FUEL FLEXIBILITY IN SOLID OXIDE FUEL CELL - A REVIEW

N. PUNIHTH\textsuperscript{a1} AND T.K. NAGARAJA\textsuperscript{b}

\textsuperscript{a}M.Tech Scholar in Thermal Engineering, Department of Mechanical Engineering, JSSATE, Bangalore, VTU Belgaum, Karnataka, India
\textsuperscript{b}Assistant Professor, Department of Mechanical Engineering, JSSATE, Bangalore, VTU Belgaum, Karnataka, India

ABSTRACT

There is a need for proper conversion of fuels with high efficiency. On such is fuel cell (SOFC). In this fuel cell we can use different fuel with different composition. In this fuel cell there is an internal or external reforming of fuel takes place because of high temperature. In this we review the working principle of SOFC and different fuel we can use in SOFC is discussed. Performance characteristics of the SOFC is discussed and reviewed.

KEYWORDS: SOFC, Biodiesel, Ammonia, Biogas, Syngas

A fuel cell is an electrochemical device which convert chemical energy to electrical energy with high conversion efficiency. There are different types of fuel based on mechanism, shape, operating temperature. We are concentrated only on SOFC because of fuel flexibility in the fuel. The working principle of the SOFC is indicated in the below planar SOFC figure 1.

Figure 1: Planar SOFC single structure

Usually SOFC is made up Nickel electrode, non-porous ceramics YSZ electrolyte operating around 600-1000°C. There are two types based on shape planar and tubular SOFC. Different fuels can be used in SOFC are Ammonia, Biodiesel, biogas, Carbon monoxide, ethanol, kerosene, LPG, methane, syngas.

Ammonia Guangyao Meng et al (2007) studied Hydrogen and Ammonia in SOFC. A. Fuerte et al (2009) studied varying the Ammonia comparison from 0-100% in the interval 20 performance is studied and compared with hydrogen. Qianli Ma et al (2006) studied the Ammonia as fuel is studied and compared with Hydrogen shows marginal difference.

Biodiesel Yusuke Shiratori et al (2013) in the biodiesel is directly feed with water by internal reformation it produce rich syngas. Has steam and carbon ratio of 2.0-3.5 produces 1A/cm\textsuperscript{2} at 0.7V at 800°C. G. Nahar et al (2011), Gaurav A et al (2010) also studied the Biodiesel as fuel for SOFC. Usually the is carbon deposition on the anode surface can be removed by increasing the steam ratio.

Biogas Y. Shiratori et al (2010) and Massimo Santarelli et al (2013) studied the biogas as fuel in SOFC producing 0.8V over 800h of running at 200mA/cm\textsuperscript{2}.

Carbon monoxide Yixiang Shi et al (2011) studied the CO has fuel for SOFC.

Ethanol Bruno L. Augusto et (2014) and Amornchai Arpornwichanop et al (2009) studied the ethanol as fuel for SOFC.


SOFC.

PERFORMANCE CHARACTERISTICS OF SOFC

Ammonia

A single cell SOFC cell performance with hydrogen and ammonia gas. Fueled by hydrogen has power densities were 1872, 1357, and 748mWcm\(^{-2}\). While with ammonia as fuel, the cell showed the maximum power densities of 1190, 434, and 167mWcm\(^{-2}\) at 650, 600, and 550 °C respectively.

![Figure 2: Cell performance with hydrogen fuel at various temperatures](image1)

![Figure 3: Open circuit voltage with different temperature](image2)

![Figure 4: Power density (hollow) and voltage (solid) with different composition of Ammonia](image3)

![Figure 5: Cell performance with Hydrogen and syngas as fuel for SOFC at 800°C](image4)

Syngas

A syngas with composition of 4% methane, 5% carbon monoxide, 13% carbon dioxide, 48% hydrogen and 30% water. Flow rate of 500 cm\(^3\)/min for hydrogen and syngas and air as flow rate of 2000 cm\(^3\)/min. Performance is studied and compared with hydrogen as shown in figure 5.

![Different Fuel](image5)

M. Lo Faro et al al (2012) studied the
different fuel in SOFC namely methane, methanol, propane, Glycerol. The various composition of fuel is shown in figure 6.

The performance of the SOFC with different fuel in comparison with hydrogen is shown in figure 7 with temperature is around 800°C. In this glycerol is diluted with water with steam to carbon ratio of 0.2 because to increase proper viscosity.

CONCLUSIONS

- We can use different fuel with hydrogen or alone along with water so that due to internal reformation there is a production of hydrogen.
- Optimum temperature and composition we can produce maximum power density.
- Carbon deposition can be reduced by increasing steam and carbon ratio.
- The power density of different fuel in the decreasing order like hydrogen, reforming fuel, propane, methanol, glycerol and methane.

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REFERENCES


Yusuke Shiratori, Tran Quang-Tuyen, Kazunari Sasaki 2013, Performance enhancement of biodiesel fueled SOFC using paper-structured catalyst international journal of hydrogen energy 38, 9856-9866.


Y. Shiratori, T. Ijichi, T. Oshima, K. Sasaki 2010, Internal reforming SOFC running on biogas


Amornchai Arpornwichanopa, Nuttapong Chalermpornpaich, Yaneeporn Patcharavorachota, Suttichai Assabumrungrata, Moses Tade 2009, Performance of an anode-supported solid oxide fuel cell with direct-internal reforming of ethanol, international journal of hydrogen energy 34, 7780 – 7788.


N. Laosiripojana, W. Sutthisripok, S. Charoijrochkul, S. Assabumrungratt 2011, Steam reforming of LPG over Ni and Rh supported on GdCeO2 and Al2O3: Effect of support and feed composition, Fuel 90, 136–141.


Gennaro Campitelli, Stefano Cordiner, Mridul Gautam, Alessandro Mariani, Vincenzo Mulone 2013, Biomass fueling of a SOFC by integrated gasifier: Study of the effect of operating conditions on system performance, international journal of hydrogen energy 38, 320-327.


Ting Shuai Li, Min Xu, Chongxin Gao, Baoqing Wang, Xiyun Liu, Baihai Li, WeiGuo Wang 2014, Investigation into the effects of sulfur on syngas reforming inside a solid oxide fuel cell, Journal of power sources 258, 1-4.