Thesis Title	Formability Analysis of Advanced High Strength Steel Sheets using Experimental and Numerical Investigations
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Abstract

In this work, methodological approaches for formability characterization of advanced high strength steel (AHSS) sheets were presented. Both experimental and numerical investigations were conducted to evaluate effects of anisotropic plastic deformation on formability of the examined steels. Additionally, formability predictions based on plastic instability and damage evolution on micro−scale with respect to crack initiation were done. In the first part, influences of constitutive yield models on description of anisotropic plastic behaviors of the TRIP780 steel sheet were studied. Different yield criteria, the Von Mises's isotropic, Hill's anisotropic (Hill'48) and Barlat's anisotropic (Yld2000−2d) function were taken into account. The hardening laws based on the Swift and Voce model were incorporated. It was found that the anisotropic yield potential and hardening law significantly affected the accuracies of calculated local stress and strain distributions of the steel sheets during plastic deformation. The second part dealt with formability prediction for the DP780 and TRIP780 steel sheets using experimentally and numerically obtained forming limit curves (FLCs) and forming limit stress curves (FLSCs). Obviously, the predicted strain and stress based forming limits were significantly affected by the yield criterion and hardening model. It was shown that the FLSCs could more precisely describe the formability behavior of both high strength steel sheets than the FLCs.

In the last part, damage criteria for ductile crack initiation and plastic instability were developed for the JAC780Y steel sheet. The damage curves (DCs) for describing ductile crack initiation were generated by a hybrid experimental and numerical analysis. Tensile tests of various sample geometries were carried out and crack initiations occurred during deformation were identified by the direct current potential drop (DCPD) method. Subsequently, FE simulations of the corresponding tests were performed to evaluate local stress triaxialities and equivalent plastic strains of the critical area, from which the DCs for both crack initiation and instability were finally constructed. Furthermore, the different yield criteria were defined in the calculations in order to investigate their effects on the resulted curves. Additionally, the obtained DCs were transformed to the strain based forming limit curves. To verify applicability of the DCs and FLCs based on both crack initiation and instability DCs, the Nakazima tests of various samples and an industrial stamping part were considered. It could be concluded that the obtained DCs and FLCs provided acceptable predictions for both laboratory and industrial scale. Nevertheless, the FLCs transformed from the DCs for plastic instability could more precisely predict the forming limit of the steel than the conventional FLC.

Keywords: Anisotropic plastic deformation / Crack initiation / Damage criteria / High strength steel / Strain and stress based forming limit curve / Yield criteria