HYBRID DIESEL POWERTRAIN

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Abstract

Recent years have brought significant progress in the field of hybrid vehicles. Today, almost all major manufacturers offer this type of cars for their clients. Hybrid drives have lower fuel consumption and less emission of toxic gases. These benefits have led to the rapid popularization of hybrid cars on the global market. The growing demand for economical vehicles leads to increased work of engineers on new improvements. The biggest drawback of such drives is their high cost of purchasing. The result is lack of small urban car with such a powertrain. Following article describes the prototype of hybrid powertrain designed for small car with diesel engine. Vehicle design is based on the construction of Fiat Panda. The project includes construction of the prototype vehicle with eAWD powertrain. Prototype vehicle will be used for research into finding the optimum powertrain control algorithms. Test results will determine possible fuel savings and economical benefits of using hybrid cars in urban driving cycle. Research results will be compared with the results of simulations carried out Matlab/Simulink program. This comparison will confirm the correctness of simulation algorithms that can be used in the process of optimizing the drive control program.

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Keywords: *hybrid powertrain, diesel, eAWD*

1. Introduction

Hybrid cars are known from the beginning of automotive history. At the beginning of nineteenth century production of the electric and hybrid vehicles was equal to production of conventional cars. However it was not until the introduction of the Prius when the hybrid cars became popular. The market success is caused by possible fuel savings and lower toxic gases emissions the other advantages are:

- the possibility of vehicle braking energy recovery,
- accumulation of excess energy
- stabilization of the internal combustion engine at a specified level throughout the drive cycle
- reduce emissions of toxic substances emitted into the atmosphere.

The project aims to create a prototype of a hybrid vehicle in order to analyze the applicability of this kind of technology in small urban vehicles. The prototype will be used in a series of tests to determine the fuel economy in standard driving cycles. Among the possible solutions the e4WD type design was chosen. Powertrain of this type will allow examining dynamics of the car in electric mode, hybrid mode and conventional mode. Moreover the off-road abilities of the car are better thanks to the electric powered rear axle.

2. Prototype hybrid car

Prototype car is based on a Fiat Panda 1.3 MultiJet. This car is one of the most popular models in the class of urban vehicles. In addition, using a model with a 1.3MultiJet engine will allow testing fuel economy of hybrid car based on a diesel engine. Test results will be valuable to know because so far the majority of hybrid vehicles are based on gasoline engines. The power characteristics of diesel motors suggest that reaching high fuel economy is possible. However, these savings must be balanced with the higher cost of buying the vehicle. The development of prototype car included:

- prototyping of the powertrain,
- conversion of standard car to 4x4 version,
- conversion of the rear axle to eAWD.

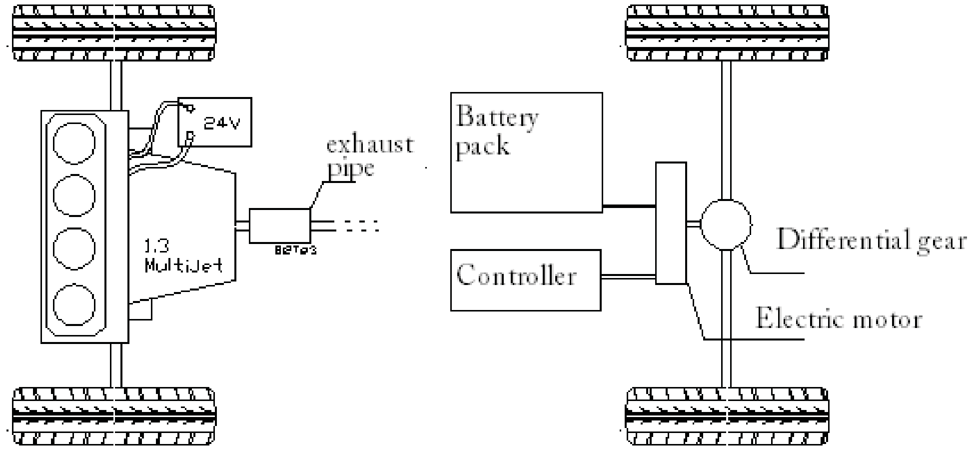

Fig. 1. Prototype hybrid powertrain layout

Traditional combustion engine remains as main source of power, which ensures the appropriate driving dynamics. The electric motor is assisting the engine and in certain cases may also serve as the main drive. The assumption that the vehicle is designed for the typical urban traffic driving cycles permits the adoption of some basic assumptions about its operation. The basic idea is to limit the maximum speed to 80 km/h in combined mode and 30 km/h in electric mode. This assumption stems from the fact that the greatest fuel savings can be achieved when driving in heavy urban traffic with low average speeds. Driving range depends on capacity of the battery pack. As expected range of a prototype vehicle in electric mode distance of three kilometres was assumed. This assumption ensures enough autonomy in electric mode to move around in the city centre and the corresponding energy buffer during the extra-urban driving cycle. The pack of six batteries of total weight of 250 kg was chosen. Because the main criterion was to keep a vehicle dynamic at least as good as in a standard car the power of electric motor has to balance the increased weight of the car.

Use of electric motor in a propulsion system allows regenerating of kinetic energy which is normally wasted during braking. This feature will have big influence on fuel savings in an urban cycle were large speed differences occurs. Ensuring the smooth operation of the vehicle requires the use of suitable control system. Powertrain controller allows measuring and analyzing main system parameters:

- current engine power,
- current induced during regenerative braking,
- current drawn from battery,
- battery voltage,
- controller temperature,
- vehicle speed.

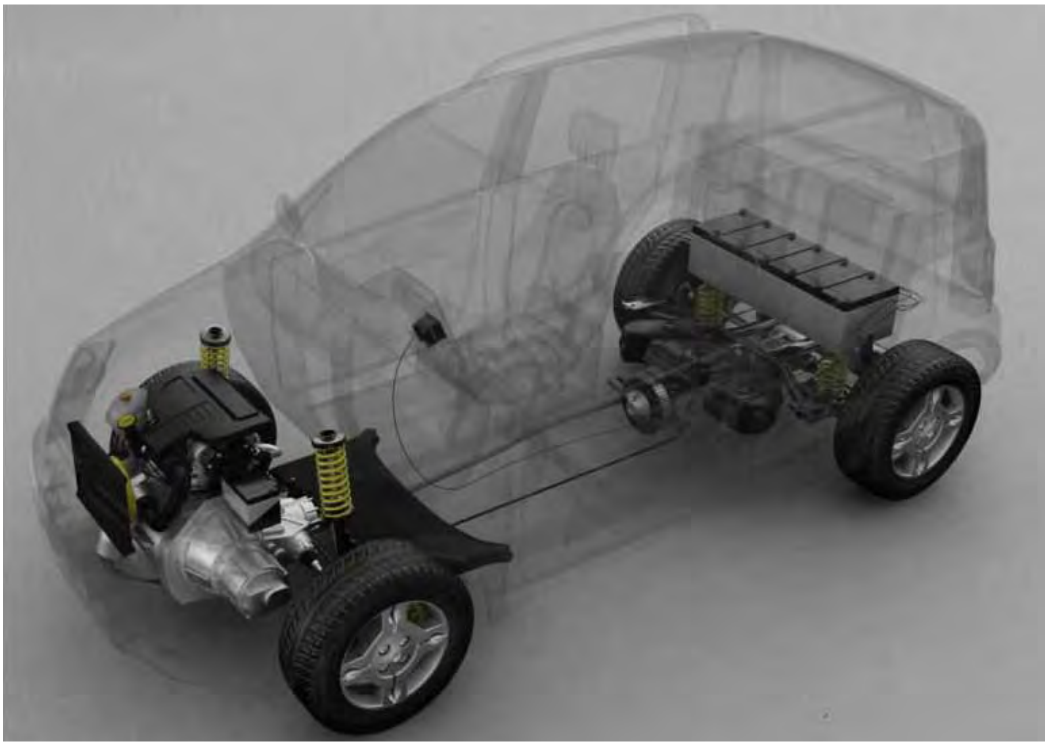

Fig. 2. Computer visualization of the prototype powertrain

Based on collected data and input parameters the controller adjusts the work of the entire system. The main input parameters are the level of assistance of the electric motor, the battery state of charge, vehicle speed and the driver demand. To ensure adequate dynamic properties of the vehicle 14 kW electric motor was chosen. This engine is characterized by high efficiency (up to 91%), lightweight (11 kg) and long brushes life. Motor was connected to the rear differential through a shaft.

Fig. 3. Mounting rear axle with differential gear

Electrical system provides adequate working conditions for the engine and battery pack. One of the key conditions is to maintain an adequate state of charge of battery pack during driving cycle. The electric system contains:

- electric motor,
- controller with regenerative braking function,
- gas potentiometer,
- contactor 72V/400A,
- pulse rectifier,
- shunt (400A/60mV).

The control program allows changing the input parameters so the best suited algorithm can be established.

Fig. 4. Electric components of the hybrid powertrain

The total weight of the additional components exceeds 340 kg. Increase in vehicle weight results in bigger fuel consumption which has to be compensated by benefits of hybrid drive.

3. Summary

The prototype car will determine what fuel savings might accrue from the use of hybrid diesel vehicle in a small urban vehicle. Measurements will be carried out in a series of tests in urban and extra urban driving cycles. Research results will be compared with the results of simulations carried out in Matlab/Simulink program. This comparison will confirm the correctness of simulation algorithms that can be used in the process of optimizing the drive control program.

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