LI-ION BATTERY MODEL WITH ELECTROTHERMAL DYNAMICS

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Introduction. Power storage systems are components of power systems, renewable energy, back-up power systems, and electric transport. They work in standby, energy saving, energy recovery and combined modes. Electrochemical storage systems are used to store electrical energy due to electrochemical processes. These systems have the following advantages: efficient energy storage, flexibility in energy management, reliability and durability, the ability to quickly release energy, environmental friendliness and the possibility of integration with renewable energy sources. Various types of batteries are used in electrochemical systems: lead-acid, nickel-cadmium, nickel-iron, lithium-ion (lithium-iron-phosphate) and others. Li-ion batteries are the most widely used in electric energy storage systems due to high energy storage density, small dimensions, low self-discharge, durability and environmental friendliness [1-3].

The efficiency of the control of electric energy storage systems depends on the electrical and thermal models of the battery, which allow accurate determination of battery temperature, static and dynamic processes, battery state of charge (*SOC*) and battery health (*SOH*) [4]. Therefore, the study of Li-ion battery characteristics based on the equivalent substitution circuit, which describes the behavior of the battery during charge/discharge cycles, is an urgent problem for students of the specialty 141 "Electric power engineering, electrical engineering and electromechanics".

The purpose of the work. Investigation of dynamic characteristics of Li-ion battery during charge and discharge cycles using electrothermal dynamics battery simulation model in modern Matlab programming environment based on Simscape language.

Materials and research results. To study the static and dynamic modes of operation of various types of Li-ion batteries, Thevenin models of the second and higher orders are used. These battery models take into account polarization effects that lower the voltage value. Electrochemical polarization characterizes the slowing down of reactions at the electrode, and concentration polarization shows that lithium ions do not have time to diffuse to the electrodes at the required speed [1].

The structure of the equivalent circuit is presented in fig. 1. Variable active resistance $R_0(SOC,T)$ characterizes energy losses in the battery due to the resistive elements of the battery (Ohm). Where *SOC* (State of Charge) is a parameter that shows the state of battery charge (%). *T* (Temperature) – battery temperature (C^o or K). Variable active resistances $R_1(SOC,T)$ and $R_2(SOC,T)$ characterize electrochemical (first) and concentration (second) polarization (Ohm). Variable effective capacities $C_1(SOC,T)$ and $C_2(SOC,T)$ are used to describe transient reactions during energy transfer (F). Variable active resistance $R_{SD}(T)$ (Self Discharge Resistor) characterizes the influence of the internal currents of the battery in the mode of idle operation (self-discharge) (Ohm).

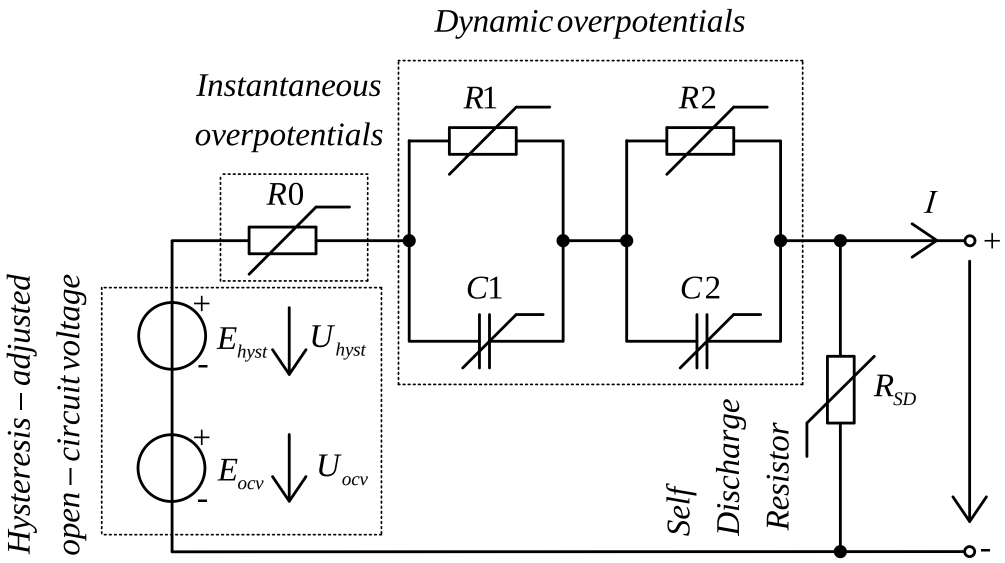

Figure 1 – Equivalent circuit diagram of battery

Conclusion. The battery model with electrothermal dynamics consists of electrical and thermal models. The electrical model is based on the equivalent circuit of the battery replacement (Thevenin model of second and higher orders) and is able to take into account polarization effects that reduce the idle voltage. The equivalent circuit model accurately shows the behaviour of the Li-ion battery during static and dynamic modes. This allows you to predict the performance of the battery under different operating conditions. Also, the electrical model can take into account hysteresis voltage, cyclic and calendar aging. The thermal model determines the temperature of the battery for each instant of time.

References

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