

สารบัญเรื่อง

บทคัดย่อ	ก
Abstract	ข
สารบัญเรื่อง	ค
สารบัญภาพ	ง
สารบัญตาราง	จ
Nomenclature	ฉ
Chapter 1. Introduction	1
Chapter 2. Mathematical model of internal reforming reaction in an anode flow channel of a planar solid oxide fuel cell	3
Chapter 3. The effect of anode porosity on the transport phenomena in an anode-supported solid oxide fuel cell	12
Chapter 4. Transient analysis of Solid Oxide Fuel Cell during start-up period	28
Chapter 5. Conclusions	45
Nomenclature	50
References	48
Appendix A	50

สารบัญภาพ

Figure 2.1. Schematic diagram of a fuel cell model.	4
Figure 2.2. Mass concentration of gases along the anode surface with $S/C = 2$.	7
Figure 2.3. Mass concentration of gases along the anode surface with $S/C = 3$.	7
Figure 2.4. Mass concentration of gases along the anode surface with $S/C = 4$.	8
Figure 2.5. Mass concentration of gases along the anode surface with $S/C = 5$.	8
Figure 2.6. Mass concentration of CH_4 along the anode surface with different S/C .	9
Figure 2.7. Mass concentration of H_2 along the anode surface with different S/C .	9
Figure 2.8. Rate of reforming reaction along the anode surface with different S/C .	11
Figure 2.9. Temperature along the anode surface.	11
Figure 3.1. Schematic diagram of a fuel cell model	13
Figure 3.2. I-V characteristics of the anode-supported SOFC	21
Figure 3.3. Rate of reforming reaction along the anode depth	21
Figure 3.4. Rate of shift reaction along the anode depth	22
Figure 3.5. CH_4 concentration along the anode depth	22
Figure 3.6. H_2O content along the anode depth	24
Figure 3.7. Mass concentration (mol/m^3) of H_2 in the anode flow channel	24
Figure 3.8. Mass concentration (mol/m^3) of CO in the anode flow channel	25
Figure 3.9. Mass concentration (mol/m^3) of CO_2 in the anode flow channel.	26
Figure 3.10. The temperature variation along the porous anode surface	26
Figure 3.11. The current density variation along porous anode/electrolyte interface	27
Figure 4.1. Schematic diagram of a fuel cell model	29
Figure 4.2. Concentration profiles of gases in case A against time at $x = 0.01$ m.	34
Figure 4.3. Temperature profiles of case A against time	35
Figure 4.4. Concentration profiles of gases in case B against time at $x = 0.01$ m.	36
Figure 4.5. Temperature profiles of case B against time	37
Figure 4.6. Concentration profiles of gases in case C against time at $x = 0.01$ m.	38
Figure 4.7. Temperature profiles of case C against time	39
Figure 4.8. H_2 concentration of case A, B and C at $x = 0.01$ m.	40
Figure 4.9. Concentration profiles of gases in case D against time at $x = 0.01$ m.	41
Figure 4.10. Temperature profiles of case D against time	42
Figure 4.11. Concentration profiles of gases in case E against time at $x = 0.01$ m.	43
Figure 4.12. Temperature profiles of case E against time	43
Figure 4.13. H_2 concentration of cases A, D and E at $x = 0.01$ m.	44

สารบัญตาราง

Table 3.1. Dimensions and physical properties of cell components.	14
Table 3.2. Boundary conditions of the fuel flow channel	18
Table 3.3. Boundary conditions of the air flow channel	18
Table 3.4. Boundary conditions at the electrodes/electrolyte interface	18
Table 3.5. Boundary conditions for electronic and ionic charge equations for electrodes and electrolyte domains	19
Table 3.6. Initial and operating conditions	19
Table 4.1. Dimensions and physical properties of cell components.	28
Table 4.2. Initial and operating conditions	33

Nomenclature

A_v	specific active area (m^2/m^3)
c	Concentration of gas (mol/m^3)
C_p	Specific heat capacity (J/kgK)
D	Diffusivity of gas (m^2/s)
E_a	Activation energy (82000 J/mol)
E_{an}	Activation energy of the exchange current density (140 kJ/mol)
$E_{act,a}$	Activation energy of the exchange current density
R	Gas constant (8.314 J/molK)
F	Faraday constant (96487 C/mol)
i	Anode current density (A/m^2)
$i_{o,an}$	Exchange current density at anode (A/m^2)
k	Thermal conductivity (W/mK)
k_o	Pre-exponential factor ($0.04274 \text{ mol}/\text{m}^2 \text{ Pa s}$)
k_p	Permeability (m^2)
k_{wgs}	velocity constant of water-gas shift reaction (forward) ($3.2 \times 10^{-7} \text{ mol}/\text{m}^3 \text{ Pa}^2 \text{ s}$)
K_{eq}	Equilibrium constant
M	Molecular mass of the component (g/mol)
p	Pressure (N/m^2)
p_{ref}	Reference pressure ($1.0133 \times 10^5 \text{ Pa}$)
Q	Heat source term (W/m^3)
\bar{r}	Average radius of the pore (m)
R	Gas constant (8.314 J/molK) or Rate of reaction ($\text{mol}/\text{m}^3 \text{ s}$)
S	Mass source term ($\text{mol}/\text{m}^2 \text{ s}$)
T	Temperature (K)
u	Fluid velocity in x and y directions, respectively (m/s)
v	Operating voltage (V)
y_i	Mole fraction

Greek symbols

β	Charge transfer coefficient (-)
ε	Porosity (-)
ϕ	overpotential (V)
η	Activation loss (V)
μ	Dynamic viscosity (kg/ms)
ρ	Density (kg/m^3)
σ	Effective conductivity (S/m)
τ	Tortuosity

ΔH_r	Enthalpy of formation of reforming reaction (kJ/mol)
ΔH_s	Enthalpy of formation of shift reaction (-41.1 kJ/mol)
ΔH_{ox}	Enthalpy of oxidation reaction (J/mol)

Subscripts

a	Anode
c	Cathode
e	Electrolyte
eff	Effective
g	Gas
i	Gas species
ox	Oxidation reaction
r	Reforming reaction
s	Solid of shift reaction