Abstract

The thesis focuses on the machine learning (ML) techniques applied to predict elastoplasticity and biaxial failure in short-fiber-reinforced polymer (SFRP) composites. First, a surrogate artificial neural network (ANN) model is developed to predict the elastoplastic response of an SFRP. The database for the ANN model is built upon the mean-field homogenization of SFRPs by varying the constituent properties. Each simulated response is fitted with a fifth-order polynomial. The parameters for simulation are considered the inputs, and the coefficients of the polynomial are considered the output of the ANN model. The elastoplastic response predicted by the ANN model is compared with experimental results. Second, a hybrid long short-term memory (LSTM) model is proposed, which makes use of simulated and experimental responses of an SFRP. The standard LSTM loss function is combined with the deviation between the simulated and experimental response to make it a hybrid loss function, and is then optimized. This model can predict the elastoplastic response of an SFRP close to the experimental response for an unseen strain path. Third, an ANN model is developed to predict the biaxial failure envelope of an SFRP. The First Pseudo-Grain Failure (FPGF) model is implemented to obtain the biaxial failure envelope. The parameters for simulation are also used as the input for the ANN model. Twenty-five failure points, covering all quadrants, are considered the output of the ANN model. The microstructural parameters are varied over a range to build a database for the ANN model. The failure envelope of an unseen SFRP predicted using the ANN model is compared with experimental and simulation results. Finally, an ANN model is developed to discover the biaxial failure envelope of an SFRP. First, the failure envelope of an SFRP specimen is obtained using the FPGF model. The failure envelope is fitted with an ellipse, and is isotropically offset to assign a label to the points in stress space. The ANN predictions for a noise falling within a threshold range give the biaxial failure envelope of an SFRP specimen.

Keywords: Machine learning, Short fiber-reinforced polymer composites , Elastoplasticity, Biaxial failure, Neural networks, LSTM