Abstract

Formability of fiber laser welded blanks (LWBs) of two different dual phase steels (DP980 and DP600) was evaluated implementing Erichsen cupping test. The results were compared with those of LWBs of interstitial free steel. Geometry and local properties of different weld regions were measured and incorporated in finite element modeling (FEM) for accurate prediction of formability. DP980 LWBs showed significant decrease in formability due to the presence of soft zone (SZ) in the outer heat affected zone (HAZ). Moreover, deep drawing test of DP980 LWBs was performed to evaluate limiting drawing ratio (LDR), thinning development and failure location, and the formability performance was compared with Erichsen cupping test results to get insight into the effect of deformation mode. Strain localization and premature ductile failure were observed in the vicinity of SZ of DP980 LWBs in both the deformation modes. The nano-indentation, SEM and TEM results confirmed that the reduction in hardness was due to decomposition of lath structure of martensite and carbide precipitation in the outer HAZ. Parametric study showed a significant change in ductility and strength of the welded DP980 samples with increase in laser scan speed. Hence response surface methodology (RSM) was implemented to optimize laser parameters in order to improve the formability with reduction in the extent of softening. Forming behavior of two different combinations of dissimilar materials tailor welded blanks (TWBs) which were fabricated from dual phase steels (DP980-DP600 and DP980-IFHS) was studied in terms of thickness distribution, failure location, weld line movement and cup edge profile using deep drawing test. The validated FEM was used to successfully improve forming behavior of TWBs by shifting the initial weld position. Further, LDR test results of TWBs were compared with other stretch forming laboratory tests such as limiting dome height (LDH) and Erichsen cupping height in terms of formability ratio. Laboratory scale two stage stretch forming set ups were fabricated to impose complex strain paths in DP600-IF TWBs. Stress based forming limit diagram (FLD) was successfully implemented over conventional strain based FLD as damage model in FEM for predicting the formability of pre-strained TWBs incorporating deformation histories.

Keywords: Laser welding; Tailor welded blanks; Formability; Deep drawing; Stretch forming; Dual phase steel; Finite element model