Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 142 (2017) 1496–1501

Energy Procedia

www.elsevier.com/locate/procedia

9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK

Development of Molten Carbonate Fuel Cells at Warsaw University of Technology

Jarosław Milewski[a,*], Tomasz Wejrzanowski[b], Łukasz Szabłowski[a], Robert Baron[b], Arkadiusz Szczęśniak[a], Karol Ćwieka[b]

[a]*Institute of Heat Engineering Warsaw University of Technology, 21/25 Nowowiejska Street, 00–665 Warsaw, Poland*
[b]*Faculty of Material Science Engineering, Warsaw University of Technology*

Abstract

This paper describes the fuel cell research and development activities at Warsaw University of Technology by reviewing in particular the progress made in the development of Molten Carbonate Fuel Cells (MCFC). Porous nickel electrodes were prepared by loose powder sintering, slurry casting and tape casting techniques. These efforts are directed toward gaining a better understanding of and improving the components of molten carbonate fuel cells operating at temperatures near 650 ^{o} C. Cell testing is performed to assess individual and collective component behavior. Nickel electrodes oxidized under in situ conditions were used as the cathode. The tape casting technique was used to make the matrix.

© 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

Keywords: Fuel cells; Molten Carbonate Fuel Cell; Materials

1. Introduction

Fuel cells [1–3] offer great promise for efficient power generation in various applications such as: residential systems, stationary commercial power generators, auxiliary power supply units, micro- and small-propulsion systems [4, 5] and even energy storage systems [6]. Molten carbonate fuel cells [7–17] (MCFC) enjoy a strong position, as is demonstrated by a 59 MW fuel cell park in Hwasung City in South Korea. This substantially shifts technological requirements from unique to industrial–grade equipment and opens up the possibility of employing mass production technologies like screen–printing and tape–casting to make the cells. MCFC and SOFC [18–26] form part of a group of fuel cells that can be harnessed for energy purposes. Currently, these types of fuel cells are used to supply hospitals and larger facilities where power stability is more important than operating cost. Due to their high operating temperature,

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: author@institute.xxx

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.
10.1016/j.egypro.2017.12.598

650 °C, and greater tolerance to pollution, they can apply internal conversion of hydrocarbon fuels [27] to hydrogen [28–32] including methane [33], methanol, crude oil, biofuels [34] etc. MCFC efficiency is limited by several factors, mainly related to the materials [35] and architecture of the components. One of the key parameters for the MCFC anode is specific surface, namely the active area for electrode reactions. Anode porosity ranges between 45 and 70% (by volume) with median pore sizes of about 5 µm, and thickness of 0.7–0.8 mm. In this paper, results obtained from investigations carried out at the Warsaw University of Technology, on the preparation and characterization of MCFC components are presented. The MCFC research and development program started at the Warsaw University of Technology back in 2011. The performance characteristics of a number of prototype MCFCs which were assembled and tested are given.

2. Development of Molten Carbonate Fuel Cells at Warsaw University of Technology

Activities in the field of MCFC are carried out in two departments at the Warsaw University of Technology. The Institute of Heat Engineering (IHE) of the Faculty of Power and Aeronautical Engineering investigates applications of molten carbonate fuel cell in the power industry, with special attention on the use of MCFC as a CO_2 reducer of coal fired power plant flue gases. IHE has validated several single cell (16–120 cm^2) laboratory scale units for natural gas, biogas and hydrogen. Since 2013 IHE has had kW–size MCFC stacks as well as a mobile container for remote investigations. IHE is also active in MCFC simulation, adopting new approaches to modeling cell voltage, called reduced order modeling. Electrochemical, thermal, electrical and flow parameters are collected in a 0-D mathematical model, which rivals the classic approach. MCFC voltage is described by a numbe of factors which have physical explanations: maximum voltage; fuel utilization factor; maximum current density; area specific internal ionic resistance; and area specific internal electric resistance [36–39]. Thus, investigation of a specific component of the fuel cell (e.g., new electrolyte material, new catalyst layer, new fuel, etc.) is related to the factor listed, not for the whole current density-voltage curve as is currently practiced.

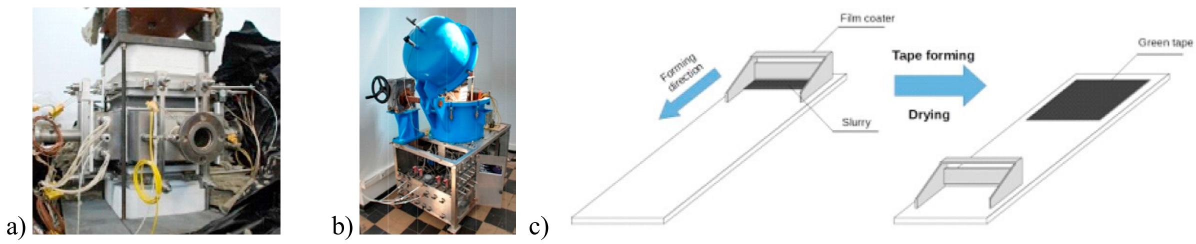

Fig. 1. (a) 1 kW MCFC stack, Warsaw University of Technology; (b) MCFC single cell test facility, Warsaw University of Technology; (c) A schematic diagram of the tape casting process for forming green tapes

Preliminary studies in 2010 and 2011 related to research on 1 kW stacks (see Fig. 1a) fed with a hydrogen/methane blend with external reforming. The MCFC stacks were bought from a company called Ansaldo Fuel Cells, where they were demonstrated successfully. A 1 kW external–reforming MCFC system was tested to evaluate the feasibility of using MCFCs for co-generation applications. The test station can be seen in Fig. 1b.

R&D has been concentrated on promoting internal reforming technologies. With support from NCBR, a concept of using MCFC for CO_2 separation is under development at the time of writing. Key issues like SOx and dust contamination are subject to deep investigation. Stability of cell performance with a certain amount of SO_2 at the cathode inlet was confirmed with a 20 cm^2 single cell, as shown in Fig. 1c It is observed that an increase in sulfur dioxide concentration in gases results in an increase in the rate of voltage drop over time. The presence of a sulfur dioxide concentration not higher than 100 ppm results in a slight voltage drop over time. After 48 h of operation the voltage drop does not exceed 2% of nominal voltage, whereas an SO_2 concentration higher than 680 ppm results in a significant voltage drop. For the experimental studies, a custom–made fuel cell manifold was designed by the team at the Warsaw University of Technology (see Fig. 1d).

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات