Consistent temperature-based integration of discrete thermo-visco-elastic dynamics

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Abstract

In this paper we present a novel integration strategy to solve the evolution equations of deformable, non-linear elements that possess viscoelastic mechanical response coupled with thermal dissipation. These types of elements may be found in a large number of mechanical systems, such as vehicle suspensions, vibration absorbers for structures and machinery, aerospace devices, etc., in which viscous dissipation is transformed into heat which can flow to the environment or change the temperature (and thus the mechanical properties) of the element itself. The proposed formulation is shown to be thermodynamically consistent, in the sense that energy is preserved and entropy never decreases in isolated systems. In addition, the conservation laws of linear and angular momentum are exactly preserved in the discrete setting.

The key difference of this work compared with related references of the literature [3, 2] and specially [1] is that temperature is considered as the thermodinamical variable instead of the entropy. The proposed approach overcomes an important drawback of the entropy-based formulations, which is the imposition of Dirichlet's boundary conditions of temperature. It also allows for considering general non-linear temperature-dependent element stiffness in a more efficient manner than the entropy-based formulation does.

The development of the proposed algorithm is presented and numerical simulations will be provided to illustrate the excellent performance of the method in terms of stability. This characteristic is directly related to the ability to preserve the structure of the continuum evolution equations, complying rigorously with the two laws of thermodynamics. The main conclusion is that the proposed methodology outperforms classical methods widely used in purely mechanical problems, and it is easy to incorporate to existing multibody formulations currently employed in many commercial and research codes.

References

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