Towards Damage Evolution for Hot Forming Processes using a Gurson-Tvergaard Needleman Model – coupled to dynamic recrystallization

Muhammad Imran[1, a)], Joanna Szyndler[1, 2, b)], Muhammad Junaid Afzal[1, c)] and Markus Bambach[1, d)]

[1]*Chair of Mechanical Design and Manufacturing, Brandenburg University of Technology Cottbus - Senftenberg, Konrad - Wachsmann - Allee 17, D-03046 Cottbus, Germany*
[2]*AGH University of Science and Technology, al. Mickiewicza 30, 30-059, Cracow, Poland*

[a)]Corresponding author: imran@b-tu.de
[b)]szyndler@b-tu.de, [c)]afzal@b-tu.de, [d)]bambach@b-tu.de

Abstract. Hot forming processes are widely used in the industry to form semi-finished and finished parts at relatively low forming forces due to the occurrence of dynamic recovery (DRV) and recrystallization (DRX) at elevated temperatures. The presence of non-metallic inclusions in steels leads to damage development at the interface of matrix and inclusion during deformation processing. However, the softening due to DRX can control the damage nucleation and growth. Moreover, the damage mechanisms are sensitive to stress states in components. In the literature, available damage models for hot forming typically consider DRX and damage separately. In the current study, a damage nucleation model for hot forming processes is developed to understand and model the damage initiation and growth taking coupling to DRX and the stress state into account. The new damage nucleation model replaces the common void nucleation model within the Gurson-Tvergaard-Needleman (GTN) model. The model is implemented in Abaqus as user material subroutine. To obtain the characteristic flow curves, hot tensile tests were performed at different temperatures and strain rates. Different stress states were induced using smooth and notched specimens. By fitting the model to experimental flow curves, the void volume fraction of the newly nucleated voids and growth of newly nucleated as well as existing voids is predicted for different deformation conditions.

Keywords: Dynamic recrystallization, stress state, nucleation criterion, GTN model, hot forming