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Identification of ductile fracture model parameters for three ASTM structural steels using particle swarm optimization

Key words:

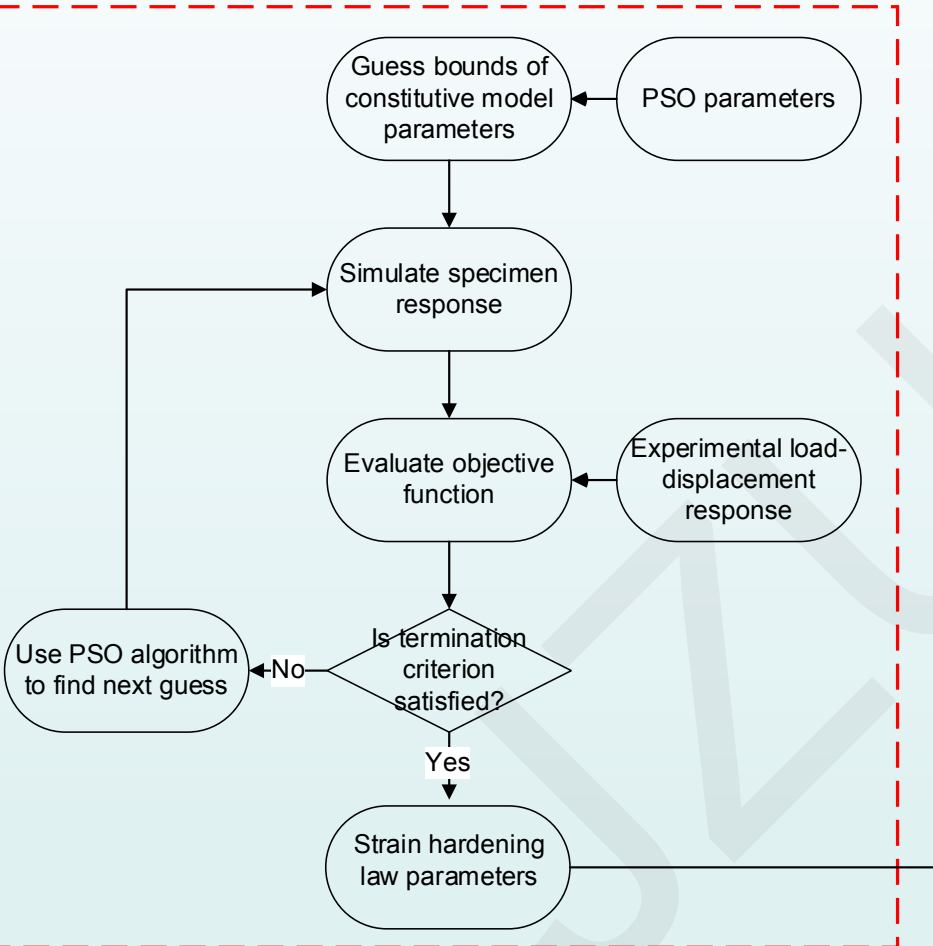
Parameter calibration; Void growth model; GTN model; A36 steel; A572 Gr. 50 steel; A992 steel; Particle swarm optimization

Motivation and Aims

- The true stress-strain curve in the FE model was conventionally adjusted by trial and error until the simulated engineering stress-strain curve reasonably matches the experimentally measured engineering stress-strain curve. The repeated trial and error process often requires dozens of iterations and is subjective and highly dependent on human experience and expertise.
- There is lack of straightforward and accurate approach to calibrating the fracture model parameters that requires the stress and deformation fields in the specimen as the continuum fields to fracture initiation are quite non-uniform and complex.
- A computer-aided instead of trial-and-error approach is urgent for identifying the parameters of the constitutive and fracture models. Inverse analysis based upon nonlinear optimization techniques has shown great potential to address the parameter identification problem

Methods

Calibration of strain hardening law



Calibration of uncoupled fracture model

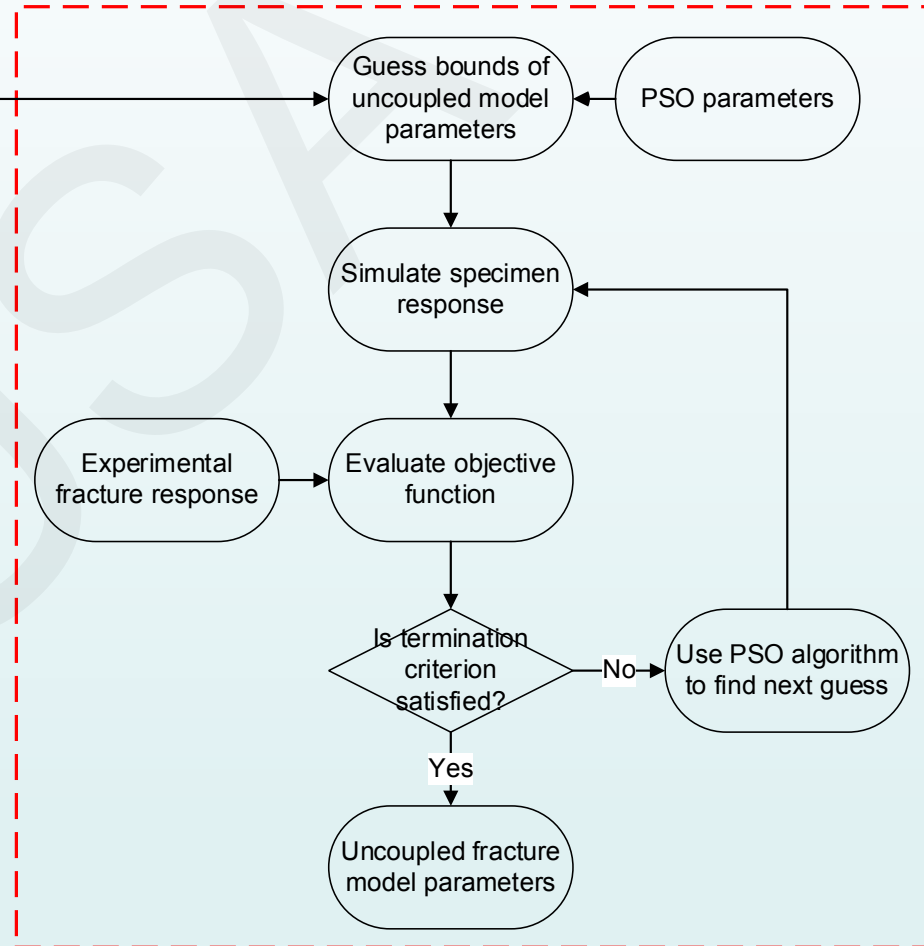


Fig. 1 Calibration process for the uncoupled fracture models by Particle Swarm Optimization

Results

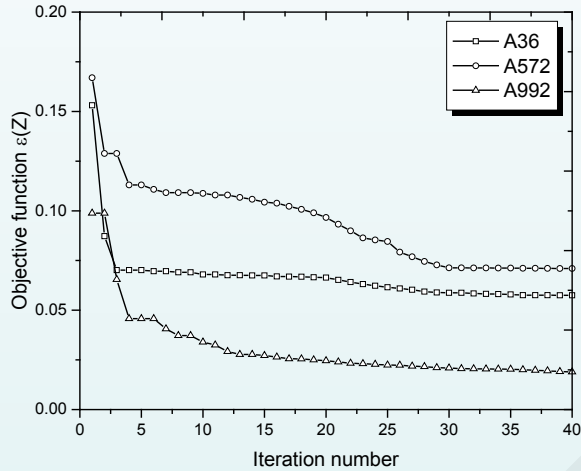


Fig. 2 Evolution of objective function in the PSO-based identification of model parameters

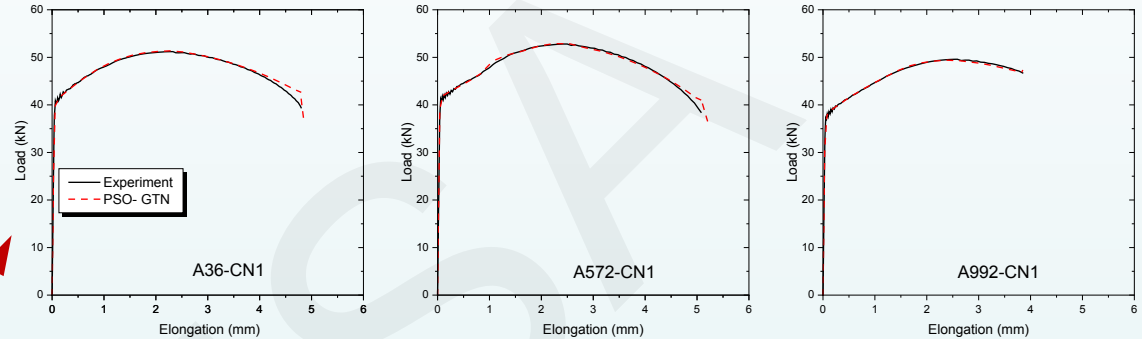


Fig. 3 Experimental vs. predicted load-displacement curves of A36, A572 Gr. 50 and A992 steels

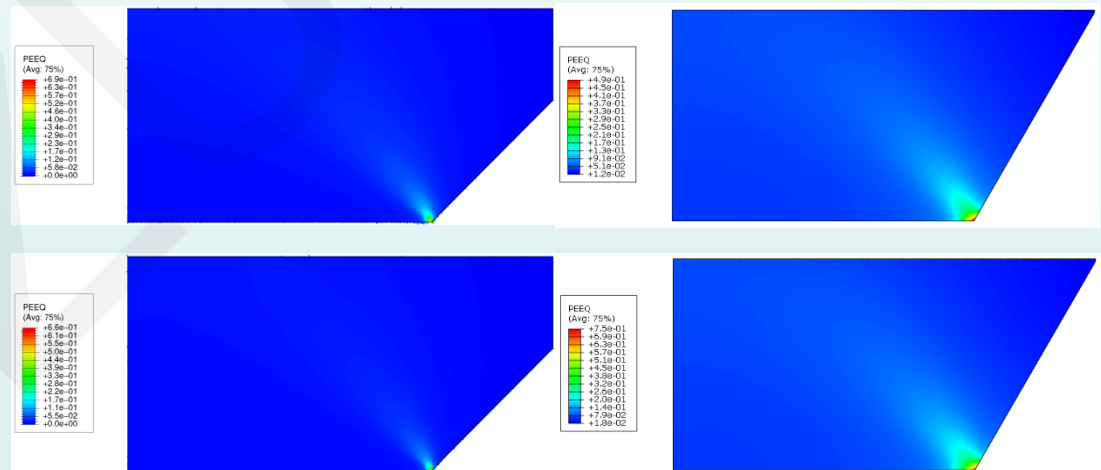


Fig. 4 Predicted fracture initiation using the calibrated parameters by PSO

Conclusions

- The particle swarm optimization offers a robust identification process for the strain hardening law parameters without any manual intervention as compared to the conventional trial-and-error operation.
- Uncoupled ductile fracture model parameters are identified using a two-step PSO calibration scheme. The whole process of PSO analysis is fully automatic, so that only the PSO parameters are required to initiate the search algorithm.
- The GTN model is again calibrated for all the three steels using the PSO method. The upper and lower bounds of the other GTN parameters required for PSO are determined based on the values used in the literature and associated with various trials of PSO calibration. The PSO analysis exhibits an effective calibration process that the objective function (measure of the error) is minimized after a small number of iterations for a given steel.