CHAPTER 5
CONCLUSION

5.1 Conclusions

The simulations of SOFC during the starting-up period by various heating-up gases were studied. It was revealed that, by using hot nitrogen gas as heat-up gas, non-reaction takes place at reformer and anode side; hence the temperature of the cell increases only by heat transfers from hot gas. In this case, the heating rate was found to be only 0.006 K/s but time duration during start-up is as long as 30 hours. On the other hand, by using hydrogen as heating-up gas, rapid exothermic electrochemical reaction occurs on anode side and results in the high heating rate of 0.93K/s, which reduces time duration to 2 minutes. Nevertheless, it not suitable for thermal cracking of material (based on the literature, the heating rate should be less than 0.5 K/s). For the case of syngas feed, the heating rate of syngas is 0.37 K/s that compatible for heat-up cell temperature without thermal cracking and time duration during heat up is 30 minutes.

The Indirect internal reforming solid oxide fuel cell (IIR-SOFC) is known to use hydrocarbon as fuel of fuel cell by reformed hydrocarbon to syngas and the coupling between the endothermic steam reforming and exothermal electrochemical reactions to obtain the autothermal operation is the great benefit. In the present work, methane, methanol and ethanol are compared as the heating-up gas for IIR-SOFC operation. It was found that the heating rates during starting-up period for methane, methanol and ethanol were observed to be 0.31 K/s, 0.11 K/s and 0.26 K/s respectively, which is also compatible with the cell material. In term of time duration, methane has lowest time than any other although power density of methane is lower than methanol. Furthermore, among these hydrocarbon fuels, SOFC fueled by methanol seems to obtain the highest power density at steady state condition.

The effect of inlet stream to carbon (S/C) ratio for IIR-SOFC fueled by these primary fuels (i.e. methane, methanol and ethanol) was also studied by varying the S/C ratio from 2.0 to 3.0 and 4.0. It was found that the changing of inlet S/C ratio does not show much affect on the heating rate during starting-up period for all types of hydrocarbon feeds. Nevertheless, it noticeably affects the temperature of the system at steady state condition, from which the use of high S/C molar ratios (S/C ratio of 4.0) results in the higher system temperature. Therefore, the low S/C ratio (S/C ratio of 2.0) has the higher power density achievement at steady state condition.

Finally, IIR-SOFC with co-flow pattern (co-flow of air and fuel steam through fuel cell) provides smoother temperature gradient along cell and higher power density at steady state condition than that with counter-flow pattern

5.2 Future work

More sensitivity analyses i.e., the effects of inlet gas temperature, inlet SOFC system temperature, and internal reformer configuration should be performed for the clearer understanding of the behavior of the IIR-SOFC system during starting-up period.