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A BAYESIAN APPROACH TO ESTIMATE COMPONENT DEGRADATION USING GAMMA PROCESS

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ABSTRACT

To modelling stochastic deterioration, we use a failure rate function or a stochastic process such as a random deterioration rate, markov process, brownian motion with drift and non-decreasing jump process (of which the gamma process is a special case). We use an gamma process model to describe a cumulative damage approach with a stochastic process. For estimates parameters of gamma process we use a bayesian approach, that provides an effective tool to reduce uncertainty in model development and can be updated when additional data are obtained. Given the continual update of the gamma process parameter, the remaining useful life estimate is also obtained to represent the additional knowledge gained by the collection of data.

Keywords: reliability, Gamma process, Bayesian analysis.

INTRODUCTION

Bayesian analysis provides an effective approach to address uncertainty in model development since parameter estimates can be updated as additional degradation data concerning the process is obtained.

In the development of the degradation model, the parameters of the gamma process are defined with the previous knowledge obtained during the use of the pump. The parameters established during testing for the gamma process can have a degree of uncertainty that can be reduced with Bayesian analysis. Degradation model parameters are updated as additional degradation data is obtained over time.

Degradation measurements are collected during processing for each spare part to update the degradation process for each individual part. The inspection interval for obtaining a degradation measure for the Bayesian update is assumed to be known and fixed. Given the continual update of the gamma process parameter, the remaining useful life estimate is also updated to represent the additional knowledge gained by the collection of degradation data.

For modelling stochastic deterioration, we have a failure rate function or a stochastic process such as a random deterioration rate, markov process, brownian motion with drift and non-decreasing jump process (of which the gamma process is a special case).

Lifetime distribution and failure rate function are especially useful in mechanical and electrical engineering. In these fields, one often considers equipment which can assume at most two states: the functioning state and the failed state. A structure, on the other hand, can be in a range of states depending on its degrading condition. A serious disadvantage of failure rate is that they cannot be observed or measured for a particular component. due to the usual lack of failure data, a reliability approach solely based on lifetime distributions and their unobservable failure rates is unsatisfactory. According to Singpurwalla," a more appealing approach would be to choose a model based on the physics of failure and the characteristics of the operating environment"

RESULTS AND CONCLUSIONS

The results from our model illustrated by a simulation are shown in Fig. 1. We refined our degradation model with new degradation measurement which represents additional knowledge regarding the true β value. To make prediction of the remaining useful life of the system we use the continual update of β. Figure 1 represents the additional knowledge acquired from various degradation measurement.

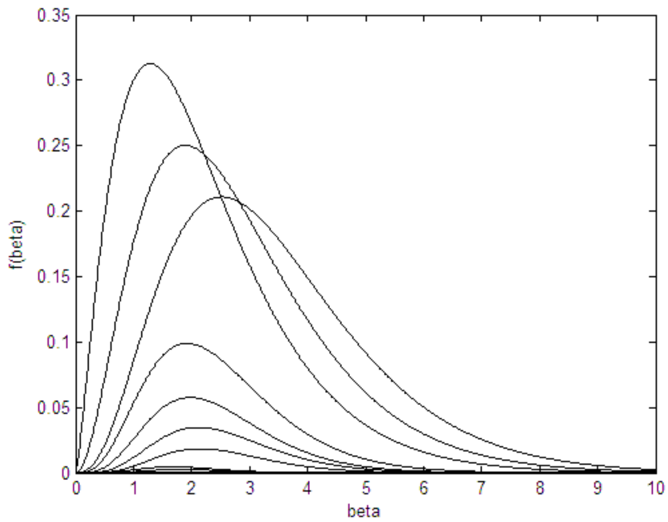

Fig. 1 - β posterior pdf update using Bayesian analysis (α= 0.7, α_0 =1.7, β_0 = 1)

This study shows that Bayesian analysis allow for the use of actual degradation measurement to update the gamma process parameters in order to provide a better estimate of the degradation process for each component.

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