UNIVERSITÀ DEGLI STUDI DI BERGAMO | Scuola di Ingegneria

A New Explicit Formulation of Johnson-Cook Model for Finite Element Simulations

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ABSTRACT

Johnson-Cook (JC) phenomenological model is the most widely used thermo-viscoplastic constitutive model for finite element simulations. The JC model is used in thermo-viscoplastic applications such as perforation and penetration mechanics, machining and crashworthiness. It is well known that plastic work transforms partly into heat. The nature of the thermal problem determines the temperature rise: only little temperature rise will be noticed if the generated heat flows away, however, for adiabatic conditions the temperature can rise noticeably. The classical JC formulation is implicit and generally consumes long numerical calculation time.

Masri R. (2014) proposed a new explicit rate-independent formulation (thermoplastic formulation) of the JC constitutive model for investigating the effects of adiabatic thermal softening on specific cavitation energy and ductile plate perforation. A recent numerical work of Masri R. and Abu-Salih S. shows that the previous explicit formulation can be extended to an explicit thermo-viscoplastic formulation of the JC model that captures constant and non-constant strain-rate effects.

This talk presents the efficiency and accuracy of the new explicit formulation of JC model. For this end, the benchmark problems of quasi-static and dynamic of spherical cavity expansion were numerically solved using the classical JC formulation and the new explicit formulation. The numerical finite element solution was achieved using the commercial COMSOL-Multiphysics and ABAQUS finite element softwares. In addition, the quasi-static plane-strain cylindrical cavity expansion problem was numerically solved in order to gain better comparison between the classical JC formulation and the new explicit formulation. As will be shown, the proposed explicit formulation is accurate as the classical one. However, the solution consuming time is shorter. Furthermore, the proposed formulation gives a better understanding of the coupling between the thermal-softening and strain-rate effects.

Keywords: Constitutive model, Johnson-Cook model, Numerical modeling of cavity expansion.

Dr. Samy Abu-Salih received the B.Sc., M.Sc., and Ph.D. degrees from the Technion—Israel Institute of Technology, Haifa, in 1995, 2002, and 2006, respectively, all in Mechanical Engineering. From 2007 through 2008, he was a postdoctoral research staff member at the MEMS Lab, Department of Mechanical Engineering, University of Alberta, Canada. He has been staff academic member at the Department of Mechanical Engineering at the ORT Braude Engineering College since 2012. His current research interests are MEMS, solid mechanics, Chemo-Electro-Mechanical response of micro Hydrogel structures and plasticity. His activity in MEMS includes modeling and simulation of electrostatic, piezoelectric actuation methods.

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