Edelen's dissipation potentials and the viscoplasticity of particulate media

J.D. Goddard

Department of Mechanical and Aerospace Engineering
University of California, San Diego
9500 Gilman Drive
La Jolla, CA 92093-0411, USA

Abstract

This presentation is mainly concerned with the usage of dissipation potentials in various theories viscoplasticity, with special emphasis on fluid-particle suspensions and granular media. As gen- eralizations of the classical Rayleigh dissipation function, such functions have been employed in plasticity theories at least as far back as the early work of Melan (1938), and have been generalized to Cosserat plasticity by Lippmann (1969).

Physical justifications for the existence of dissipation potentials are often based on the assump- tion of maximum dissipation, which is less than evident for many complex fluids and solids. By contrast, in a remarkable body of work that seems to have been largely ignored, the late D.G.B. Edelen (1972-73) offers a purely mathematical construct that gives any force-dependent velocity or thermodynamic flux as the gradient of a dissipation potential plus a non-dissipative term rep- resenting a thermodynamically orthogonal or "gyroscopic" flux. It is conjectured that the latter may represent certain kinematic constraints such as "jamming" and Reynolds dilatancy in granular materials.

The present work casts Edelen's formulae in a more transparent form, provides the extension to Legendre-Fenchel dual potentials and considers the special role of homogeneous potentials. This allows for a compact representation of constitutive equations for the viscoplasticity of fluid-particle suspension and granular media with evolutionary microstructure, and some extensions to elasto- plasticity are also considered.