**Design and performance of** **a** **compact air-breathing jet hybrid-electric engine coupled with solid oxide fuel cells**

Zhixing Ji; Jiang Qin[[1]](#footnote-1); Kunlin Cheng; He Liu; Silong Zhang; Peng Dong

*Key Laboratory of Aerospace Thermophysics, Ministry of Industry and Information Technology, School of Energy Science and Engineering, Harbin Institute of Technology, Harbin, China*

## **Supplementary materials S. Basic equations for the Fuel cell model**

Steam reforming reaction and water gas shift reaction occurs in the SOFC anode channel, which utilizes the water steam from the electrochemical reaction [32]. Energy and mass conservation equations for these reactions are listed in Table S.1.

Table S.1 Chemical reaction equations in the SOFC anode [32, 34]

|  |  |  |
| --- | --- | --- |
| Components | Equations | NO. |
| Water-gas shifting reaction |  | (S.1) |
| Methane water reaction |  | (S.2) |
| Electrochemical reaction |  | (S.3) |
| Electrochemical reactions heat |  | (S.4) |
| Mass balance equation in fuel cell |  | (S.5) |
| Energy balance equation in fuel cell |  | (S.6) |

Electrochemical reactions occur in the three-phase boundaries of fuel cells. The concentrations of working fluids are calculated by porous-media gas-phase transport models [33] as shown in Table S.2.

Table S.2 Concentration equations for reactant and product at the TPB boundary [33].

|  |  |  |
| --- | --- | --- |
| Components | Equations | NO. |
| The partial pressure of H2 at TPB boundary |  | (S.7) |
| The partial pressure of H2O at TPB boundary |  | (S.8) |
| The partial pressure of O2 at TPB boundary |  | (S.9) |

The open-circuit voltage is the maximum voltage that can be achieved by a fuel cell as (S.10) in Table S.3. Polarization loss includes ohmic, concentration, and activation polarization in Table S.3, which leads to the decline of the open-circuit voltage.

Table S.3 Polarization reaction equations for fuel cells [33, 35-37]

|  |  |  |
| --- | --- | --- |
| Components | Equations | NO. |
| Open-circuit voltage |  | (S.10) |
| Actual voltage | () | (S.11) |
| Ohmic polarization |  | (S.12) |
| Concentration polarization |  | (S.13) |
| Anode activation polarization |  | (S.14) |
| Cathode activation polarization |  | (S.15) |
| Anode exchange density |  | (S.16) |
| Cathode exchange density |  | (S.17) |

The performance parameters of SOFCs include power, efficiency, and fuel utilization, which are defined in Table S.4.

Table S.4 Performance equations for fuel cells

|  |  |  |
| --- | --- | --- |
| Components | Equations | NO. |
| Output power |  | (S.18) |
| Electric efﬁciency |  | (S.19) |
| Fuel utilization |  | (S.20) |

1. Corresponding author. E-mail address: qinjiang@hit.edu.cn [↑](#footnote-ref-1)