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A THREE-INVARIANT, EXPERIMENTAL BASED, ELASTOPLASTIC FORMULATION FOR STEEL MATERIALS

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The pressure sensitivity of metals is addressed in this work.
A series of experimental tests, considering different load scenarios able to activate non-deviatoric stress tensor invariants, were performed on steel solid round bars [1, 2]. The load was applied to the specimens in the form of uniaxial tension/compression and torsion combinations which will result in combined tensile and shear stresses that will maintain a constant ratio during the experiment.
A digital image correlation system was used to monitor the experiments and provide the displacement field and the strain field distribution at different stages of the tests. This photogrammetric non-contact device was mounted in front of the painted sample, for continuous recording of the relative movement of black dots on the white specimen during the deformation.
3D analyses were carried out and the need to expand the von Mises elastoplastic constitutive model, with an associated flow rule, to a formulation that takes into consideration also the first invariant of the stress tensor and the third invariant of the deviatoric stress tensor was highlighted; so reproducing the main features of the experimental results.
A more sophisticated hardening law was proposed as a function of three invariants of the plastic strain tensor [1, 2]. Plastic flow rule was derived by integration of the plastic strain rate through the physical domain of the specimen (elaboration of DIC results) and expressed in terms of the three invariant formulation of the stress tensor to activate the proposed hardening law.

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