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Thermodynamics and analysis of rate-independent adhesive contact at small strains

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ABSTRACT

We address a model for adhesive unilateral frictionless Signorini-type contact between bodies of heat-conductive viscoelastic material, in the linear Kelvin–Voigt rheology, undergoing thermal expansion. The flow rule for debonding the adhesion is considered rate-independent and unidirectional, and a thermodynamically consistent model is derived and analysed as far as the existence of a weak solution is concerned.

1. Introduction

We are interested in the modelling of elastic bodies glued together by an adhesive, which can undergo an inelastic process of the so-called delamination (sometimes also mentioned as debonding). "Microscopically" speaking, some macromolecules in the adhesive may break upon loading and we assume that they can never be glued back, i.e., no "healing" is possible. This makes the process *unidirectional*; sometimes it is also referred to as *irreversible*, although this adjective has an alternative thermodynamical meaning as dissipative in general. On the glued surface, we consider the *delamination process as rate-independent* and, in the bulk, we also consider rate-dependent *inertial, viscous-like*, and *thermal-expansion effects*. Moreover, we confine ourselves to *small strains* and, just for the sake of notational simplicity, we restrict the analysis to the case of *two* bodies Ω_+ and Ω_- glued together along the *contact surface* Γ_C. The material in the bulk is considered as heat conductive, and thus the system is completed by the nonlinear heat equation in a thermodynamically consistent way. The contact surface is considered infinitesimally thin, so that the thermal capacity of the adhesive is naturally neglected. The coupling of the mechanical and thermal effects thus results from thermal expansion, dissipative/adiabatic heat production/consumption, and here also from the possible dependence of the heat transfer through the contact surface Γ_C on the delamination itself, and on the possible slot between the bodies if the contact is debonded.

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