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NUMERICAL PREDICTION OF PORTEVIN-LE CHÂTELIER EFFECT BY MEANS OF RATE-DEPENDENT PLASTICITY MODELS UNDER SEVERAL STRAIN PATHS

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Abstract. In some metallic alloys and under some circumstances due to temperature and loading conditions, plastic deformation appears in a localized mode, in bands, that propagate throughout the gauge area of the sample. Such a phenomenon, called Portevin-Le Châtelier (PLC) effect, has been extensively investigated, mainly under tension loading and from both an experimental and theoretical point of view. Recently, Coër et al. [1] have shown that for a 5000 series aluminium alloy, PLC effect can also be observed under simple shear loading. The aim of this work is to present some theoretical models classically used in order to reproduce PLC effect, and also some improvements of these models. More precisely, McCormick's physically based model, as well as Johnson-Cook phenomenological model with a negative strain rate sensitivity [2], were extended to take into account plastic anisotropy. The numerical implementation of the enhanced models is done via a user subroutine UMAT within Abaqus finite element software and will also be discussed. The influence of strain rate, temperature and loading paths on the occurrence of PLC instabilities are investigated from a numerical point of view. Moreover, the apparition of the jerky flow characterized by the presence of serrations on the mechanical response of the material is investigated in details. Finally some comparisons with experimental results obtained using a Digital Image Correlation device are given in order to quantify the ability of the models to reproduce observations related to PLC instabilities.

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