MODELING OF RECHARGEABLE NiMH BATTERIES

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Nickel MetalHydride (NiMH) batteries are nowadays successfully applied in the field of consumer electronics and Hybrid Electrical Vehicles (HEV) and have several advantages over NiCd and Li-ion batteries. In the present work we introduce a new mathematical model for NiMH batteries, which includes the developments of battery voltage, internal partial gas pressures and temperature. This enables one to simultaneously simulate the battery voltage, internal gas pressures (both oxygen and hydrogen) and temperature during battery operation. The model takes into account the relevant thermodynamics, kinetics and diffusion processes occurring at/in both electrodes and in the electrolyte. Suitable computer software has been developed.

To develop a complete battery model we have considered chemical processes, taking place in the NiMH battery. The overall storage reactions at the Ni and MH electrodes can be represented by:

$$x\ Ni(OH)_2 + x\ OH^- \leftrightarrow x\ NiOOH + x\ H_2O + x\ e^-$$

$$M + x\ H_2O + x\ e^- \leftrightarrow MH_x + x\ OH^-$$

The thermodynamics of the MH electrode has been modelled by using the mean-field theory and lattice gas model.

The reaction sequence of the MH electrode is rather complex and consists of four different reaction steps, taking into account atomic hydrogen adsorption, absorption, molecular hydrogen dissolved in the electrolyte and in the gas phase. Together with the hydrogen intercalation reaction at the Ni electrode the following reaction scheme for hydrogen is obtained (Fig.1).

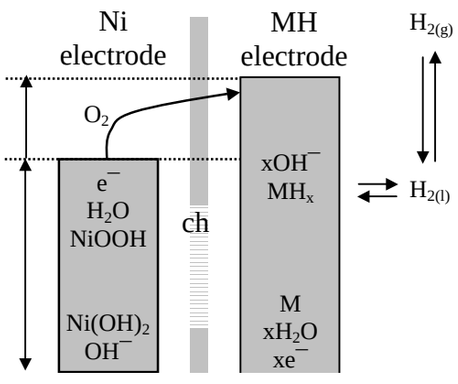
The electrochemical charge transfer kinetics of both electrodes is modelled by Butler-Volmer-type of equations. The effect of side reactions also has been taken into account. Hydrogen diffusion inside the MH electrode has been described Fick's laws [1].

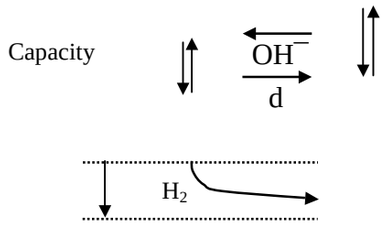
During the battery operation oxygen and hydrogen side reactions are taking place in the battery. Obviously, the total internal battery pressure is the sum of the partial oxygen and hydrogen pressures.

The temperature of the battery depends on the heat flux generated by the battery and heat dissipation to the environment [1].

A typical simulation result revealing the battery voltage, pressure (oxygen and hydrogen) and temperature during constant current charging is represented in Fig. 2.

Finally, suitable computer software has been developed and reveals a good agreement between simulation and experiments.





Separator with KOH

Fig. 1. *Basic reactions occurring inside the NiMH battery*

References

[1] H.J. Bergveld, W.S. Kruijt and P.H.L. Notten, "*Battery management Systems: design by modelling*", Kluwer Academic Publishers, Dordrecht, Netherlands (2002).

Fig. 2. *Simulation results of the battery voltage (V), total internal gas pressure (P_{tot}) and battery*