Proceedings of the International Conference on Industrial Engineering and Operations Management
Manila, Philippines, March 7-9, 2023

Effect of Performance Discrepancy of Cells on the Reliability Analysis of an EV Battery Pack

Pin-Chen Wang, Yung-Cheng Tseng and Wen-Fang Wu
Department of Mechanical Engineering
National Taiwan University
Taipei, Taiwan
r10522541@ntu.edu.tw; b05502039@ntu.edu.tw;
wfwu@ntu.edu.tw

Abstract

With the rapid development of electric vehicle (EV), researches related to EV battery systems have flourished in recent years, partly because the battery system accounts for almost half of the cost of an EV. For the battery system, its capacity degraded gradually along with charge-and-discharge cycles and hence increases the risk of the EV. The reliability issue of the battery system thus arises. The present study proposes an analytical model based on reliability engineering for studying the capacity degradation and quantitative reliability of EV battery packs. The model, in turn, is constructed in consideration of states of health (SOH) of battery cells and their uncertainties. As compared to the traditional system reliability model that judges the pack's reliability purely based on considering if or not a battery cell's SOH exceeds a prescribed threshold, the proposed model adopts the k-out-of-n system reliability concept and considers that SOHs of battery cells within the pack do not differ too much to assure the pack's reliability. This study also adjusts a few parametric values in the model to investigate their influences on battery pack's life and reliability. Through numerical case studies, it is found the proposed model results in a more conservative system reliability prediction of a battery pack than the traditional model, and the capacity degradation trend of the battery pack coincides with a real case. In consideration of an effective battery management system that avoids fierce temperature changes, the influence of temperature is not very obvious in this study. The uneven performance of battery cells reflected by discrepancies of their SOHs is found crucial to the battery pack. If the performance of each battery cell is balanced, the battery pack's life and reliability would increase significantly. The above trends coincide with those factors considered in a real battery management system (BMS) of an EV.

Keywords
Electric vehicle, Battery system, State of health, System reliability and K-out-of-n system.

Acknowledgements
The research was sponsored by the National Science and Technology Council (NSTC) of Taiwan, and the authors acknowledge the financial support of NSTC under a project numbered MOST 111-2221-E-002-137 for attending the conference.

Biography / Biographies
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.
Yung-Cheng Tseng received his B.S. and M.S. in Mechanical Engineering from National Taiwan University in 2020 and 2022, respectively. He has studied reliability engineering and carried out related research.
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.