

ON IMPLICIT CONSTITUTIVE RELATIONS IN CONTINUUM MECHANICS AND THERMODYNAMICS

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Abstract

Constitutive relations are relations that describe the response of a body in a given class of processes. If we restrict ourselves to mechanical phenomena in continuum mechanics of fluids the specification of constitutive relation means that one needs to find a relation between the Cauchy stress and the kinematical quantities such as the symmetric part of the velocity gradient. The prevailing theoretical approach to the constitutive relations is that the Cauchy stress is given explicitly in terms of the kinematical quantities. It will be shown that this standard approach must be generalized to the setting where one assumes an implicit relation between the Cauchy stress and the kinematical quantities. (The same applies to the constitutive response of solids and non-mechanical processes.) This seemingly insignificant change has immense impact on the theory of constitutive relations, that is on the development of mathematical models in continuum mechanics. After discussing the need for implicit constitutive relations to describe the response of both non-linear fluids and solids, we will discuss applications wherein they can be gainfully exploited. It will be shown that implicit type constitutive relations can explain phenomena that have hitherto defied adequate explanation. Moreover, implicit type constitutive relations possess characteristics which are of interest from the point of view of qualitative and numerical analysis.