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DISLOCATION DENSITY BASED PLASTICITY MODEL APPLIED TO METAL FORMING

Andreas Lundbäck[1], Jun Liu[2], Jonas Edberg[3], Ming Jen Tan[4], Sylvie Castagne[5], and Lars-Erik Lindgren[6*]

[1] Luleå University of Technology, 97187 Luleå Sweden, andreas.lundback@ltu.se and www.ltu.se
[2] Imperial College, London SW7 2AZ United Kingdom, jun.liu@imperial.ac.uk and www3.imperial.ac.uk
[3] Luleå University of Technology, 97187 Luleå Sweden, jonas.edberg@ltu.se and www.ltu.se
[4] Nanyang Technological University, Singapore 639798, mmjtan@ntu.edu.sg and www.ntu.edu.sg
[5] Nanyang Technological University, Singapore 639798, scastagne@ntu.edu.sg and www.ntu.edu.sg
[6] Luleå University of Technology, 97187 Luleå Sweden, lars-erik.lindgren@ltu.se and www.ltu.se

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A dislocation density based plasticity model [1] in the framework of Bergström [2] is utilised in forming simulations. It is based on well known relations in materials science [3] but is less commonly used in manufacturing simulations. The model is phenomenological but the formats of the underlying relations do have a physical basis. Furthermore, some features of the models simplify their connection to models for microstructure evolution like precipitate growth during ageing [4]. Internal state variables are used for the evolution of the dislocation density and the models do not require considerably more computing time than material models where the effective plastic strain is the memory of past deformation. The most basic form of the model for flow stress is

$$\sigma_y = \sigma_G + \sigma^* \tag{1}$$

The σ_G term is an athermal stress due to long-range disturbances of the lattice due to immobile (forest) dislocations. It is called athermal, as thermal vibrations cannot assist the dislocation to overcome the disturbance of the lattice. The term σ^* is a contribution due to short-range obstacles. The long range term is given by

$$\sigma_G = \alpha m G b \sqrt{\rho_i} \tag{2}$$

where α is a proportionality factor, m is the Taylor factor, ρ_i is the density of immobile dislocations and G is the temperature dependent shear modulus and b is the magnitude of the Burgers vector. This term requires evolution equations for the immobile dislocation density. The evolution equation for the dislocation density consists of hardening and softening contributions. Further equations relates these to various deformation mechanisms in the material [1]. This model has been used for forming of the titanium alloy Ti-6Al-4V [5] and the aluminium alloy AA5083 [6]. Examples of material model fitted versus test data are shown in Figure 1. The formed part of an inner ring of an aerospace component made of Ti-6Al-4V and the simulation of warm forming of AA5083 are shown in Figure 2.

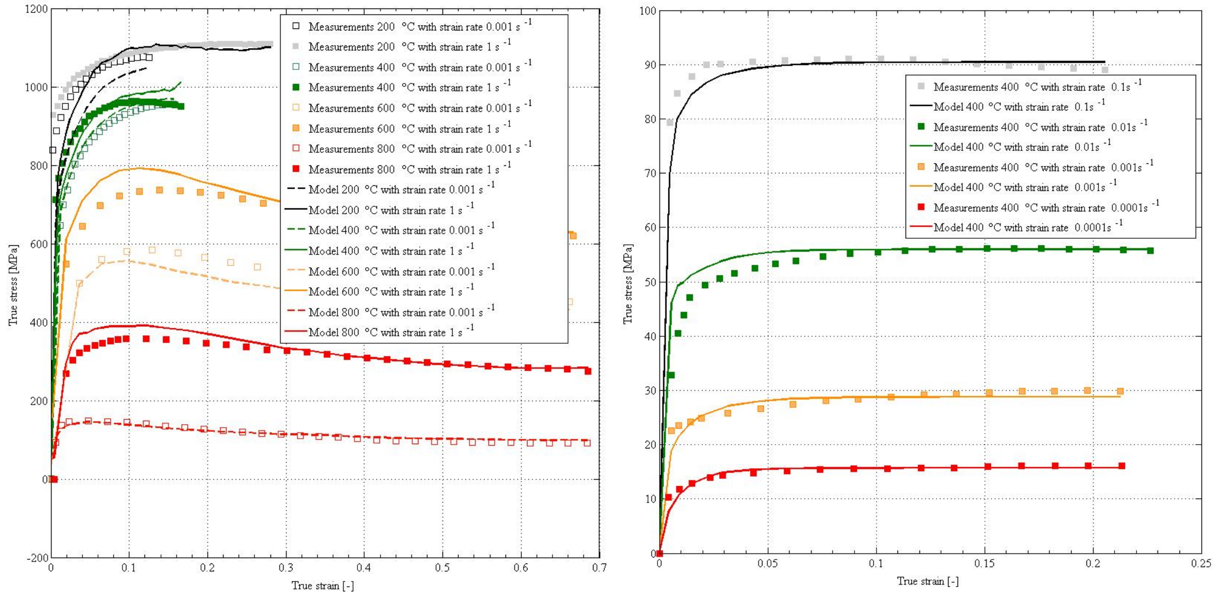

Figure 1. Examples of stress-strain curves for Ti-6Al-4V (left) and AA5083 (right).

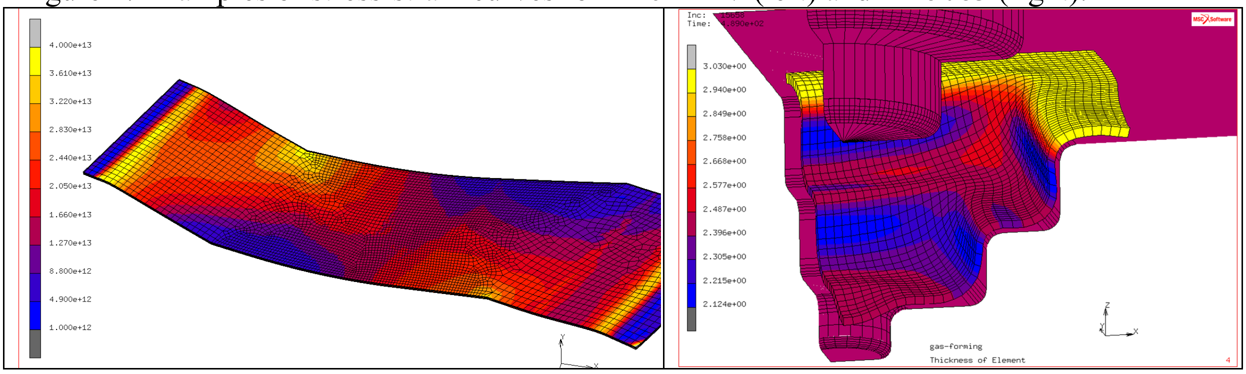
Figure 2. Ti-6Al-4V with plot of dislocation density (**a**) and AA5083 plot of thickness (**b**).

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