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An Equivalent Circuit Model Approach for Battery Pack Simulation in a Hybrid Electric Vehicle System Powertrain

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Abstract : The progressing need for powertrain electrification calls for more accurate and reliable simulation models. A battery pack serves as the most vital component for energy storage in an electrified powertrain. Hybrid electric vehicles (HEV) do not behave the same way as they age, and there are several environmental factors that account for the degradation of the battery on a system level. Therefore, in this work, a battery model was proposed to study the state of charge (SOC) variation and the internal dynamic changes that contribute to aging and performance degradation in HEV batteries. An equivalent circuit battery model (ECM) is built using MATLAB Simulink to investigate the output characteristics of the lithium-ion battery. The ECM comprises of circuit elements like a voltage source, a series resistor and a parallel RC network connected in series. A parameter estimation study is conducted on the ECM to study the dependencies of the circuit elements with the state of charge (SOC) and the terminal voltage of the battery. The battery model is extended to simulate the temperature dependence of the individual battery cell and the battery pack with the environment. The temperature dependence model accounts for the heat loss due to internal resistance build up in the battery pack during charging, discharging, and due to atmospheric temperature. The model was validated for a lithium-ion battery pack with an independent drive cycle showing a voltage accuracy of 4% and SOC accuracy of about 2%.

Keywords : battery model, hybrid electric vehicle, lithium-ion battery, thermal model
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