

**Travail de fin d'études et stage[BR]- Travail de fin d'études : Energy converter
integration study in a series hybrid powertrain[BR]- Stage d'insertion professionnelle**

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Energy converter integration study in a series hybrid powertrain

Master thesis submitted in partial fulfillment of the requirements for the Degree of Master in Mechanical engineering (Sustainable Automotive Engineering) by

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Fuel cells are becoming more and more important for the energy transition. They can offer clean and stable power compared to other renewable energy conversion systems such as photovoltaic, wind, etc. Their efficiency can be further improved when connected to other systems such as gas turbines, steam turbines, etc.

The focus of this master thesis is to evaluate a fuel cell, in particular a solid oxide fuel cell, combined to a micro gas turbine, as a range extender in a series hybrid electric vehicle. For this purpose, a complete thermodynamic modelling tool is developed to predict and compare the performance of various system layouts. The implementation of the tool is performed with MATLAB language. All chemical and thermophysical properties of the fluids are obtained through the REFPROP 9.1 package.

The layout of this work is organized as follows. Chapter 1 describes the technology of fuel cells and particularly solid oxide fuel cells, its auxiliary components and potential combination with gas turbines, as well as research and industrial applications. Chapter 2 is focused on the description of the physics of a SOFC stack and its thermodynamic and electrochemistry modelling. Chapter 3 is dedicated to the understanding and modelling of specific fuel processing inside the stack such as the anode gas recirculation while considering other improvements in reforming and water management. As the full SOFC system includes several additional components to the SOFC stack and reformer, Chapter 4 is devoted to the modelling of such auxiliaries. The performance of the full SOFC system is analyzed in Chapter 5. The connection between the SOFC system and the gas turbine is studied in Chapter 6. Eventually, this work is concluded by a brief technological analysis of the integration of the system in a series hybrid electrical vehicle in Chapter 7.

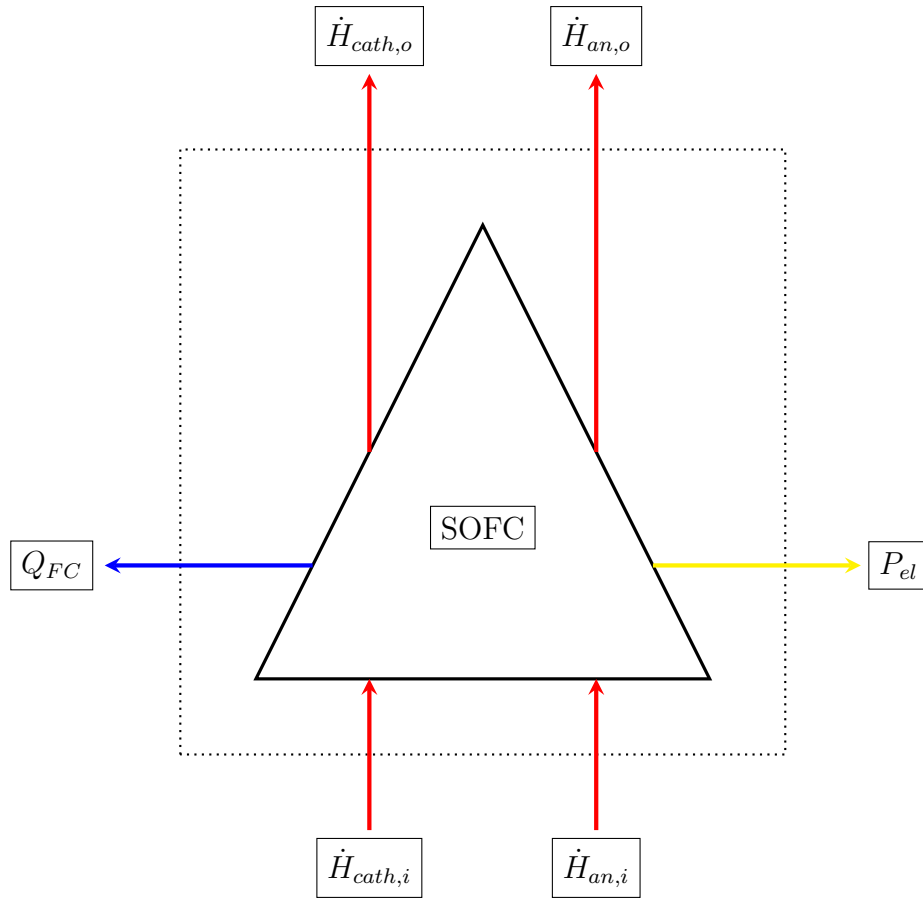


Figure 1: SOFC control volume.

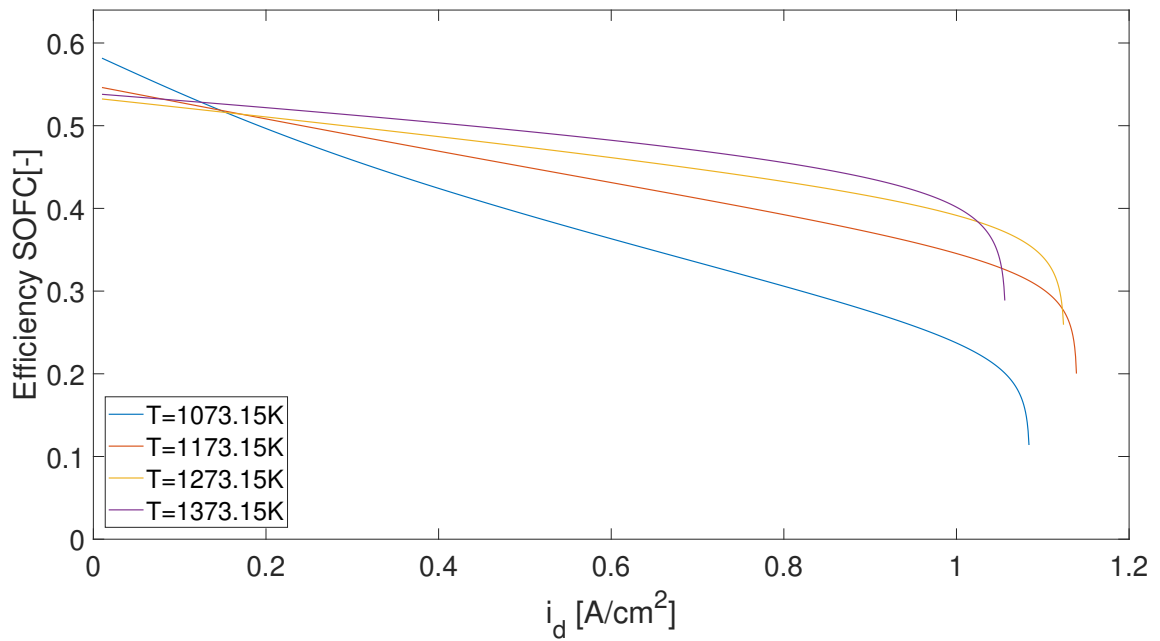


Figure 2: Efficiency of the SOFC [-] as a function of the current density [A/cm²] for different temperatures ($p_t = 200$ [kPa], $U_f = 0.7$ [-], $\lambda = 1.5$ [-], $\dot{m}_{CH_4} = 3.2E-4$ [kg/s], $\dot{m}_{H_2O} = 4.95E-4$ [kg/s]).

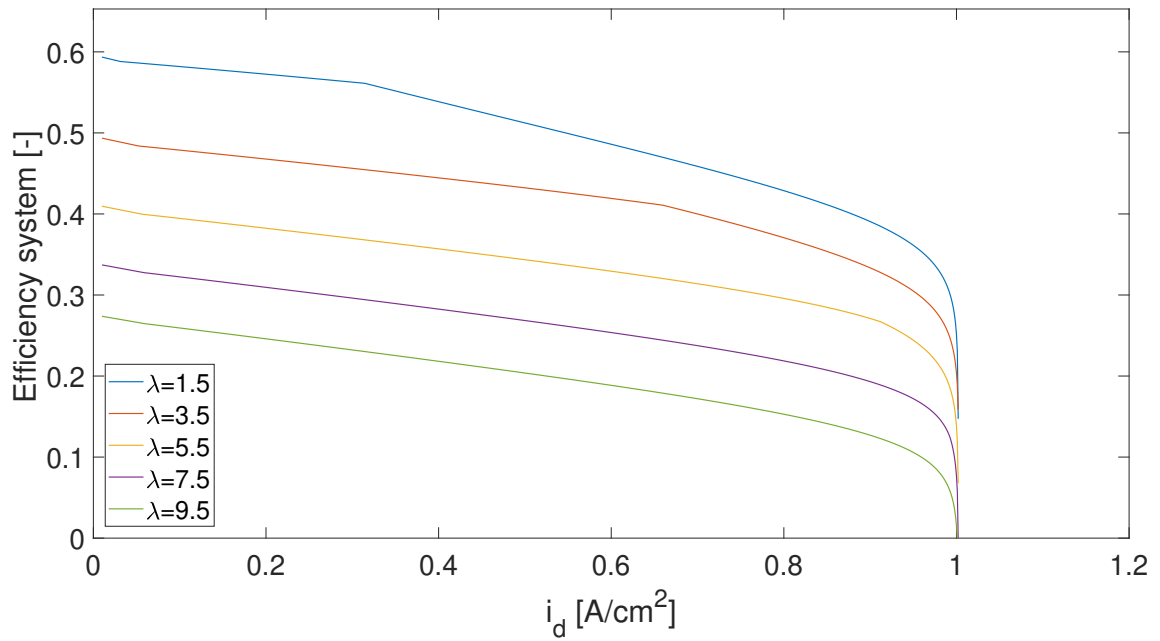


Figure 3: Efficiency of the SOFC system [-] as a function of the current density [A/cm²] for different air excesses. ($R_R = 0.7$ [-], $T = 1173.15$ [K], $p_t = 200$ [kPa], $U_f = 0.7$ [-], $\dot{m}_{CH_4} = 3.4E-4$ [kg/s], $\dot{m}_{H_2O,NR} = 8.1E-5$ [kg/s]).

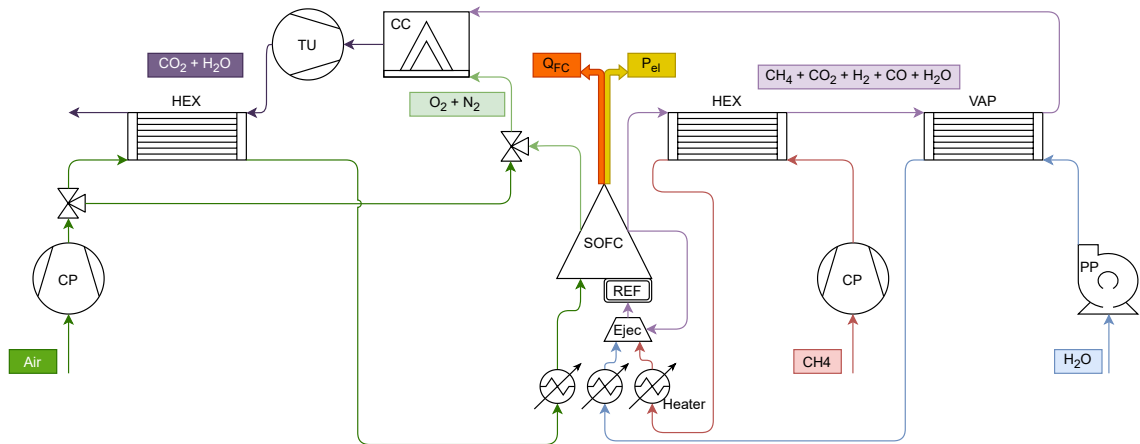


Figure 4: SOFC-GT bypass configuration.