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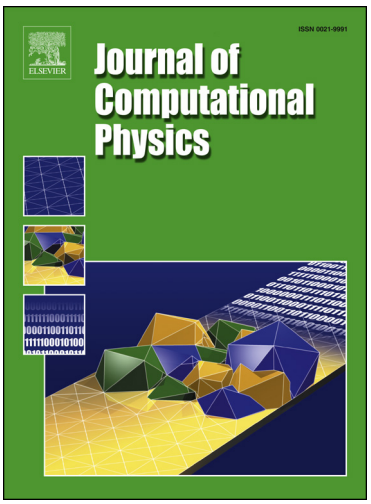

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Lax-Wendroff and TVD finite volume methods for unidimensional thermomechanical numerical simulations of impacts on elastic-plastic solids

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Abstract

We present in this work two finite volume methods for the simulation of unidimensional impact problems, both for bars and plane waves, on elastic-plastic solid media within the small strain framework. First, an extension of Lax-Wendroff to elastic-plastic constitutive models with linear and nonlinear hardenings is presented. Second, a high order TVD method based on flux-difference splitting [1] and Superbee flux limiter [2] is coupled with an approximate elastic-plastic Riemann solver for nonlinear hardenings, and follows that of Fogarty [3] for linear ones. Thermomechanical coupling is accounted for through dissipation heating and thermal softening, and adiabatic conditions are assumed. This paper essentially focuses on one-dimensional problems since analytical solutions exist or can easily be developed. Accordingly, these two numerical methods are compared to analytical solutions and to the explicit finite element method on test cases involving discontinuous and continuous solutions. This allows to study in more details their respective performance during the loading, unloading and reloading stages. Particular emphasis is also paid to the accuracy of the computed plastic strains, some differences being found according to the numerical method used. Lax-Wendoff two-dimensional discretization of a one-dimensional problem is also appended at the end to demonstrate the extensibility of such numerical scheme to multidimensional problems.

Keywords: Thermo-elastic-plastic solids, Finite volume method, Impacts, Lax-Wendroff, High order TVD method

I. Introduction

The numerical simulation of hyperbolic initial boundary value problems including extreme loading conditions such as impacts requires the ability to accurately capture and track the wave front of shock waves induced in the medium. Indeed, this permits to correctly follow the path of waves and hence understand the mechanical phenomena occuring within that medium. For solid-type media, it allows also for an accurate assessment of the plastic strain field and hence that of residual stresses and distortions within the structure. High speed forming processes like electromagnetic material forming