Accepted Manuscript

A differential-exponential hardening law for non-Schmid crystal plasticity finite element modeling of ferrite single crystals

A. Mapar, H. Ghassemi-Armaki, F. Pourboghrat, K.S. Kumar

PII: S0749-6419(16)30298-4

DOI: 10.1016/j.ijplas.2016.11.009

Reference: INTPLA 2128

To appear in: *International Journal of Plasticity*

Received Date: 28 January 2016

Revised Date: 8 November 2016

Accepted Date: 24 November 2016

A Differential-Exponential Hardening Law for Non-Schmid Crystal Plasticity Finite Element Modeling of Ferrite Single Crystals

A. Mapar[a,b], H. Ghassemi-Armaki[c,1], F. Pourboghrat[d,*], K. S. Kumar[c]

[a]*Department of Mechanical Engineering, Michigan State University, MI 48824, USA*
[b]*Department of Chemical Engineering and Materials Science, Michigan State University, MI 48824, USA*
[c]*School of Engineering, Brown University, Providence, RI 02912*
[d]*Department of Integrated Systems Engineering, Department of Mechanical and Aerospace Engineering, The Ohio State University, Columbus, OH 43210, USA*

Abstract

Crystal plasticity finite element (CPFE) modeling of multi-phase, third generation advanced high strength steel (3GAHSS) requires finding the hardening parameters of slip systems operating in different phases (e.g. FCC, BCC, BCT). It is common to see the Schmid law used to model the deformation of BCC crystals. However, researches by Bassani and others have shown that BCC crystals could obey the non-Schmid law. In this paper we examined the differences between using a CPFE model based on the Schmid versus a non-Schmid law to model the uniaxial compression of single crystal ferrite micropillars with distinct orientations carved out of dual phase DP980 and three-phase QP980 steel sheets. To accurately model the changing hardening rate of the single crystal, a new exponential hardening model was developed that would differentially harden slip systems. Criteria for transitioning from stage I to stage II hardening of single crystals were also developed and verified.

Finally, it was shown that it is not sufficient to use only one single crystal micropillar compression force-displacement curve for the calibration of the non-Schmid CPFE model. The predictions of the resulting model would be

*Corresponding author
Email address: pourboghrat.2@osu.edu (F. Pourboghrat)
[1]Present address: ArcelorMittal Global R&D, East Chicago, IN 46312