A Cell-centered Finite Volume method on Lagrangian grid for solving elastic-plastic flows in two-dimensional axisymmetric geometry

I. Bertron[†]**, B. Rebourcet**[‡] **and** **P.-H. Maire**[†]

[†] CEA/CESTA 33116 Le Barp cedex, France (isabelle.bertron@cea.fr, pierre-henri.maire@cea.fr)

[‡] CEA/DIF, 91297 Arpajon cedex, France (bernard.rebourcet@cea.fr)

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ABSTRACT

The numerical simulation of the response of solid materials undergoing large strains is of particular interest in many industrial applications such as high-velocity impacts [3]. In this presentation, we shall describe a cell-centered Lagrangian scheme devoted to the numerical simulation of solid dynamics on two-dimensional unstructured grids. This method is the extension to axisymmetric geometry of the work initially presented in [2]. The underlying physical modeling relies on the classical elastic-plastic material model initially proposed by Wilkins [4]. This hypoelastic model is characterized by the decomposition of the Cauchy stress tensor into the sum of its deviatoric part and the thermodynamic pressure which is defined by means of an equation of state. Regarding the deviatoric stress, its time evolution is governed by a classical constitutive law for isotropic material. The plasticity model employs the von Mises yield criterion and is implemented by means of the radial return algorithm. The numerical scheme relies on a finite volume cell-centered method wherein numerical fluxes are expressed in terms of sub-cell force. The generic form of the sub-cell force is obtained by requiring the scheme to satisfy a semi-discrete dissipation inequality. Sub-cell force and nodal velocity to move the grid are computed consistently with cell volume variation by means of a node-centered solver, which ensures total energy conservation. The nominally second-order extension is achieved by developing a two-dimensional extension in the Lagrangian framework of the Generalized Riemann Problem methodology, introduced by Ben-Artzi and Falcovitz [1]. We also address and solve the issue of developing a piecewise linear monotonic reconstruction of the stress tensor which maintains the Galilean invariance of the second-order spatial discretization. Finally, the robustness and the accuracy of the numerical scheme are assessed through the computation of several test cases.

References

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