

Improving capabilities of constitutive modeling of shape memory alloys for solving dynamic problems via application of neural networks

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Abstract: The paper addresses an issue of improving capabilities of the constitutive models elaborated for shape memory alloys (SMA) to solve dynamic problems. Artificial neural networks (ANN) are utilized to simulate the experimentally identified complex behavior of the mentioned type of smart materials. Although SMA are known and widely used in various engineering applications for many decades, both understanding and, therefore, modeling of their physical behavior suffer continuous limitations regarding accuracy and performance. The present work reports the results of the properties assessment carried out for the proposed ANN based constitutive model for SMA. As presented, the application of ANN allows to reliably model the hysteretic character of the stress-strain relationship observed by the authors for the experimentally tested SMA material — a wire made of Nitinol. The work is complemented with the results of a study on the influence of an ANN structure and training method on the quality of numerical results. The combined ANN-finite element method code is used to provide solutions for the given dynamic problems. Finally, improvement perspectives regarding SMA constitutive modeling are discussed making a reference to the identified capabilities of the ANN based material model. This study was funded by National Science Center, Poland (Grant No. OPUS 2017/27/B/ST8/01822 Mechanisms of stability loss in high-speed foil bearings — modeling and experimental validation of thermomechanical couplings).

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