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State-of-Health Prediction and Reliability Analysis of Li-ion Battery

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Abstract

Electric vehicles have become a trend in vehicle development in recent years due to their low noise, low pollution, and reusable batteries. However, the batteries of electric vehicles will gradually fade out with the number of charge-and-discharge cycles, and may cause fire or explosion hazards. Battery life and reliability have thus become important research issues. Among the commonly used batteries for electric vehicles, lithium-ion batteries are often used by electric vehicle manufacturers today because of their high-power storage, small size, and high energy density. The state-of-health (SOH) is the most commonly used indicator for evaluating the fading degree of lithium-ion batteries. For the battery, its SOH will gradually decrease with the number of charge-and-discharge cycles. When the average value of a battery system drops to be less than 80%, the vehicle manufacturer will advise the vehicle owner to replace the battery system to avoid inconveniences and potential hazards. In order to ensure the safety of battery cells used in electric vehicles, this study proposes a semi-empirical model to predict the SOH of a battery based on its ambient temperature during battery operation, the number of charge-and-discharge cycles, the discharge rate, and the nominal capacity and specifically discusses the number of charge-and-discharge cycles experienced when SOH is lower than 80%. The proposed model can be used as an evaluation tool to understand the degree of battery aging through quantitative reliability analysis, and explores how the uncertainty of coefficients in the semi-empirical model for understanding its impact on the prediction results. At the end of this study, through the analysis of different types of lithium-ion batteries, and assuming that the effects of the internal chemical reaction of the battery do not affect the prediction of SOH during the charge-and-discharge cycle, the difference in the model's SOH curve-fitting under different conditions are discussed in particular. Different applications are also addressed. In this study, the number of charge-and-discharge cycles predicted by the semi-empirical model can be used to estimate the degree of battery aging, and the reliability analysis can be used to evaluate the battery usage, so that it can determine whether the battery needs to be replaced, and can minimize the probability of occurrence of hazards.

Keywords
Electric vehicle, Lithium-ion battery, State of health, Semi-empirical model and Reliability.

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Biography / Biographies
Yu-Chen Hsu is a graduate student at National Taiwan University working toward her M.S. degree in Industrial Engineering. Her previous research was focused on the forecast model with quality management. She is currently engaged in research related to reliability analysis of battery system of electric vehicles.
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Pin-Chen Wang is a graduate student at National Taiwan University working toward her M.S. degree in Mechanical Engineering. She is currently engaged in research related to battery management system of electric vehicles.
Wen-Fang Wu received his B.S. degree from National Taiwan University (NTU) in 1977 and Ph.D. from University of Illinois at Urbana-Champaign in 1985. He had worked at Florida Atlantic University and Columbia University before joining NTU as a faculty member in 1988. He is now a professor of Mechanical Engineering and Industrial Engineering. His research interests include vibration, reliability engineering and probabilistic risk assessment.