Rajagopal, K. R.; Srinivasa, A. R.
Restrictions placed on constitutive relations by angular momentum balance and Galilean invariance. (English) Zbl 1268.74005

Summary: In this note, we will show that for describing the response of a wide class of bodies, it is sufficient to invoke only the balance of angular momentum to obtain the restrictions on the constitutive functions that one obtains by appealing to frame indifference. While this result is known for hyperelastic materials (although it is not found in any standard text on the subject), we extend this result to classes of elasto-plastic and viscoelastic materials as well as for a class of implicit constitutive equations for viscous fluids. In particular, we show that for a class of bodies capable of instantaneous elastic response that is dictated by a stored energy function, the symmetry of the Cauchy stress alone is enough to obtain all the necessary restrictions. The result is related to Noether’s theorem; if we know that there is a conserved quantity (i.e., angular momentum), we can then show that the energy function must be invariant under a group of transformations. For a class of generalized Newtonian fluids (including the Navier Stokes fluid and the Bingham fluid), the symmetry of the stress and Galilean invariance of the response functions are all that are required to obtain restrictions that are usually obtained by enforcing frame indifference.

MSC:
74A20 Theory of constitutive functions in solid mechanics

Keywords:
Galilean invariance; frame indifference; constitutive equations; restrictions; viscoelastic solids; Noether’s theorem

Full Text: DOI

References:


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