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Layerwise numerical and experimental impact analysis of temperature-dependent transversely flexible composite plates with embedded SMA wires in thermal environments

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Abstract

In the present research, impact analysis of rectangular composite plates with embedded SMA wires is accomplished through including the following items for the first time: (1) the layerwise impact-induced temperature-rise (2) effects of the ambient/impact-induced temperature-rises on the material properties and the direct and converse phase transformations, (3) transverse flexibility of the layers, (4) a refined layerwise description of the displacement field, employing virtual sub-layers, (5) a modified constitutive law for the SMA wires, (6) effects of stiffness of the lower layers on the stiffness of the contact region, (7) considering the shape memory effect in addition to the pseudo-elastic nature of the SMA wire, and (8) partially verifying the results based on experimental results extracted by the authors. The coupled thermoelasticity and impact governing equations of the indenter-plate system are determined by means of a combined Galerkin-Energy finite element approach and solved by means of an updating-based Newton-Raphson procedure. Present results show a good concordance with the experimental results. Results reveal that the impact-induced temperature-rise and temperature-dependency of the material properties increase the start and finish stresses of the direct and converse phase transformation mechanisms and lead to larger hysteresis loops, strains, and stresses and in the SMA wire.

Keywords: Coupled thermoelasticity; Impact analysis; layerwise; transverse flexibility; constitutive law for SMA; experimental results.

1 Introduction

Impact strength of the engineering structures has to be checked at the design stage for either protective structures or structures subjected to unintentionally impact loads due to falling or thrown objects. The impact responses may be mitigated through dissipation of the absorbed energy through transformation of the energy to heat (as in the viscoelastic materials) or consuming it in a phase transformation mechanism. Using phase-transformation-based mechanisms may lead to another important advantage if shape memory alloys are utilized. A dented or damaged structure with shape memory alloy wires or layers may regains its original shape after a heat treatment; a fact that is currently used in manufacturing of bumpers and

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