www.cadanda.com
Computer-Aided Design AND APPLICATIONS

XAM 2.0: from Student Competition to Professional Challenge

Massimiliana Carello, Andrea Airale, Alessandro Ferraris and Alessandro Messana

Politecnico di Torino Department of Mechanical and Aerospace Engineering,
massimiliana.carello@polito.it, andrea.airale@polito.it,
alessandro.ferraris@polito.it, alessandro.messana88@gmail.com

ABSTRACT

In 2012 the Team H_2politO from the Politecnico di Torino has taken part in the impressive Future Car Challenge, an international competition for electrical, hybrid and hydrogen vehicles. The most important car manufacturers such as Renault, Opel, Nissan, Jaguar, Mercedes and of car prototypes such as Gordon Murray Design cars were present at the competition. The Team H_2politO has always been in search of new technical, technological solutions and of concept of product nearer the market. This is why the Team H_2politO has been working for years in planning and carrying out low consumption prototypes such as IDRA and XAM, that took part to the international competition called Shell Eco-marathon. XAM 2.0 competed at the Future Car Challenge and it represents the number-plated evolution of the XAM vehicle (eXtreme Automotive Mobility), presented at the Politecnico di Torino on 13^{th} June 2011. XAM 2.0 is road legal so it is capable to travel on the road and not on a motor racing track. Behind the Team H_2politO there is a Research Group and thanks to the Team H_2politO activities was born an innovative Spin Off in automotive field.

Keywords: hybrid vehicle, technological test bench, composite material, FEA analysis, CFD optimization, mathematic vehicle model.

1. INTRODUCTION

The future of urban mobility may change radically in the next thirty years. In 2050 the increasing of world populations and the rapid growth of energy request will cause an unsustainable environmental pollution levels: over 75% of people will live in a city and congestions could represent a strong obstacles toward progress. So the time of huge, bulky, consume and pollute vehicles is coming to end.

The Team H_2politO try to answer to the question "Why get around in the city with a vehicle of 1.500 kg, or more, to move only themselves?" The response is to realize an extremely light, low consumption and performance vehicles, with a cost that would enable to have a market price at reaching of all.

A possible solution is the electric mobility. In fact it makes possible to have:

- zero emissions and performance suitable for traffic city;
- low weight means low volume and batteries weight bulky;
- a range extender system (where it's necessary) that increases autonomy allowing also extra-urban travel.

The challenge that Team H_2politO accepted was to design and prototype a light electric urban car, focused on personal urban mobility and last mile delivery, which must meet the requirements of homologation, manufacturability and possible industrialization.

Thanks to the experience gained by the design and the construction of two prototypes, IDRA and XAM dedicated to the competition of low consumption vehicle called Shell Eco-marathon, the Team H_2politO was able to face the problems and the difficulties coming from the realization of a road legal heavy quadricycle prototypes: XAM 2.0.

Moreover, PACE project gives to H_2politO student's the possibility to grow up professionally thanks to the clusters of software that students and researcher use during the designing phases of the car.

XAM 2.0 is a technological demonstrator that gives also a continuation using technological transfer to go from research and students training to a professional

Taylor & Francis

environment, but using the expertise and the network created over the years thanks to the work of the Team H2politO experience.

The final idea is to make and sell, through a BeonD spin off linked to the Team, a product of design and engineering combined with a product of the process. In doing so, it's possible to sell to the customer a design, engineering and production plan "package" for a light electric or range-extender vehicles for urban mobility with a high technological content. Not only, the dream and the challenge of the spin-off is to help companies and manufacturers to define and design the car of tomorrow: safe, efficient, attractive style and an affordable price for all.

2. POLITECNICO DI TORINO AND PACE PROJECT

The collaboration with PACE and Politecnico di Torino has been started since 2010, when the Politecnico entered in the PACE programs (Fig. 1). During the 2011, it was opened the PACE lab inside the Politecnico with six workstations.

Fig. 1: Politecnico di Torino's PACE lab opening ceremony.

In the same year, the Team H_2politO took part to SUT project for the powertrain area and also the PACE program support the design phases of hybrid urban concept for student low consumption competition called XAM. For the results of this project, the team received a special mention from John Calabrese, vice president of GM (Fig. 2).

In the 2012, the number of workstations was increased up to ten and in the same year the team H_2politO decided to develop a new hybrid car: the XAM 2.0 project was started. Actually, in 2013 Politecnico PAMD team 7 was born.

3. TEAM H_2POLITO'S URBAN CONCEPTS

During the last three year, the Team H_2politO has designed and built two different urban concepts: XAM and its evolution XAM 2.0.

Fig. 2: SUT project team.

XAM was developed in 2011: the acronym mean "eXtreme Automotive Mobility". It was designed by students to take part to the Shell Eco-marathon, an international student competition for innovative low consumption vehicle (Fig. 3).

The Shell Eco-marathon main goal is to run as many kilometers with the smallest amount of any energy source (Gasoline, GTL, Hydrogen...).

Fig. 3: XAM during its debut in Shell Eco-marathon 2011.

XAM is a parallel hybrid that use 2° generation of bio-ethanol E100 and supercap as energy storage (Tab. 1). It was equipped by a 1 kW four stroke internal combustion engine coupled to a permanent magnet electrical motor, through a single drive transmission. The students also had modified the fuel system from the carburetor one to an indirect injection system.

The chassis is a tubular chassis made of aluminum alloy and the body is made of natural fiber. The external shape of the car is a perfect trade-off between aerodynamic performance and design style: in fact the C_X coefficient is about 0,3, quite low considering the vehicle dimension. The car is also equipped with four double wishbone suspension with a pull rod system, equal in the rear and in the front. At SEM, XAM won two different off-track awards and achieved a consumption of 107 km/L (Fig. 4).

Fig. 4: XAM during aerodynamic tests in Pininfarina wind tunnel.

Mass	197 kg
Length	2800 mm
Width	1300 mm
Height	1280 mm
Chassis	Aluminum 6061
Max speed	30 km/h
Powertrain	PHEV
Energy Storage	Supercap 48 V
Fuel Tank	0,35 L
Power	2 kW
CO_2 *Emissions*	26 g/km
Transmission	Single Drive
N° seats	2
Road Legal	No

Tab. 1: XAM technical information.

In 2012, one year after the XAM debut, the Team realized that it was necessary to do something new on using the XAM base. A new project was set and XAM 2.0 was designed (Fig. 5).

This vehicle has the same chassis and the same shape of XAM, but the vehicle architecture is completely different in-fact XAM 2.0 is an E-REV. The car was designed by students and researchers, and took part to an important competition for innovative low consumption vehicle called Future Car Challenge (FCC). In order to participate to the competition, it was necessary to have a road legal vehicle since the competition took place in open traffic roads. For this reasons the car need a plate to race, so XAM 2.0 is not a really racing car, but a technological demonstrator for future electric city vehicle (Fig. 7).

Fig. 5: XAM 2.0 presentation at Museo Nazionale dell'Automobile "G.Agnelli" of Torino.

Mass	411 kg
Length	2880 mm
Width	1300 mm
Height	1280 mm
Chassis	Aluminum 6061
Body	Carbon Fiber
Max speed	80 km/h (limited)
Powertrain	E-REV
Engine	Wankel 126 cm^3
Energy Storage	Li-Po 6,9 kWh
Fuel Tank	20 L
Torque	350 Nm
Power	15 kW
CO_2 Emissions	27 g/km
Transmission	Single Drive+Retro
N° seats	2
Road Legal	Yes (L7e)

Tab. 2: XAM 2.0 technical information

XAM 2.0 is a totally electrical vehicle driven by 15 kW IPM electrical motor. The vehicle max speed is about 80 km/h and it accelerates from 0–50 km/h in 7 seconds. The 6.9 kWh lithium polymers batteries provide a 60 kilometers autonomy: they can be charged from the home network in about 10 hours. The Range Extender of XAM 2.0 is composed by an internal combustion engine, and a SPM electrical motor that has two different roles: starter and generator so as to charge the batteries. Thanks to the Range Extender, XAM 2.0 can run up to 400 kilometers with only 10 liters of petrol or of E85 (Tab. 2 and Tab. 6).

The XAM 2.0 frame is made of aluminum alloy. It has a cell that provides the passengers protection from the low speed collisions. The car is equipped by and hydraulic braking system both in the front and in the rear axles. The double suspension system is the same of the one installed on XAM but with different material and set. The body is made of low temperature polymerization carbon fiber, in order to obtain the maximum in lightness and structurality of panels combined with a low impact process. The driver and passenger compartment is bright and comfortable, ventilation and warming is assured by last generation heater that permits you to get warm in winter and to demist the car windows without an excessive decrease of its autonomy.

In the center of the dashboard there is a 7-inch exportable touch screen tablet that permits to receive all the information necessary to drive and gives the opportunity to know if something is wrong, moreover an explanatory screen explains how the hybrid propulsion works in its different driving phases.

Fig. 7: XAM 2.0 along UK roads.

3.1. How PACE Project Supported Team H_2politO

Thanks to PACE program, it was able to use very professional software that support the designer during

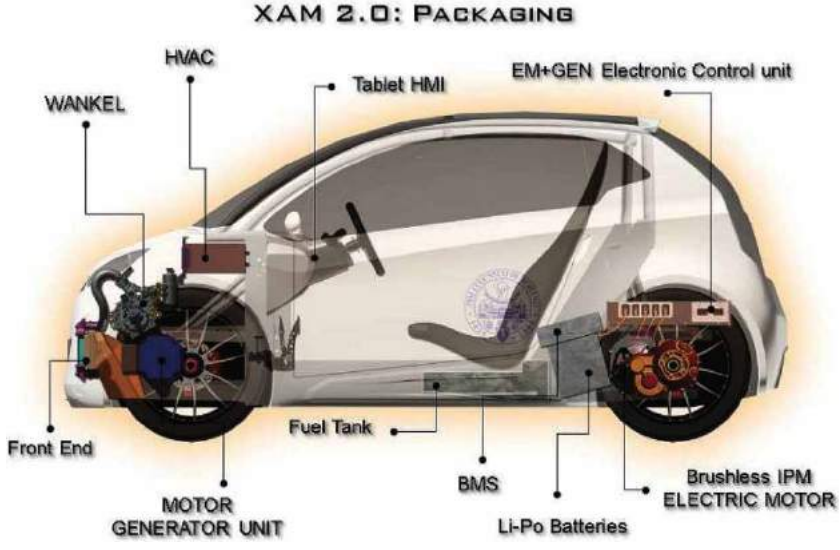

Fig. 6: XAM 2.0 Packaging.

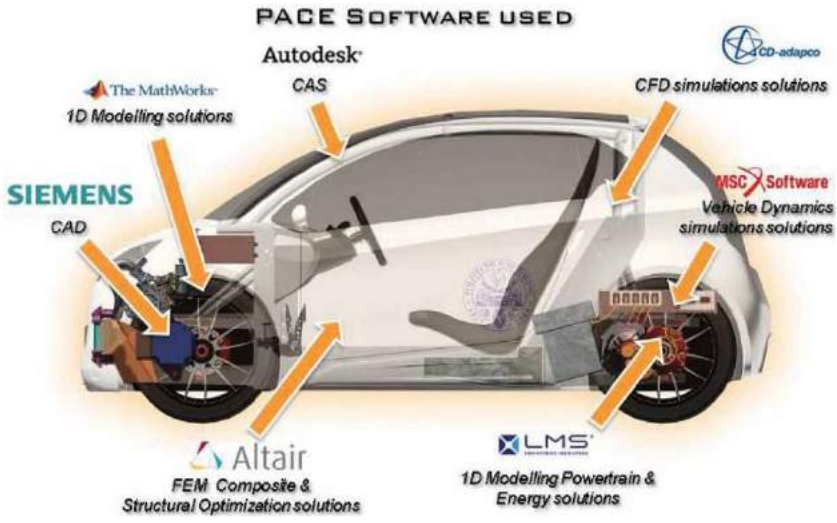

Fig. 8: PACE software used for XAM 2.0 project.

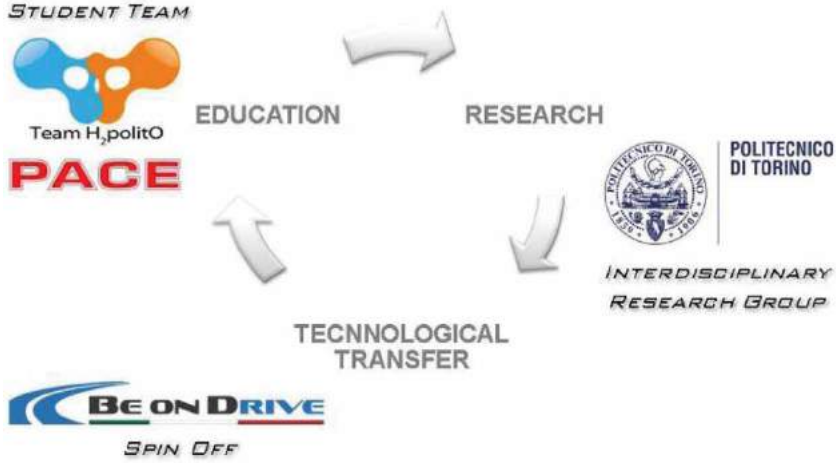

Fig. 9: Three different entities of the Work Team in which Team H_2politO is added.

the different developing phases (Fig. 8). As CAD and CAS it was used NX and Alias, while for CAE phases it was used Hypermesh for FEA, StarCCM for CFD analysis and ADAMS-CAR for vehicle dynamics. As modeling software, it was used AMEsim for power-train dimensioning and energy flow simulation and Mathlab Simulink to model the Wankel.

3.2. Team Organization behind XAM 2.0

There are three different levels (Fig. 9): the first is the Team H_2politO that is the initial approach. It's mainly concentrated in the training and educational path of every student members in order to learn software, work methods and to grow up in very professional way.

The second level is the research group, made by the best team students that become PhD students or researchers, leading by Prof. Massimiliana Carello. The researchers work on high technological engineering skills in order to do experimental activities tested in the car. In this way it's possible to work with Car Maker and Tier One Automotive Supplier to test the next generation of subsystems on vehicles that we design, built and test.

At the end, the know-how obtained by research it' used for outsourcing activities and automotive supply for companies, through the BeonD spin-off.

BeonD born to give a quick answer to companies in innovative design activities, but also in construction of one-off, show car, prototypes or small series production vehicles.

4. THE FUTURE CAR CHALLENGE COMPETITION

The FCC competition represents an important event especially for carmakers, where they show their innovative vehicle in public. In fact the Team H_2politO were the only one student team and the first Italian team participant (Fig. 10).

Fig. 10: XAM 2.0 and Team H_2politO in London.

The race starts from Brighton and finishes in London and it's long about 90 km. The competition is organized by Royal Automotive Club and there are allowed two mainly categories: Production Vehicle and Prototype, which are divided in sub-categories such as pure electric, E-REV, Plug-in Hybrid Electric Vehicle, Hydrogen fuel-cell electric vehicle and internal combustion engine with less than 100 g/km CO_2 emission. The most important car manufacturers such as Renault, Opel, Nissan, Jaguar Mercedes and of car prototypes such as Gordon Murray Design cars took part in the competition (Fig. 11).

After 103 km XAM 2.0 proudly represented Italian Universities thanks to award it won for the best E-REV Prototype and totalize a consumption of 140 Wh/km (five position in the total ranking) (Fig. 12). It was a very impressive result also because the car was designed and assembled in only five months.

5. CONCLUSION

The Team H_2poliO, Politecnico di Torino, BeonD and their Industrial Partners target is very clear: they want to make available the skills and know-how obtained in different innovative engineering fields for companies outsourcing, in Europe and US. This is possible because researchers constantly improve XAM 2.0 in order to be a technological demonstrator for companies.

A specific field of investigation is composites material with thermoplastic and thermosetting: we are concentrating in FEA optimization, static and dynamic, in order to reduce components mass and validate FEA composite mathematical model through a comparison between lab tests and simulation.

Also for aerodynamic, we are doing the same study in order to reduce the gap between wind tunnel

Fig. 12: The award won by Team H_2politO at FCC.

Fig. 11: XAM 2.0 at the finish line.

Fig. 13: Some ideas to design and built new vehicle.

tests and virtual ones. Not only, because we are Italian, it's very important for us to combine style with aerodynamics efficiency.

In the field of vehicle dynamics, we are concentrating our efforts to develop a torque vectoring system for active safety. Moreover we are studying a new geometry for an innovative and economic composite suspension for urban cars.

Another important field is manufacturing and production analysis, making cost engineering, make or buy analysis and sustainable study.

As powertrain, we want to improve the E-REV system implementing the regenerative breaking and reducing the vehicle total consumption to 40 Wh/km (now is 55 Wh/km) working on the electric driveline. We are also working on the ICE motor to reduce emissions and noise, but above all optimize the combination with and ICE and an EM. About battery packaging, we are studying a system to integrate in a safe way the Li-ion batteries inside the chassis (under the 2 seats) and simulate crash tests in a virtual way.

Below there a some idea about new vehicle prototype that we will be M1 vehicle with the aim to participate at professional low consumption competition for electric vehicle (Fig. 13).

ACKNOWLEDGEMENTS

Thanks to all Team H_2politO students that made possible the realization of XAM 2.0.

The H_2politO project is financially supported by the "Committee on Contribution and funds for students' projects" of the Politecnico of Torino and the sponsors and technical partners (reported on the website of the Team) that have cooperate in XAM 2.0 manufacturing.

More informations: www.polito.it/h2polito