Optimal Design for Accelerated Destructive Degradation Tests

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Abstract

Degradation tests are powerful and useful tools for lifetime assessment of highly reliable products. In some applications, the degradation measurement process would destroy the physical characteristic of units when tested at higher than usual stress levels of an accelerating variable such as temperature, so that only one measurement can be made on each tested unit during the degradation testing. An accelerated degradation test giving rise to such a degradation data is called an accelerated destructive degradation test (ADDT). The specification of the size of the total sample, the frequency of destructive measurements, the number of measurements at each stress level, and other decision variables are very important to plan and conduct an ADDT efficiently. A wrong choice of these decision variables may not only result in increasing the experimental cost, but may also yield an imprecise estimate of the reliability of the product at the use condition. Motivated by a polymer data, this article deals with the problem of designing an ADDT with a nonlinear model. Under the constraint that the total experimental cost does not exceed a pre-fixed budget, the optimal test plan is obtained by minimizing the asymptotic variance of the estimated 100pth percentile of the product's lifetime distribution at the use condition. A sensitivity analysis is also carried out to examine the effects of changes in the decision variables on the precision of the estimator of the 100pth percentile. A simulation study further shows that the simulated values are quite close to the asymptotic values when the sample sizes are large enough. (This is a joint work with Prof. Sheng-Tsaing Tseng, Prof. N. Balakrishnan, and Prof. Chien-Tai Lin)