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Prev Article | **Next Article**

Abstract

A fatigue model with local sensitivity analysis

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ABSTRACT

The goal of this paper is two fold. First, it introduces a general parametric lifetime model for high-cycle fatigue regime derived from physical, statistical, engineering and dimensional analysis considerations. The proposed model has two threshold parameters and three Weibull distribution parameters. A two-step procedure is presented to estimate the parameters. In the first step, the two threshold parameters are estimated by minimizing a least squares regression function. In the second step, the parameters are estimated by the maximum likelihood method after pooling together the data from different stress levels. Since parameter estimation should always be accompanied by a sensitivity analysis of the fitted model, the second goal of this paper is to propose a method for sensitivity analysis for fatigue models. We show that the proposed sensitivity analysis methods are general and can be applied to

any fatigue or lifetime model, not just to the one proposed here. Although several fatigue models have been proposed in the literature, to our knowledge this is the first attempt to produce methods for sensitivity analysis for fatigue models. The proposed method makes use of the well-known duality property of mathematical programming, which states that the partial derivatives of the primal objective function with respect to the constraints right hand side parameters are the optimal values of the negative of the dual problem variables. For the parameters or data, for which sensitivities are sought, to appear on the right hand side, they are converted into artificial variables and set to their actual values, thus obtaining the desired constraints. Both the estimation and sensitivity analysis methods are illustrated by two examples, one application using real fatigue data and the other using simulated data. In addition, the sensitivity proposed method is also applied to an alternative fatigue model. Finally, some specific conclusions and recommendations are also given.

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