11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

A Study on the Statistical Calibration and Validation of Computational Model of Pyrotechnically Actuated Devices

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Abstract

Computer model is a useful tool that provides solution via physical modeling instead of expensive testing. In reality, however, it often does not agree with the experimental data owing to simplifying assumption and unknown or uncertain input parameters. In this case, calibration method is widely used to improve the accuracy of the unknown parameters of predictive model by using the actual test data. However, if the parameters are calibrated without considering uncertainties due to a limited test data, errors of test and modeling, the result can mislead to wrong conclusions. To solve this problem, a lot of studies have been published that utilized statistical method to quantify uncertainty for calibration of computer model. In this study, a Bayesian approach is proposed to calibrate the computer model in a probabilistic manner using the measured data. The Pyrotechnically Actuated Device (PAD) which is a component that delivers high power in remote environments by the combustion of a self-contained energy source is employed to demonstrate this approach. The computer model of interest the process of elasto-plastic piston insertion into the housing due to the generated pressure in the PAD. Finite element model is constructed to determine the resistance force in terms of displacement using the commercial code ANSYS. Experimental data are made by making quasi-static movement of piston using the UTM machine. The difference of the finite element analysis against the experiment is minimized by calibrating some unclear input parameters such as the supporting boundary condition and friction coefficient between the piston and housing. Markov Chain Monte Carlo technique is employed to estimate the parameters in the probabilistic way. Once the calibration is carried out for a baseline model, the calibrated model is applied to the analysis of new models, and the result is validated by the corresponding experiments in a probabilistic way.