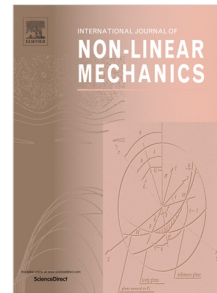


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R. Bustamante, K.R. Rajagopal



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Modeling residual stresses in elastic bodies described by implicit constitutive relations

R. Bustamante^{1*} and K. R. Rajagopal²

¹ Departamento de Ingeniería Mecánica,
Computational and Applied Mechanics Laboratory
and Center for Modern Computational Engineering, Universidad de Chile
Beaucheff 850, Santiago Centro, Santiago, Chile

² Department of Mechanical Engineering
University of Texas A&M, College Station TX, USA

Abstract

In this paper we study the response of bodies that are residually stressed within the context of a new class of constitutive relations, wherein the strains are assumed to be functions of the stresses. Such bodies are said to have residual stresses if there are stresses within the bodies even though the bodies are unstrained in the configuration of interest in the absence of external traction. Problems within the context of the norm of the gradient of the displacement field being small are considered, with regard to the determination of the residual stresses in an anisotropic cylindrical annulus with two preferred directions, and the nature of residual stresses within an anisotropic slab. The residual stresses in a body that is subject to incremental stresses are also studied.

Keywords: Nonlinear elasticity; Initial stresses; Residual stresses; Small strains

1 Introduction

This paper concerns the development of response relations for elastic bodies when one has to take into consideration ‘residual stresses’, within the context of implicit constitutive theories recently introduced by Rajagopal (see Rajagopal [1, 2]; see also Rajagopal and Srinivasa [3]). By ‘residual stress’ one means a body not being free of stress in the interior of the body though it is free of traction on the boundary of the body. Before one can embark on such a venture, one needs to first come to grips with what one means by ‘residual stresses’. According to the Oxford English Dictionary [4], the primary meaning ascribed to the word ‘residue’ is: *The remainder, rest; that which is left*. Thus, the terminology ‘residual stresses’ implies that a body, in some configuration was subject to deformations, and at the end of the process the stresses ‘which are left’, that is the stresses remaining within the body are the ‘residual stresses’ in the body. The terminology ‘pre-stress’ on the other hand refers to stresses that were present in the body before it is subject to a particular process. Of course, it is most likely, the ‘pre-stress’ in a body might be the ‘residual stress’ due to some prior process the body was subject to. We may never be able to decide on whether the state of stress in a body is a ‘pre-stress’ or ‘residual stress’. However, since we are interested in describing the response of a body that we have in hand, when it is subject to deformations, it would be most appropriate to refer to the state of stress prior to our deforming the body as ‘pre-stress’ rather than ‘residual stress’. We shall however refer to it as ‘residual stress’ in keeping with the current usage.

*Corresponding author. Fax:+56-2-6896057; e-mail: rogbusta@ing.uchile.cl

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