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Parameter identification method of large macro-micro coupled constitutive models based on identifiability analysis

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Summary

Large macro-micro coupled constitutive models, which describe metal flow and microstructure evolution during metal forming, are sometimes overparameterized with respect to given sets of experimental datum. This results in poorly identifiable or nonidentifiable model parameters. In this paper, a systemic parameter identification method for the large macro-micro coupled constitutive models is proposed. This method is based on the global and local identifiability analysis, in which two identifiability measures are adopted. The first accounts for the sensitivity of model results to single parameters, and the second accounts for the degree of near-linear dependence of sensitivity functions of parameter subsets. The global identifiability analysis adopts a sampling strategy that is a combination of Latin-hypercube sampling and one-factor-at-a-time sampling with only a limited number of model evaluation. The global identifiability measure is the integration of the corresponding local measure Based on the global identifiability analysis result, a identifiable parameter subsets is selected. Then the genetic algorithm is adopted to identified the model parameter. The obtained parameter is further refined through the improved Levenberg-Marquardt algorithm. The niching method is used to maintain the population diversity and to choose the initial value for the Levenberg-Marquardt algorithm. A transition criterion between the genetic algorithm and the Levenberg-Marquardt algorithm is proposed, through the improvement on the average objective function value of the chromosomes and the objective function value of the best chromosome. During optimization by the Levenberg-Marquardt algorithm, the local identifiability analysis is taken at the beginning stage of each iteration, and then the variable with poor identifiability remains unchanged in this iteration; the problem of violation constraint for some solution is solved through adjusting the search step length, At last, taking Ti-6Al-4V as an example, a set of satisfactory material parameters is obtained. The calculated results agree with the experimental results well. The results show that the proposed method is more robust than traditional method; at the same time, the identifiability analysis can provide a guide to experiment design.