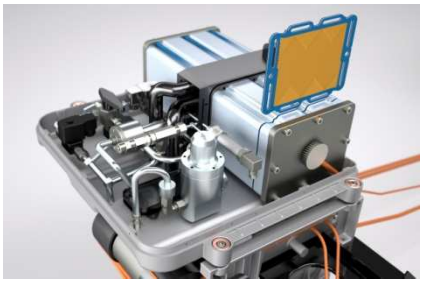
# Fuel Cell Activities

**Sherpa Engineering** has been involved in fuel cell activities for automotive and other industries for more than ten years.

The acquisition of know-how through several research and industrial projects with European car manufacturers has allowed us to develop performing tools for modeling and control system design.



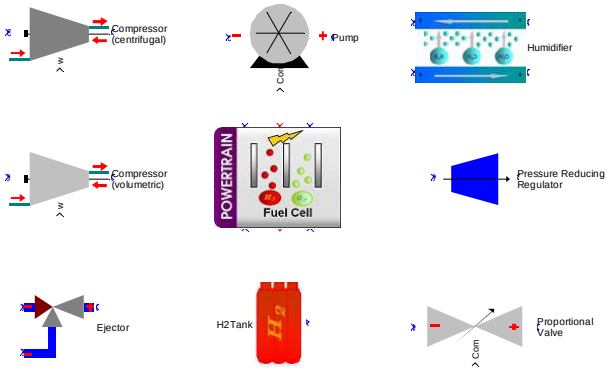
Fuel Cell System « GENEPAC 20 » (PSA, CEA)

Thanks to our innovative projects with PSA (Peugeot-Citroen) and the research laboratory CEA, we have gained recognition in control systems and in diagnosis.

## Fuel Cell Activities

The control system design and the fuel cell system diagnosis are essential engineering tasks. We have an active role in these tasks when working with our customer since we take in charge the system design process from the system specifications until validation on test bench or prototype vehicles.

### Modeling and Simulation




System Components Library

Sherpa Engineering has developed a **Fuel Cell System Library** which extends Simulink modeling and simulation features with specific tools for fuel cell systems. Our models, inside the Fuel Cell System Library, include components such as fuel cell stack, air compressor, hydrogen ejector or valves. The library also provides a representative set of thermo-fluid components and building blocks for customized component development.

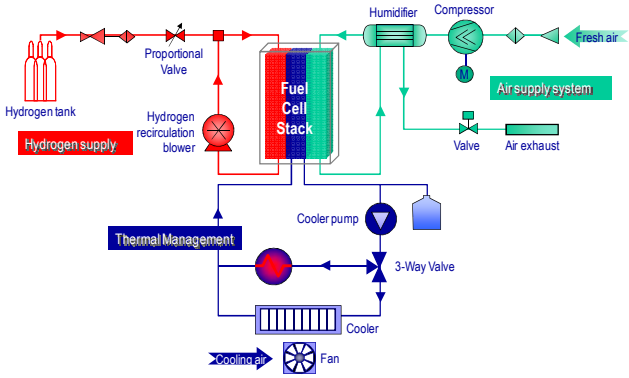
The Fuel Cell System Library provides nonlinear dynamic models suitable for control systems.

### Network Design

Sherpa is strongly involved in the network design and in the choice of the actuators (air compressor, radiator, valve, etc).

We ensure the best choice of components using a dynamic environmental model of the system (thanks to φ-Graph methodology). This model, based on the thermo-fluid equations of the system, takes into account the characteristics of each component and helps to validate the requirements of the system.

### Control system design and analysis




Fuel cell system configuration

A control system includes basic control laws, diagnosis, monitoring and the global supervisor of the system.

Sherpa Engineering has developed a model based control approach of the entire fuel cell system including the fuel cell stack and following three main subsystems:

- air subsystem: supply of the air at the required pressure, flow rate, temperature, and humidity
- hydrogen subsystem: supply of hydrogen at the required pressure and flow rate
- cooling subsystem: guarantee adequate cooling of fuel cell stacks and ensure small temperature gradient across stacks

The model based control design approach consists on making a hierarchical decomposition of the system while using a model based predictive control (MBPC) methodology. MBPC approach handles the multivariable interactive control problems in an effective way.

This modular and efficient approach is easily applicable to different fuel cell system types and also to traditional systems such as the thermal management of classic thermal engines.

 - SHERPA Engineering, 12 Avenue de Verdun, F- 92250 La Garenne-Colombes
www.sherpa-eng.com - Tel: + 33 147 820 823 – e-mail : phi-sim@sherpa-eng.com

## Diagnosis

The objective of the diagnosis system is to avoid any deterioration of the fuel cell stack and to increase its lifespan.

Sherpa Engineering proposes a simple and efficient diagnosis-oriented model. It includes the following three main monitoring modules:

- Cell voltage monitoring
- Vital parameters for a safe and proper operation: membrane temperature, air flow rate, stoichiometric ratio, hydrogen and air pressure stack inlet, pressure differential, etc.
- Actuators and sensors diagnosis

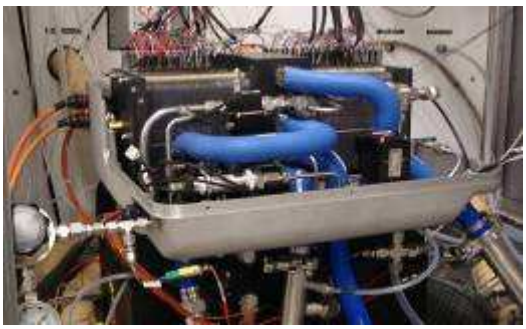
The fault detection and identification procedure is based on a reduced model of the fuel cell. Residuals (difference between observation and predicted value) are calculated and used to decide on the occurrence of any fault, its type and its location.

## Detection of hydrogen leaks

A common safety issue in fuel cell systems is hydrogen leaks, which may cause very dangerous faults.

In addition to hydrogen sensors, we have developed a method for leaks detection in fuel cell system. This procedure includes a hydrogen storage tank, a primary shut-off valve and a secondary shut-off valve in a supply line.

## Validation



Bench validation

Validation process includes three steps:

- Fast Prototyping with Simulink and dSPACE systems
- Hierarchical decomposition: partial bench to validate subsystems before the final validation of the entire fuel cell system
- Model based design: by running the same tests on the model, we anticipate its performance in the lab or in the real vehicle

## FISYPAC R&D Project

FISYPAC is a research project founded by the ANR (Agence Nationale de la Recherche) aiming at developing and testing a fuel cell system for a fuel cell electric vehicle.

Sherpa Engineering is in charge of the design and the validation of the control and the diagnosis systems as well as of the global system energy management strategy.

Peugeot 207 ePure concept

The hydrogen fuel generates 20 kW, giving the car a 350 km range and a maximum speed of 130 km/h.

The vehicle corresponds to a range extender using 2 hybridized energy sources: a 20 kW fuel cell generator supplied with a 700 bar hydrogen storage system and a 13 kWh Li-ion battery (maximal speed 155 km/h- range on battery 75 km or 450 km in hybrid mode).

 - SHERPA Engineering, 12 Avenue de Verdun, F- 92250 La Garenne-Colombes
www.sherpa-eng.com - Tel: + 33 147 820 823 – e-mail : phi-sim@sherpa-eng.com