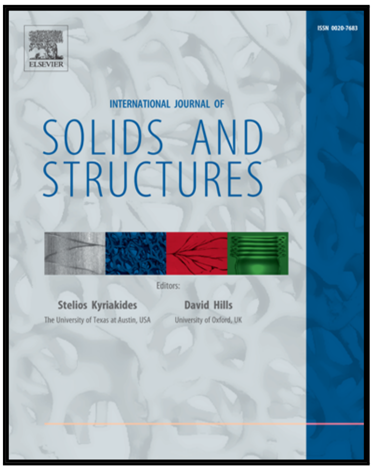

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A poro-viscoplastic constitutive model for cold compacted powders at finite strains

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Abstract

A novel finite strain poro-viscoplastic phenomenological model for cold compacted materials is proposed. The model relies on the three-stage density evolution paradigm and describes the material evolution from loose to solid state. This model accounts for rate dependence, elasto-plastic coupling, pressure sensitivity, and transition to full solid state. The model has been implemented, verified, and validated against experimental analyses available in the literature for copper powder compounds.

Keywords: Cold compacted media, Metal powders, Finite strains, Visco-plastic rate-dependent model, elasto-plastic coupling, pressure sensitivity

1. Introduction

Modeling granular materials is an important and challenging task, which is needed for several applications. These include applications in the pharmaceutical industry [1], powder metallurgy [2], ceramics [3], soil mechanics [4], and many others. Overall (effective) chemical and mechanical properties arise from microstructural processes, which occur at the particles scale. Processing options permit selective placement of phases or pores to achieve targeted effective properties. For instance, mixing two or more metal or ceramic powders and exposing them to specific pressure and temperature conditions may lead to material synthesis. An example of this is the use of high energy ball milling to obtain reactive metallic composites [i.e. 5].

In this work, we focus mainly on metal/ceramic powders. Components made with metal/ceramic powders are produced by cold or hot compaction (see [6]) for a detailed description of the manufacturing process). During the compaction, the applied pressure controls the change in the material's elastic and strength properties. It is commonly accepted that the transition from loose state to full solid state is defined by three stages [eg. 7]: stage I corresponds to granule sliding and rearrangement, stage II is characterized by granule deformation, and stage III is dominated by granule densification and hardening (see Fig. 1).

In order to capture the behavior described above, both microscopic and phenomenological approaches have been proposed [8]. In the microscopic approach, the grains are often modeled as spherical with different

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