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Architecture and modelling of hydrogen light vehicles' traction systems with fuel cells: adaptation of the computational model and first order simulations

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Abstract

The overall objective of this project is the structuring of the architecture, modelling and simulation of hydrogen and fuel cell vehicles, in the framework of Unicamp Hydrogen Laboratory (LH2). The specific goals are the recommendation of an appropriate software for the activities of hydrogen vehicles simulations to the LH2 group of researchers; the acquirement of familiarity with its use towards many architectures of traction systems – initially applied to a combustion vehicle; the analysis of the safety norms regarding the handling of hydrogen in fuel cells; the study of the types of hydrogen storage tanks for light vehicles and the determination of the state of the art of the available fuel cells.

Key words:

Hydrogen fuel cells, Hybrid vehicles, Vehicle simulation

Introduction

In the current days, one of the main goals in the challenge of combatting global climate changes is the reduction of greenhouse gas (GHG) emissions. The geothermic, hydraulic and solar are great solutions concerning the stationary generation of energy, but in the case of the transportation sector, which contributes heavily with GHG emissions, the use of hydrogen in fuel cell vehicles appears as one of the main alternatives.

The LH2 has started, in 1992, the project of a fuel cell hydrogen vehicle, inserting Unicamp in this area. The results were two vehicle prototypes (VEGA I and VEGA II) [1]. By the time, the computational tools required for simulations of these vehicles were not available, which became evident during the prototypes' construction: resources, material and time expenses could have been avoided otherwise, and the data acquired treated in a more convenient manner.

This project of scientific initiation aims at structuring the field of simulation and modelling of vehicles (by the evaluation of possible softwares and computational tools).

Results and Discussion

Throughout the complete project of the architecture of fuel cell hydrogen vehicles (Image 1) several distinct models of traction systems were analyzed, starting with the simulation of a combustion vehicle.

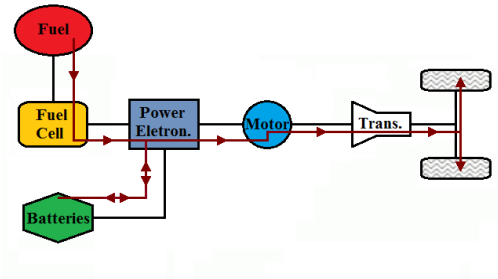

Image 1. Architecture of the traction system of a hybrid vehicle with hydrogen fuel cells (FCEV) and batteries

The first part of the project was dedicated to the comparison of three simulation tools - AVL CRUISE™, ADVISOR® and LMS Amesim – in order to choose the most adequate, taking into account a set of parameters such as cost, possibility of acquirement, user-friendliness and quality of results. LMS Amesim was chosen to be used in the following steps of the project, and the modelling of a light combustion vehicle was carried out within it, with the help of previous works.

Besides that, a study was made regarding the types of hydrogen storage tanks and the safety norms for the handling of hydrogen in fuel cells. At last, it was determined the state of the art of fuel cells available in the market.

Conclusions

The input parameters for the modelling were set based in commercial models such as Toyota Mirai, Honda Clarity and Hyundai Tucson and are shown in Chart 1. ADVISOR® and LMS Amesim were found to be the most suitable softwares for the activities carried out in LH2. Thus, LMS Amesim was the chosen one and the simulations will take place in the next steps of the project.

Chart 1. Main caracteristics of the FCEV to be modeled

Caracteristics		FCEV
Fuel Cell (PEM)	Max. power (kW)	100
	Eficiency (%)	50
	Weight (kg)	600
Electric Engine (AC Synchronous)	Max. power (kW)	100
	Peak torque (Nm)	300
	Eficiency (%)	95
	Weight (kg)	40
Hydrogen Tank (Carbon Fiber)	Op. pressure (Mpa)	70
	Weight (kg)	900
	Mass of H2 (kg)	5
Batteries (Ion-lithium)	Stored energy (kWh)	1
	Eficiency (%)	90
	Weight (kg)	4
Vehicle	Weight (kg)	1900
	Autonomy (km)	500
	Max. Velocity (km/h)	170
	H^2 Consumption (g/km)	10

Acknowledgement

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[1] AMARAL, E.G. **Veículo Elétrico com Sistema Energético Híbrido: Célula de Combustível / Baterias Eletroquímicas.** Tese de Doutorado, FEM/Unicamp, 1998.