Parameter Identification Strategies
For Composite Constitutive Models In Crashworthiness Analysis

Xinran Xiao and Ching-Chieh Hsieh
Department of Mechanical Engineering, Michigan State University

The standard material tests are insufficient to describe the large deformation and facture behavior of composite materials in crashworthiness events. Composite constitutive models developed for crashworthiness simulations usually contain parameters which have to be calibrated by correlating the load-displacement responses generated by simulations with structural experimental results. When multiple parameters are involved, the calibration process can be very time consuming. Moreover, the process itself is a subjective one. The current study investigates the use of inverse method for parameter identification through simulation based optimization.

For a constitutive law with a number of unknown parameters, the parameter set obtained by optimization with respect to a single experimental response is seldom unique. Furthermore, the sensitivity of a material parameter varies with the type of the experiment. Rarely one can find an experimental response that satisfies the sensitivity requirement of all parameters. To identify parameters for general applications, multi-objective optimization (MOO) with multiple cases and an appropriate strategy is needed.

Two strategies are proposed for MOO with multiple cases. These are sequential identification (SI) and concurrent identification (CI), as shown in Figure 1. The design of a CI procedure is relatively straight forward. In addition to select the type of the structural responses, the designer has little choice of optimization strategies itself. In SI, MOO is carried out one load case at a time, starting from the one with fewer but most sensitive parameters. SI requires good understanding of the material model and structural responses. The two strategies were investigated in a case study using Azdel R401, a random, chopped glass mat reinforced PP composite. It shows that MOO using CI tends to lead to error finish in crash simulations. Not all samples will lead to stable crash simulations in a wide design space. Using SI, fewer variables are involved in each case which reduces the chances of instabilities. With a narrower design space and initial values established by SI, a success MOO using CI was achieved. A combination of SI and CI (SI for initial search and CI for confirmation) appear to be the best strategy.

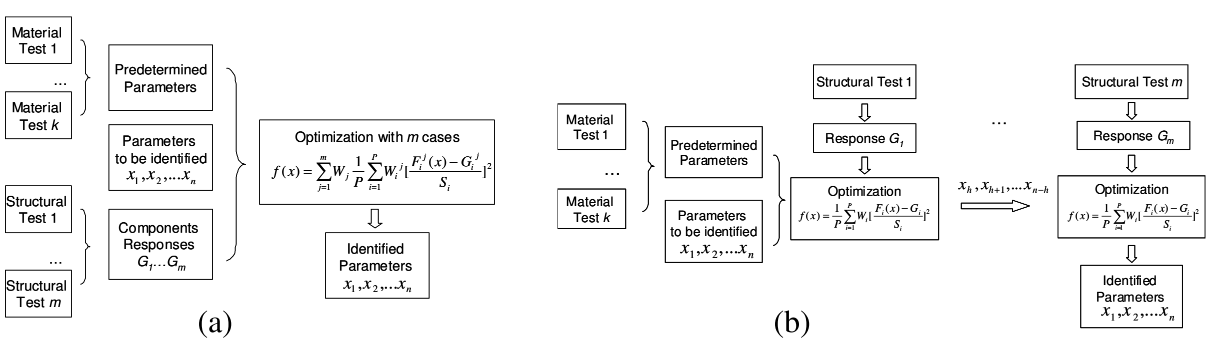

Figure 1. (a) Concurrent identification (CI) and (b) sequential identification (SI) of multi-objective optimization (MOO) using multiple cases.