Chapter 5
Nonlinear Dynamic Traction Battery Modeling

ABSTRACT

The role of the battery as the source of power in Hybrid Electric Vehicles (HEVs) is basic and significant. The process of battery adjustment and its management is crucial during the hybrid and electric drive design. The approach to battery modeling based on the linear assumption (as the Thevenin model) and then adopted for the data obtained in experimental tests, is here ignored, because the dynamic nonlinear modeling and simulations are the only tools for the optimal adjustment of the battery’s parameters according to the analyzed vehicle driving cycles. The battery’s capacity, voltage, and mass should be minimized, considering its overload currents. This is the way to obtain the minimal cost of the battery. Chapter 5 presents the method of determining the Electromotive Force (EMF) and the battery internal resistance as time functions, which are depicted as the functions of the State Of Charge (SOC). The model is based on the battery’s discharge and charge characteristics under different constant currents that are tested in a laboratory experiment. The algorithm of battery’s State-Of-Charge (SOC) indication is depicted in detail. The algorithm of battery State-Of-Charge (SOC) “online” indication considering the influence of temperature can be easily used in practice. The Nickel Metal Hydride (NiMH) and Lithium ion (Li-ion) batteries are taken into consideration and thoroughly analyzed. In fact, the method can also be used for different types of contemporary batteries, if the required test data is available.

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INTRODUCTION

Certainly, the battery modeling is of major concern for HEV and EV power trains. The basic data obtained from laboratory bench tests as a voltage for different values constant currents versus delivered to, or taken from, the battery charge (Ah), are commonly available. These static battery’s characteristics are designated by producers and are the fundamental real data strictly depicted considered battery type, during its charging and discharging. For this reason, this data, after its proper transformation, can be used as the background to battery modeling. The dynamic nonlinear battery modeling related to a vehicle driving cycle is the target. The most important result of this process, based on the measurements of the real time battery voltage, current, and temperature, is the indication online of its state-of-charge (SOC) momentary value.

Battery modeling is of major concern for HEV and EV modeling. Accurate battery modeling is very important and necessary because of three reasons:

1. Simulation research for dynamic behaviour, considering power train architecture, is impossible without an accurate battery model;
2. An accurate battery model is the base of methodology to design battery monitoring and the management system (BMS), especially for the state of charge (SOC) calculation.
3. An accurate battery SOC indication is the background to a generation of proper feedback signals transmitted to the power train’s master controller, using the most efficient online operation.

For the Ni-MH and Li-ion batteries, especially for HEV application, researchers in the world are working hard in order to find good and accurate models for these batteries. The major issue lies in the highly nonlinear characteristics of the battery in HEV applications. The challenge is associated, in particular, with the difficulty that the characteristic parameters of the battery, namely, the accurate data of the electromotive force (EMF) and the internal resistance are hardly obtainable in practical conditions. For this reason, most authors negate determination of EMF and the internal resistance of the battery, and their real and only direct influence on SOC in dynamic conditions. Some authors use a simplified model, but it’s not useful for dynamic simulation of HEV - especially for optimization of drive operation. Some models are of sufficient enough complexity and accuracy, but they are difficult to use in practice, as the basis of methodology for BMS design. The HEV environment requires that the BMS has no direct control over current and voltage.
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