INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

4GM Research Project 2022/2023

INSA de Toulouse – Mechanical Engineering Department

Title: Modelling and sizing of Proton Exchange Membrane Fuel Cells (PEMFC)
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Address: 3 Rue Caroline Aigle, 31400 Toulouse
Scientific disciplines: Modelling, preliminary design, electrical engineering, thermodynamics
Scientific keywords: Modelica, Fuel cell,
Number of students (4max) : 4
Open for students ("I-Méca", "I-Système" or both): I-Système

Context of the project:

In the context of the electrification of land and air transport means, and especially the electrification of their propulsion system, Fuel Cells (FC) are one of the main contender for providing the required electrical energy. One of the most mature technology in this area that seems to step up is the Proton Exchange Membrane FC (PEMFC). It is exhibiting good efficiency, specific power, and operation temperature. At the system level, this energy source is not consisting only from the FC. It contains several other subsystems that are mandatory for the operation of a PEMFC, as shown in Figure 1. Here can be seen the FC itself surrounded by thermal components, compressor, pumps, humidifier, valves, etc. The operation of this system is very related to the electrical power demand as well as the environmental conditions (air temperature, pressure, humidity). All these factors render this system a perfectly multiphysical system. Therefore, the design/preliminary sizing of such a system can be challenging due to multiple interactions between the different physics involved in the system. Also, the choice of the operating point of the FC is of utmost importance as is greatly determines the final sizing and performance of the whole system.

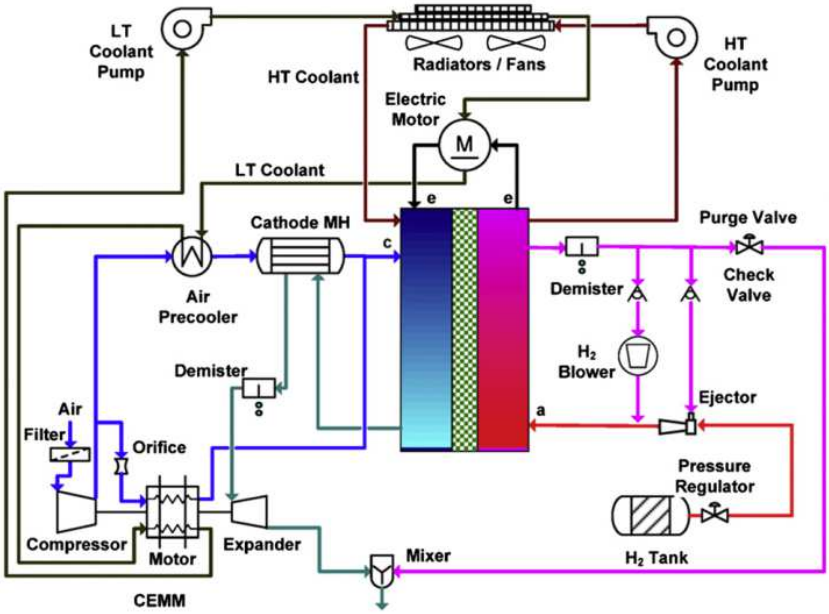

Figure 1. An automotive fuel cell system configuration

Nowadays, the preliminary design of complex systems like PEMFC is very often carried out and validated through simulation. Although PEMFC are today relatively mature technologies, the multidisciplinary simulation platforms

are lacking FC models that could be used in simulation. The aim of this project is to build models of components for simulating an entire PEMFC-based power supply in a a-causal simulation environment like Modelica/Dymola. Along with the simulation models, a preliminary sizing procedure will be established in Python environment.

Objectives for the students:

The objective of this project is twofold:

- Build a Modelica library for the main components of a FC system and demonstrate it by modeling and simulating of a FC system
- Design a FC sizing procedure based on a chosen design point. This procedure should be coded in Python environment.

References (Max 3):

- Anubhav Datta (2021), PEM Fuel Cell MODEL for Conceptual Design of Hydrogen eVTOL Aircraft, NASA/CR—20210000284

- Guangsheng Zhang, Satish G. Kandlikar (2012) A critical review of cooling techniques in proton exchange membrane fuel cell stacks, International Journal of Hydrogen Energy, 2412-2429.