in combustion engineering and applied fluid dynamics. Since 1987, he has been employed by the Tokyo Electric Power Company, and involved in the fuel cell R&D activities. Currently, he is acting as Manager and Senior Researcher of the Material Science Group in the Energy and Environment R&D Center.