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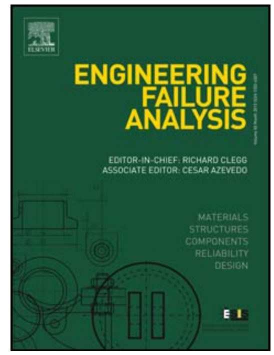

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Remaining Useful Lifetime Prediction Based on the Damage-marker Bivariate Degradation Model: A case study on lithium-ion batteries used in electric vehicles

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Abstract: Remaining useful lifetime (RUL) refers to the available service time left before the performance of a system degrades to an unacceptable level. Recent innovations to lithium-ion battery packs have raised expectations with regard to energy storage capability in electric vehicles (EVs). This has catalyzed new research on RUL prediction, since accurate RUL prediction for lithium-ion batteries used in EV is highly desired for safe and lifetime-optimized operation. A battery's maximum releasable capacity (MRC) usually decays over time, thus it is a primary factor which determines the remaining cycle life of the battery. However, MRC usually needs to be measured under strict laboratory conditions and cannot be easily assessed during field use in EVs. This naturally inhibits potential applications of many online RUL prediction methods that rely on MRC measurements. We found two markers of MRC decay, named as time-to-voltage-saturation (TVS) and time-to-current-saturation (TCS), from constant-current constant-voltage charging (CC/CV) curves, which can be used in place of MRC measurements during field use. We propose a RUL prediction method based on a damage-marker bivariate degradation model in which one term represents damage (MRC decay), the other represents a composite marker constructed from TVS and TCS. We model this degradation process using a two-dimensional Wiener process to obtain the RUL distribution, using method of maximum likelihood for population parameters' estimation. Bayesian methods are used to update the estimators of parameters with online data. The effectiveness of the model is verified with public data of four 18650 batteries from NASA.

Keywords: remaining useful lifetime; marker processes; bivariate Wiener process; lithium-ion battery; electric vehicle

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