Ethanol Reforming 1 kW_{el} Fuel Cell System

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Introduction

Fuel Cell Systems offer a high potential for efficient and clean heat and power generation. An 1 kW_{el} PEM fuel cell system for independent and standalone power generation for stationary or mobile applications has been developed. It consists of an adopted FLOX® compact steam reformer which fulfills the capability of reforming ethanol or bio-ethanol, a high performing PEM fuel cell with low pressure drop and a system layout which allows to operate the system efficient and with low requirements for the fuel cell. The system is equipped with a lithium-ion battery for startup and peak power supply. The system layout was targeted to obtain both high simplicity and efficiency of the system.

Results

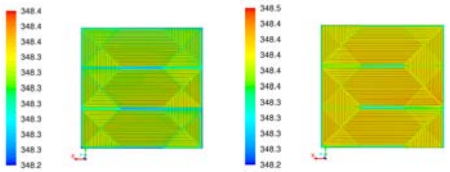
Fuel Cell Performance and Modelling Results

Stack Specifications

• Cells	48
• Nominal load	1,2 kWel
• Peak load	1,5 kWel
• Actice area	100 cm²
• Dimensions	130*140*240 mm
• Weight	5,8 kg
• Operation	reformate/air
• Utilization degree	75%/50% reformate/air

Stack design (modelling)

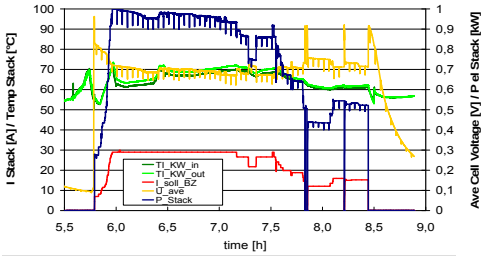
Flow field selection based on CFD results on flow distribution and operating pressure, reactant conc. and temperature distribution.



Simulation of anodic and cathodic cell temperature distrib. under reformate operation (H2, 35%N2), Tcell = 75 °C [1]

Stack performance

Test results of 48 cell stack in 1 kW_{el} PEM fuel cell system are shown below.



Stack performance in 1 kW_{el} PEM Fuel cell system

System Layout and Specifications

• Feed	Ethanol / Bio-Ethanol
• Nominal load	1 kW_{el}
• Peak load	2 kW_{el} (Li-ion battery)
• Heat output	2 kW_{th} (optional)
• Dimensions	655 x 430 x 585 mm
• Weight	≈ 80 kg
• Tank capacity	5 l (adaptable)
• Ethanol consumption	≈ 0,5 l/h at nominal load

1 kW_{el} PEM Fuel cell system based on ethanol

Main Results

- Successful operation of an ethanol based 1 kW_{el} PEM fuel cell system
- System hybridization with a Li-ion battery
- Electrical efficiency > 29 % (net) demonstrated
- Full water recovery (closed water loop) realized

Ethanol Steam Reformer

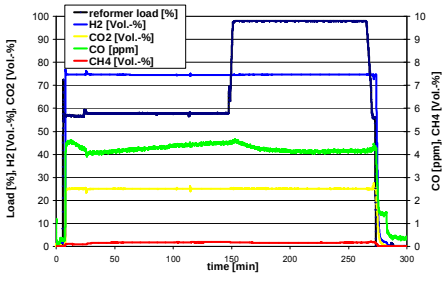
• Feed	Ethanol / Bio-Ethanol
• Operating temp.	900 °C
• Start burner	Ethanol-based
• Nominal H_2 output	1 Nm³/h H_2; 75 Vol. % H_2
• Gas quality	< 10 ppm CO
• Emissions	NO_x, CO, C_xH_y < 10 ppm

Source: WS Reformer GmbH

Ethanol Steam reformer (nominal output: 1 Nm³/h H_2)

Main Results

- Stable operation with no carbon formation
- Ultra low emissions due to FLOX® burner
- Reformate suitable for NT-PEM fuel cells



Reformate gas composition and quality

Summary and Conclusions

A 1 kW_{el} PEM fuel cell system based on ethanol has been built and successfully set into operation. The steam reformer and the surrounding system has been designed in a way, that carbon formation during the reforming of ethanol can be avoided even applying denaturated ethanol fuel. The system modelling was done with IPSEpro. Electrical efficiencies > 29 % (net) have been demonstrated resulting in an ethanol consumption of approx. 0.5 liters per hour at nominal load of 1 kW_{el}. A high overall efficiency of the system is obtained by a high thermal integration of all components. A full recycling of product water (closed loop) could be obtained.

Acknowledgement

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[1] S. Enz, M. Messerschmidt, J. Scholta: Numerical simulations of a complete PEMFC single cell with variations in current density, UECT 2012 poster contribution