Finite Element Modelling of Material Deformation in Tension under Cyclic Bending and Compression Test

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Abstract. Material deformation behavior is determined by the strain and stress states which are produced by loading conditions applied on the material during a manufacturing process. Different testing methods, for example uniaxial tensile test and dome test, have been used to investigate the material deformation behavior in developing various sheet metal forming processes. However, under a complex deformation mode, a material displays a distinctive deformation behavior. In double side incremental sheet forming (DSIF) process, it has been widely acknowledged that the material deformation consists of stretching, bending, shearing, compression and cyclic loading, leading to a significant material formability enhancement compared to conventional sheet forming processes. This phenomenon cannot be explained by using the current testing methods while the complexity of the DSIF process prohibits a systematic evaluation of the effect of individual deformation modes. To investigate the individual and interactive effects contributing to the formability enhancement in DISF, this paper presents a novel testing method of Tension under Cyclic Bending and Compression (TCBC). A TCBC test rig is developed, in which the effect of stretching, bending, compression and cyclic loading can be independently controlled and evaluated. To observe the material deformation history during the testing process, a finite element damage modelling of the TCBC test has been developed by incorporating the shear-modified Gurson-Tvergaard-Needleman (GTN) model into the Abaqus/Explicit solver. The results show that the damage propagation in the material is suppressed due to the localized and cyclic deformation. An enhanced material formability has been obtained by the model, showing that the TCBC test could be a representation of the DSIF process. The modelling results also show that the compression effect and the cyclic effect are the more important contributors to the material formability enhancement than bending effect, while the existence of stretching has an adverse effect on the material formability.

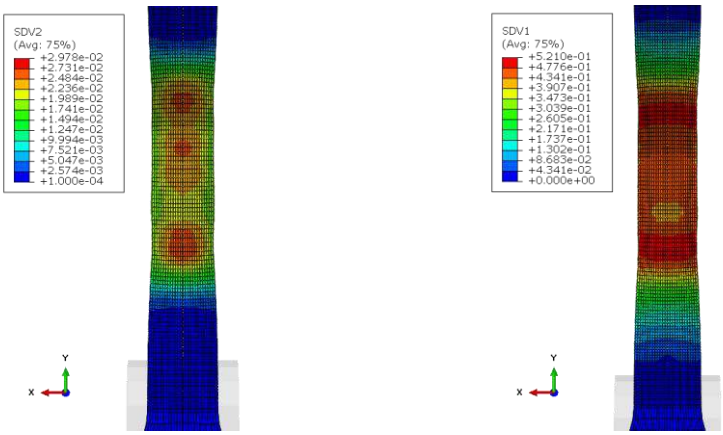

Figure 1 Distribution of state variables in the TCBC tested specimen:
(a) Void volume fraction (SDV2); (b) Equivalent plastic strain (SDV1)