

WATER-NEUTRAL DIESEL REFORMING

Subir Roychoudhury

Ambient Temperature Air, Water, Fuel In SOFC Quality Reformate Out



Fuel sulfur converted to H_2S in ATR and sorbed in sulfur trap (included in hardware shown above).



Size: 3 liters; Weight: 5.2 kg
Room-temp start-up; No preheat required
Off-the-shelf pumps & blowers being implemented
Automated "push button" start, load changes & shutdown
Control logic/algorithm implemented via PC-based interface
Readily integrated w/SOFC, PEM, H_2 generation systems

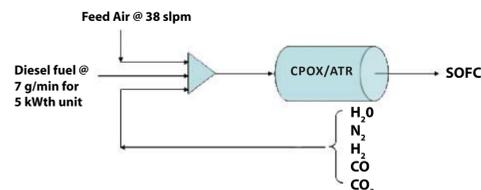
Condensation Approach: Water Recovery

Required % H_2O recovery is a function of:
% hydrogen in the hydrocarbon feed
Reformer product H_2 and H_2O
Fuel Utilization in the Fuel Cell
Location of anode gas burner in the system
Bypass ratio & Recycle ratio
Ambient conditions

Condensation Approach: Water Neutrality

- Both direct anode recycle & condensation approach demonstrated for water neutral operation
- Pros/Cons of AGR and Condensation Approaches characterized

Water Recovery: Direct Anode Recycle (AGR) Approach



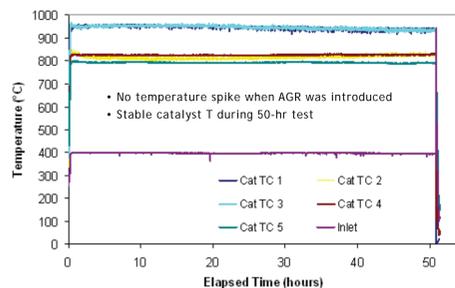
- Used surrogate gas mixture to simulate AGR composition and flow rate
-Assumptions: 60% SOFC Fuel Utilization; 50% AGR split to achieve target O/C and S/C
- Reactor startup under CPOX (waterless); then transitioned to ATR (w. AGR)
- Successfully demonstrated 50-hr durability of ATR using AGR for water neutral operation
- Test results in good agreement w. thermodynamic equilibrium analysis; no HCs slippage

Low Pressure Drop Nozzle: Temp Profile & GC Analysis

- Successful startup/shutdown on 5 kW_{th} ATR w. Tier II Diesel
- Cold startup successfully demonstrated
- Operates at 5 kW_{th} with ~1.6 psi air-side pressure drop
- Uniform flow distribution & stable temperature profile

H_2	CO	N_2	CO_2	CH_4	C2s	C3s
31.2	17.0	44.3	7.4	0.14	0.014	0.003

AGR Approach: 50-hr Durability Test



Species	Conc. (mole %, dry basis)	
	hr test (average)	ASPEN model
H_2	12.4	12.4
CO	14.8	15.3
CO_2	12.6	10.9
N_2	60.2	61.4
CH_4	0.02	0

Heat Integrated 3kW_{th} Steam Reformer Prototype

Performance Summary

- Up to 3 kW_{th} CSR operation
- 500 hr operation at S/C of 3.0 with low sulfur fuel without coke formation
- Product composition in good agreement with thermodynamic prediction
- Fuels tested: n-C12 and Synfuel S-8

Scale-up: 250 kW_e Fuel Processing System Design



250 kW_e Fuel Processing System Design & Hardware consisting of fuel/air/steam injector, ATR, steam generator hex, and downstream sulfur cleanup

Scale-up: 1MW_{th} VOC Reformer



1 MW_{th} Microlith[®] Autothermal Reformer to reform VOC ncompounds from process waste streams

Scale-up: 5MW_{th} Natural Gas Processor



BOP & System Integration



BOP Components, Control & System integration towards stand-alone reformate generation

