ARCHYBALD project on new HEV powertrains for different heavy trucks

Technical paper for the special session

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O. Pape[1,6], W. Lhomme[2,6], D Depernet [3,6] , B. Vulturescu [4,6], L. Bregeon [5,6]

[1] NEXTER Systems, Versailles, France
[2] University of Lille Nord de France, L2EP, 59 000 Lille, France
[3] University of Technology of Belfort-Montbeliard, FEMTO-ST, Belfort, France
[4] INRETS-LTN, Versailles, France
[5] BATSCAP, Quimper, France
[6] MEGEVH French National Network on Hybrid Electrical Vehicles

***Abstract*— This technical paper gives an overview of the project ARCHYBALD. The objective is to design a hybrid powertrain for a heavy vehicle, especially in the military field. The consortium consitued with L2EP, FEMTO, INRETS, BATSCAP and NEXTER allows to adress the following topics : electric machine, storage with ultracap and batteries, mechanical box, end user application and system modelisation.**

Keywords-Powertrain; Hybrid; Military;

I. INTRODUCTION

The reduction of the oil resources, their price increase and their effects of the environment lead the transport industries to innovate and to develop solutions with a low fuel consumption and low air pollution. One solution is to design a hybrid powertrain, which contains the whole of the elements linking up the necessary sources of energy to move the vehicle, with the wheels. The expression "hybrid powertrain" means that there is a mix between multi-source energies. In our case, it is between chemical energy (diesel) and two electrical sources (batteries and supercapacitors).

The project ARCHYBALD (ARChitectures HYBrides Adaptées aux véhicules Lourds à forte Disponibilité) is funded by the ANR (Agence Nationale de la Recherche)/ADEME (Agence De l'Environnement et de la Maîtrise de l'Energie) in order to design a hybrid powertrain of heavy trucks for:

- Civil applications (bus, dustcart…)
- Military applications (transport of troop…)

The PREDIT (Programme de Recherche Et D'Innovation dans les Transports terrestres) selected the project proposed by the company Nexter, project coordinator, with the industrial partner, BATSCAP and three research laboratories: FEMTO-ST (Franche-Comté Electronique Mécanique et Optique – Sciences et Technologies), L2EP (Laboratoire d'Electrotechnique et d'Electronique de Puissance de Lille) and the INRETS (Institut National de REcherche sur les Transports et la Sécurité). The study belongs to the research group MEGEVH (Modélisation Energétique et Gestion d'Energie de Véhicules Hybrides) French network on EVs and HEVS [8]. The project ARCHYBALD began in January 2008 and lasts 36 months.

II. THE TECHNICAL ARCHITECTURE OF THE HYBRID POWERTRAIN

The objective of the project ARCHYBALD is to design a hybrid powertrain with a high availability for a heavy vehicle. The development of this study concerns several partners and each has defined tasks.

After analyze and a comparative study, the different partners of the project have decided to develop a series-parallel hybrid powertrain. They also decided to design it to be integrated in the military vehicle: the VBCI (8x8 wheeked vehicles infantry combat vehicle for a military application and a garbage truck for a civil application.

The technical architecture is composed of three main elements. At first there is the storage system. It is developed by the INRETS and it has the particularity to couple two elements: batteries and supercapacitors from BATSCAP. Then there are two electric machines and theirs converters developed by FEMTO-ST. They must be compact and high-yield. The mechanical transmission, a Ravigneaux planetary gear train, is designed by Nexter Systems. It combines different energy generated by the Internal Combustion Engine (ICE) and the Electric Machines (EMs). The entire vehicle is modeled by the

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L2EP [4]. The architecture proposed to adhere to the specifications is represented on Fig. 1.

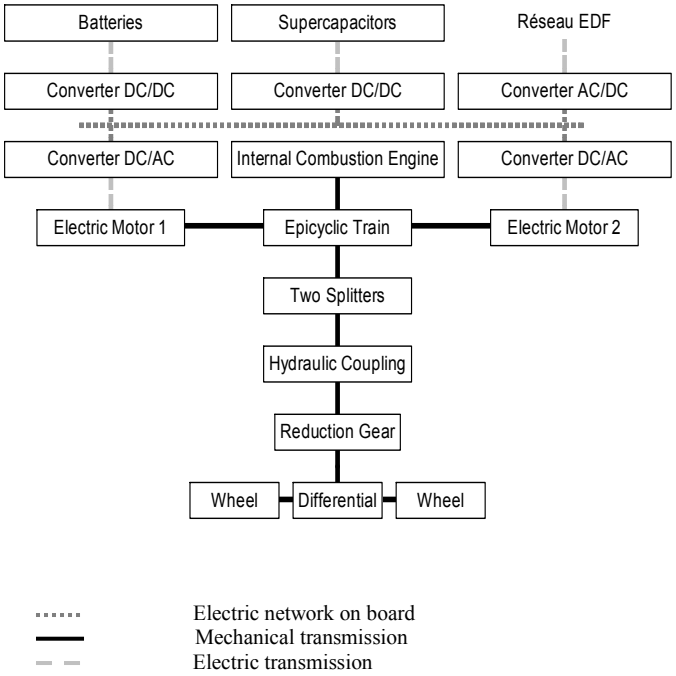

Figure 1. Technical architecture of the powertrain ARCHYBALD

The architecture is composed of four main subsystems [2], [3], [5].

A. *The mechanical transmission*

The mechanical transmission and the motors have replaced the gearbox. The main element is a Ravigneaux planetary gear train developed by Nexter Systems [2]. It can combine three energy sources (EM 1 and 2, ICE) to move the wheel. At the output both splitters are placed to have a ratio four-speed transmission. Then the hydraulic coupling transmits the engine torque with progressiveness. The reduction gear is an epicyclic gear in order to reduce the speed. The differential allows the good functioning from the vehicle if there is a speed difference at the wheel in the bend.

B. *The electric architecture*

The power network connected two electric machines, batteries, supercapacitors, a cooling system for the electric equipment, a low voltage network (power supply for the vehicle) and the workshop electric network to reload the storage elements. The control network is set up of four electronic control and checking units (Engine, energy storage, power storage, batteries), a calculator of in-car energy management, a detector of the insulation defect of the power network circuit. The equipment of this control network is fed by a direct low voltage 28V.

There are two possible architectures: a mono-bus or a double-bus. There are three main advantages to use the double-bus: redundancy (if a equipment failed, the system can still run), the sharing of power and the reduction of the charge of the feeders and the volume diminution of the converters.

C. *The energy storage elements*

Both batteries and supercapacitors energy storage components are considered in the frame of this project. The idea is to use batteries for long-lasting energy deliveries and supercapacitors for peak power management. An architecture where batteries and supercapacitors are connected in parallel is being studied. The goal of the works led by INRETS is to demonstrate that use of supercapacitors will protect the batteries against over-current demand effects (including regenerative power) and as a consequence that batteries life time will be significantly improved.

D. *The electric machines*

Both electric machines have the same specifications: the power is 70 kW, the maximum torque is 1,000 Nm, 2,000 Nm in transient state and the maximum speed is 4,200 rpm. The electric machines and their power converters are together designed to take up four challenges: compactness, efficiency, cost and hard environment.

CONCLUSION

A new series parallel HEV powertrain is proposed for different heavy tracks using a Ravigneaux planetary gear train. The different subprojects aim to develop general methodologies to design and control this new topology. Two different heavy trucks are considered, and their different technical requirements will inputs for the general methods in order to define the right vehicle for each applications.

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