Chapter 9
Basic Simulation Study during the Process of Designing the Hybrid Power Train Equipped with Planetary Transmission

ABSTRACT

Chapter 9 is devoted to simulation research showing the influence of changes of the power train’s parameters and control strategy on the vehicle’s energy consumption, depending on different driving conditions. The control strategy role is to manage how much energy, frankly speaking, how much of the torque-speed relations referring to the power alteration, are flowing to or from each component. In this way, the components of the hybrid power train have to be integrated with a control strategy, and of course, with its energetic parameters to achieve the optimal design for a given set of constraints. The hybrid power train is very complex and non-linear to its every component. One effective method of system optimization is numerical computation, the simulation, as in the case of the multivalent suboptimal procedure regarding the number of electrical mechanical drive’s elements, whose simultaneous operation is connected with the proper energy flow control. The minimization of a power train’s internal losses is the target. The quality factor is minimal energy, as well as minimal fuel and electricity consumption. The fuel consumption by the hybrid power train has to be considered in relation to the conventional propelled vehicle. First of all, the commonly chosen statistic driving cycles should be taken into consideration. Unfortunately, this is not enough. The additional tests as for the vehicle’s climbing, acceleration, and power train behavior, referring to real driving situations, are strongly recommended during the drive design process.

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INTRODUCTION

The approach of the design hybrid drive system is based on dynamic modeling and simulation. The transient operation process can be studied in details with this dynamic model in Matlab - Simulink, and also, the control strategy can be optimized by running the simulation and monitoring the operation of each component: the operating points of ICE, fuel consumption (energy consumption), the power distribution, the torque and rotary speed of the ICE and motor, the operating efficiency of the motor, the change of battery SOC, current and voltage.

A power control strategy is needed to control the flow of power and to maintain adequate reserves of energy in the storage devices. Although this is an added complexity, not found in conventional vehicles, it allows the components to work together in an optimal manner to achieve multiple design objectives, such as high fuel economy and low emissions. In HEVs, the composing of power train components and the way they are connected, are hybrid drive system configuration (hardware), and the management of the power flow among the components is called the ‘control strategy’.

The flexibility in HEV design comes from the ability of the control strategy to manage how much power is flowing to, or from, each component. This way, the components can be integrated with a control strategy, to achieve the optimal design for a given set of constraints. The hybrid power train is very complex and nonlinear respectively, with its every component. One effective method of system optimization is numerical, computation simulation, as in the case of multivalent, suboptimal procedure regarding the number of the electrical mechanical drive’s elements, whose simultaneous operation is connected with the proper energy flow control. The minimization of power train internal losses is the target. The quality factor is minimum energy, as well as fuel and electricity consumption. The power train parameter optimization can be worked out, by also using the above-mentioned method. This means powers, torques, voltage, capacity, proper adjustment, etc.

Essentially, this chapter shows the required design approach based on digital simulation, whose result is an energy flow optimization (Szumanowski, 1999; Szumanowski, Hajduga, & Piórkowski, 1998a; Szumanowski & Nguyen, 1999).

The vehicle model, including a proper driving vehicle with load resistance equations reduced on its traction wheel, is depicted in Chapter 1, and identified as a block diagram, useful for computation in Figure 2.

The planetary transmission model is discussed in Chapter 8, and illustrated by Figure 3.

For the reason of strong nonlinear features of drive components optimizing the hybrid power train’s parameters is possible, only by use computer simulations.
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