Data-led Mechanical and Thermal Analysis of Layered Structures Based on Parametric Finite Element Analysis and Neural Network

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Abstract
The mechanical and thermal behaviours of layered structures at different scales is of great importance for many advanced material systems and loading conditions. Both responses are controlled by the constitutive properties of each layer as well as the layer profiles and thicknesses. The condition of the interface (e.g. perfect contact and imperfect contact) influences the mechanical and thermal conduction processes in a different way, and this may become a challenging issue for materials design for an optimum mechanical and thermal performance in particular for non-uniform loading conditions outside the domain for analytical solutions. A comprehensive data-based approach is essential for both material analysis and design in direct or inverse problems.

In this work parametric numerical modelling and Artificial Neural Network (ANN) are jointly used to develop a data system for layered structures. Thermal-mechanical finite element (FE) models are used to produce data for different material property domains (elastic, elastic-plastic, hyperelastic and hyperfoam models). ANN program is established and evaluated for different loading conditions. Using indentation loading as a typical case, the data was applied for nonuniform loading with different materials and design combinations. The effect of the curved interface on some important mechanical features (e.g. indentation resistance, contact area, recovery), and thermal feature (e.g. anisotropic thermal conduction) is analysed. Use of the data system in establishing dominating factors, synergetic effect on mechanical-thermal performance in advanced materials design is also discussed.