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Review

Integrated fuel processors for fuel cell application: A review

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Abstract

This report documents the key technological progress made over last two decades in the field of development of integrated fuel processor for hydrogen generation. Studies on process optimization based on numerical simulation/calculation, mass and energy management, parametric adjustment have been reported. A number of these studies discuss the application of reforming process assisted by other technologies such as pressure swing adsorption and membrane separation to enhance the hydrogen productivity and/or purity. However, for such systems the extent of integration among and between components remains limited. Accordingly, the net efficiency is compromised due to the mass/heat transfer rate and reaction dynamics either in the individual units or the complete system. Process intensification technologies such as engineered catalysts, on-site heat production/removal and product purification can not only allow precise control of reaction and heat/mass transfer rates, but also help optimize the operation conditions, and, consequently, improve overall efficiency and mitigate the requirement for materials and capital investment. It seems that micro-scale technologies, possessing the typical characteristics of process intensification technologies, have potential for making the integrated fuel processor into practice.

Keywords: Fuel processor; Hydrogen generation; Fuel cell; Balance of plant; Process intensification; Process optimization; Micro-scale technologies

Contents

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Nomenclature

H	enthalpy, kJ/mol
y	oxygen/fuel ratio in the overall reaction
Y	yield for hydrogen, mol/mol C

Subscript

c	combustion
f	formation
m	hydrogen atom number in $C_nH_mO_z$
n	carbon atom number in $C_nH_mO_z$
z	oxygen atom number in $C_nH_mO_z$

Greek letters

α	a kind of structure for Al_2O_3
Δ	change in a property
η	efficiency of the fuel processor
θ	general temperature and pressure

Acronyms

ACR	Autothermal Cyclic Reforming
ANL	Argonne National Laboratory
ATR	Autothermal Reforming
CPO	Catalytic Partial Oxidation
CVD	Chemical Vapor Deposition
DOE	Department of Energy (USA)
FC	Fuel Cell
GM	General Motor
HBT	Hydrogen Burner Technology
HPM	Hydrogen-permeable Membrane
HTM	Hydrogen Transport Membrane
HT-WGS	High-temperature Water Gas Shift
INEL	Idaho National Engineering and Environmental Laboratory
ITM	Ion Transport Membrane
JM	Johnson Matthey
LHV	Lower Heating Value
LPG	Liquid Petroleum Gas
LT-WGS	Low-temperature Water Gas Shift
MCFC	Molten Carbonate Fuel Cell
MON	Motor Octane Number
NG	Natural Gas
OTM	Oxygen Transport Membrane
PEMFC	Polymer Electrolyte Membrane Fuel Cell
PNNL	Pacific Northwest National Laboratory
POX	Partial Oxidation