Chapter 2
The Energy–Power Requirements for HEV Power Train Modeling and Control

ABSTRACT
The first step in the hybrid vehicle power train design, of course, after choosing the drive architecture, is the analysis of the power distribution and energy flow between the Internal Combustion Engine (ICE) (considered in this book only as the primary source of energy – PS) and the energy accumulator (called the source of power, or a secondary energy source – SS). The role of the Primary Source (PS) is to deliver to the system the basic energy, while the Secondary Source (SS) feeds the hybrid power train during its peak power loads and stores the vehicle’s kinetic energy during the regenerative braking. The target of these considerations is to search for the minimal necessary power of the Primary Source (PS) and the minimal energy capacity of the Secondary Source (SS). Certainly, this computation requires the proper energy flow model and the basic vehicle driving cycle, in the role of which the statistic driving cycle is recommended. The main aim of this chapter is the depiction of the above problem, as well as the finding of its solution. The background of the energetic evaluation of the hybrid drive structure is the dynamic determination of the internal watt efficiency of each of the propulsion system’s components. The complex construction of the hybrid drives requires an appropriate control strategy from its designers. In order to achieve this aim numerical optimization methods of nonlinear programming can be applied.

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INTRODUCTION

The main aim of the proper adjustment of the hybrid vehicle drive is to determine the power distribution and the energy flow between the internal combustion engine – ICE (called the primary source of energy – PS) and the energy accumulator (called the source of power or the secondary energy source – SS). The role of the primary source (PS) is to deliver the basic energy, regarding the assumed control strategy – in a continuous or interrupted way (e.g. see Figure 3). The secondary source (SS) has to supply the energy for power peaks of the external load, while the vehicle accelerates, or recuperate kinetic energy when the regenerative braking takes place. This source of power operation involves the internal combustion engine (ICE), which is the most common element used as a primary energy source, with a stable working condition, significantly increasing this engine’s (PS) efficiency, which also means the decrease of its fuel consumption. Next to the vehicle’s kinetic energy recuperation, this is a fundamental feature of the hybrid power trains. The hybrid drive is complex and consists of several components. The power train’s total efficiency directly influences fuel and electricity consumption. The first step in the hybrid power train design is the energy/power dynamic distribution modeling presented in this chapter.

The process of power distribution strongly depends on the selection of the drive structure and the transitional efficiency of its components, especially at the Primary Source (PS) (in this book, the Internal Combustion Engine (ICE) is basically considered) and on the secondary power source (SS), as well as the nickel metal hydride (Ni–MH), and lithium ion (Li–ion) batteries.

There are two well-known hybrid structures: the series and the parallel, whose standard simple compilations have too many bad features of the practical application. It is necessary to look for a new concept of the hybrid drive structure, which can connect the positive properties of the above–mentioned hybrid systems in one propulsion structure. The target of this searching procedure is to keep the engine at its highest possible operational efficiency level, which entails the minimal fuel consumption and atmospheric pollution. This design target can be obtained by entire power train nonlinear dynamic modeling and the internal combustion engine – as the basic energy source (PS) – a mathematical model is directly connected with the energy/power distribution.

Modeling and simulation methodology is the only way to acquire such a Formulated goal. The most important problem in modeling is the determination of the efficiency of the energy split as the function of the driving time. The solution to this problem is the approach of the power distribution determination on the generalized hybrid drive system.
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