Optimal Design of A Degradation Test

Sheng-Tsaing Tseng  
Institute of Statistics  
National Tsing-Hua University  
Hsin-Chu, Taiwan, ROC  
Email: sttseng@stat.nthu.edu.tw

Key words- Highly-reliable products; Inspection frequency; Termination time; Stochastic diffusion process.

Introduction

Due to the market competition, how to provide the customers with the product’s lifetime information is a great challenge to the manufacturer. However, for highly reliable products, it is difficult to assess the lifetime of the products by using traditional life tests that record only time-to-failure. Even using the technique of censoring and/or accelerating the life by testing at higher levels of stress such as elevated temperatures or voltages provide little help, because no failures are likely to occur in a reasonable amount of time. If there exist quality characteristics whose degradation over time can be related to reliability, then collecting “degradation data” can provide information about product reliability.

Nelson (1990, chapter 11) surveyed literature on this subject. Lu & Meeker (1993) proposed a method which used a degradation model to estimate the failure time distribution of a product. Carey & Koenig (1991) described a data analysis strategy and a two-stage model-fitting method to extract reliability information from observations on the degradation of integrated logic devices that are components in a new generation of submarine cables. Tseng et al. (1995) used a degradation model to improve the reliability of the fluorescent lamp. Tseng & Yu (1997) and Yu & Tseng (1998) proposed a method to determine the termination time for a degradation test and an ADT, respectively.

In conducting a degradation experiment, the restriction of experimental cost and the precision of estimating the lifetime information of the product are two major concerns of the experimenter. Several decision variables are related to these two subjects. Among them, the sample size, the inspection frequency, and the termination
time (the total number of measurements) should be given a special consideration. Recently, Yu & Tseng (1999) dealt with the optimal design for a degradation test. A random-effect model is proposed to describe the degradation path. Under the constraint that the total experimental cost does not exceed a predetermined budget, the optimal decision variables are obtained by minimizing the variance of the estimated 100 $p$th percentile of the lifetime distribution.

There are two weak points in their models. First, the error terms in Yu & Tseng’s model are assumed to be independent and identically distributed. However, this assumption may not be adequate and a stochastic process is more appropriate for the correlated process. Secondly, to simplify the computation, parameter $\theta$ in their model is assumed to be a known constant. Unfortunately, in practical use, this assumption is very restricted. To overcome the above difficulties, we use the Wiener process to describe a typical degradation path and the lifetime distribution of the product can be expressed in terms of an inverse Gaussian distribution. Using the same criterion by Yu & Tseng (1999), these decision variables of a degradation test can be easily obtained.

Reference