Producer Gas Fuelled Operation of a Solid Oxide Fuel Cell - Numerical Investigation

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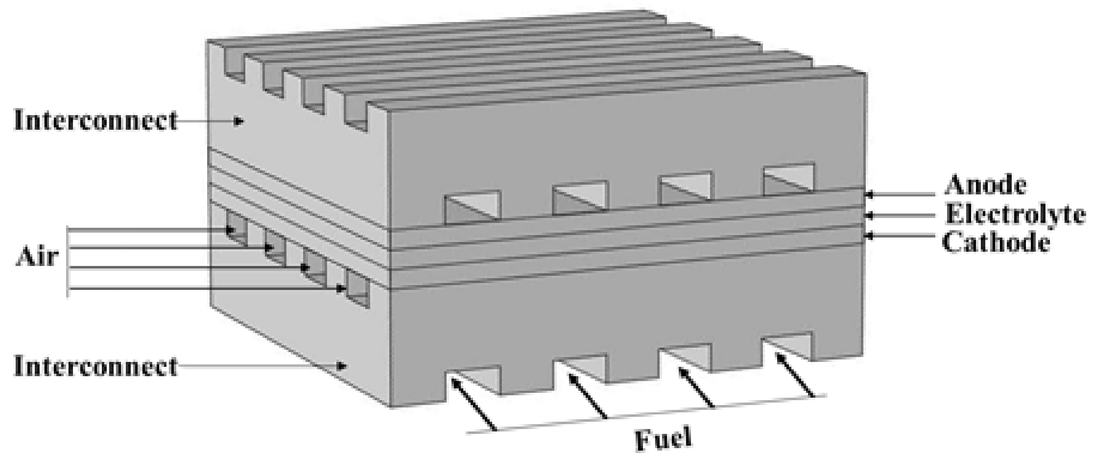
- Fuel cell is an electro-chemical device which converts chemical energy into electrical energy.
- Solid Oxide Fuel Cell is a type of fuel cell characterized by flexibility of the input fuel.
- Producer gas is gaseous bio fuel being used for power generation through the internal combustion engines route.
- Using producer gas in fuel cells is of interest considering the potential gain in conversion efficiencies.

The current study numerically evaluates the performance of a solid oxide fuel cell on fuelling with producer gas

Fuel cell operation

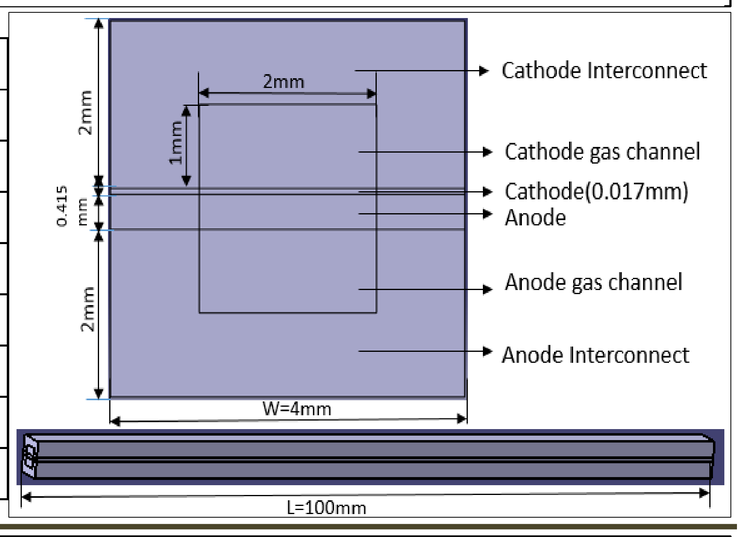
- Convective transport of gases in the gas flow channels
- Diffusive transport of gases through the electrode
- Reforming reactions at anode
- Ion formation and electron transport through the external circuit
- Oxygen ion transport through the electrolyte
- Fuel-oxygen combination anode triple phase interface
- Removal of the products by diffusive and convective transport



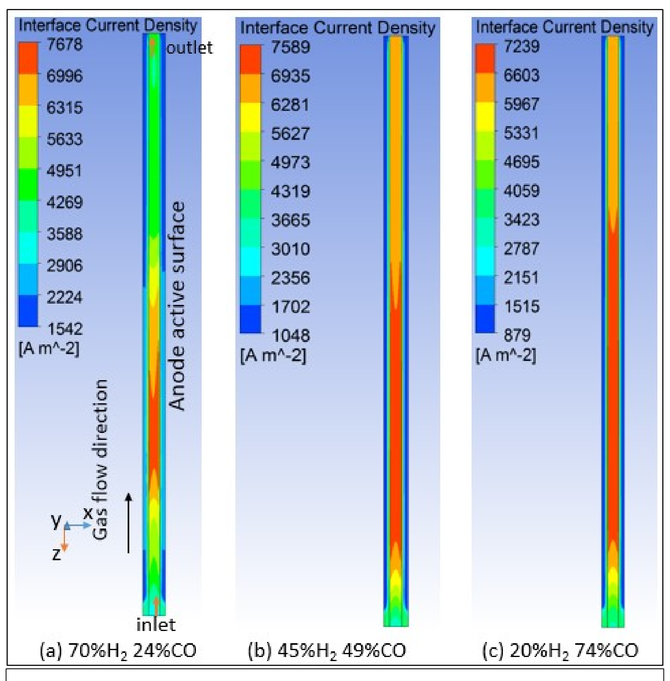
Model formulation

- Solution based on conservation equations for mass, momentum, energy, species & charge
- Butler-Volmer equation is solved to predict the performance of fuel cell.
- ANSYS Fluent® used (SIMPLE algorithm) for modelling a 3D planar SOFC operation during steady state conditions.

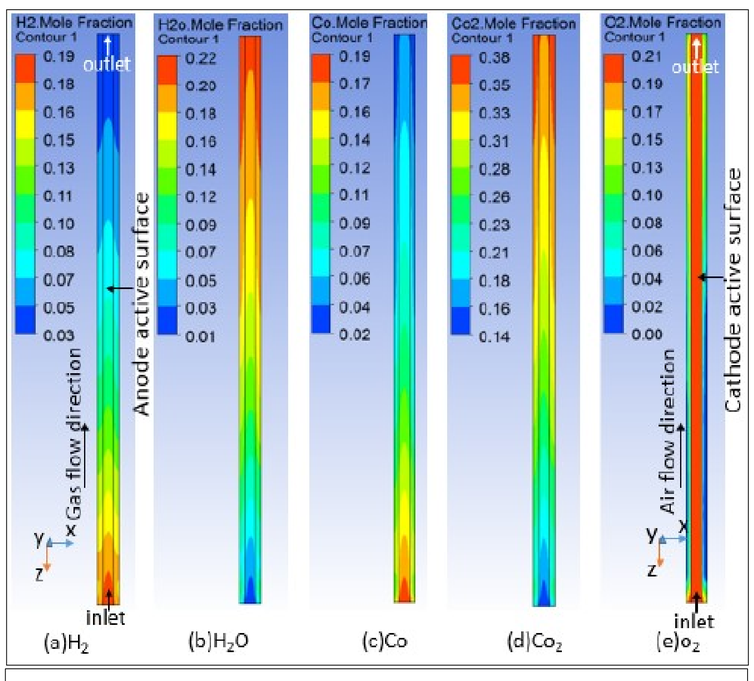
Fuel flow rate at inlet	$1.91 \times 10^{-7} kg/s$
Inlet temperature of fuel	1073 K
Air flow rate at inlet	$9.45 \times 10^{-6} kg/s$
Inlet temperature of air	1073 K
Cell operating pressure	1bar
External Surfaces	Adiabatic
Fuel composition at inlet	mass fraction : $95\%H_2, 5\%H_2O$
Air composition at inlet	mass fraction : $23.2\%O_2, 76.7\%N_2$
Cell voltage	0.7 V



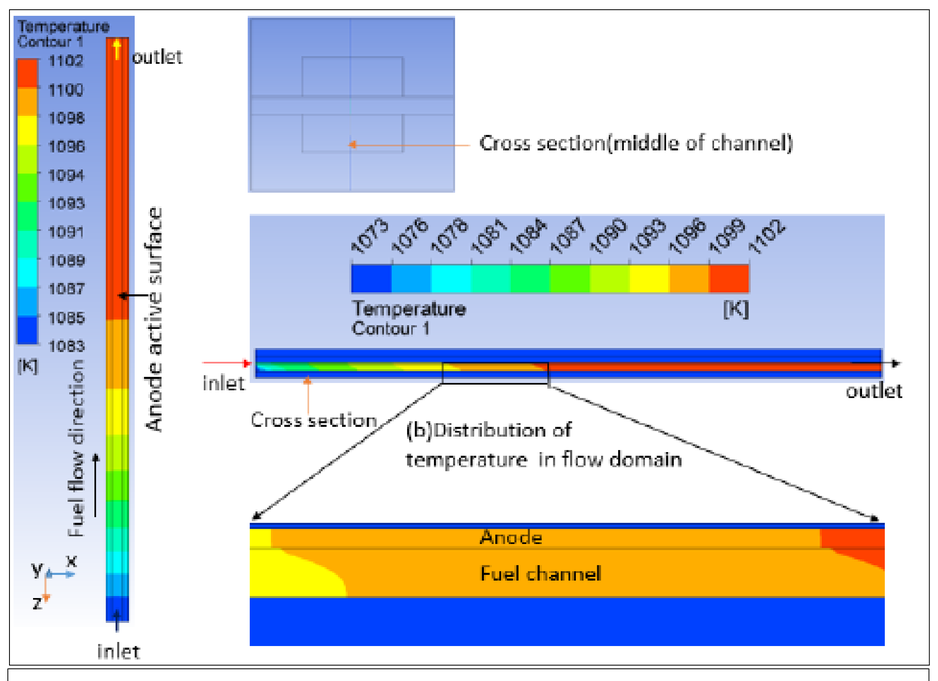
Key results



Syngas current density variation



Gas mole fraction variation



Anode active surface temperature distribution

- In syngas analysis, current density and fuel utilization fractions increases with H_2 fraction.
- Increasing fuel CO fraction adversely influences the fuel cell operation
- Fuel utilization of 82% with maximum current density of 2777 A/m^2 realized for producer gas fuelled operation.
- Constraint on fuel utilization arises from slow reaction rates for CO as compared to H_2

The influence of condensable higher hydrocarbons in producer gas on the fuel cell performance is in the future scope

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