The Influence of the Loading Conditions on the Transformation Behavior of Retained Austenite in TRIP Steel

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Transformation Induced Plasticity (TRIP) is a promising strengthening mechanism in high strength low alloy multiphase steels. A potential 15-25% of vehicles' weight reduction makes these steels attractive for use in the automotive industry in particular. The source of the strengthening is the strain-induced martensitic transformation occurring during deformation where metastable retained austenite transforms into martensite. The metastable retained austenite transformation, 10 - 20% volume fraction, is well know to be influenced by several physical conditions such as strain, strain rate and stress state (triaxiality) amongst others. These conditions are similar to those encountered during dynamic events such as crash. Therefore a precise understanding of their influence on the transformation kinetics of the retained austenite warrants mechanical lab experiments on various samples under various conditions. This understanding would ultimately lead to the accurate mathematical modeling of TRIP steels and allow for a full exploitation of these steels' potentials. Therefore the accurate quantification of the retained austenite volume fraction in the tested samples is imperative to the success of this project. Various methods exist for quantifying retained austenite content in steels including optical methods, X-ray diffraction, Mössbauer Spectroscopy and neutron diffraction, but of these techniques neutron diffraction is the most precise.

TRIP steel is prepared following a two-stage heat treatment process in which the parameters at each stage are temperature and time. The variation of time and temperature at each stage results in steel with various amounts and properties of retained austenite. In the initial stage of this project, varying the time and temperature at each stage produces a matrix of materials used to determine the material with the optimal properties and amount of retained austenite that will be further investigated.

Thus far, two steels with different chemical composition have been mapped to understand the effect of the heat treatment parameters on the resultant retained austenite content. To date, there has no other such study on hot rolled TRIP steels. Moreover, the variation of retained austenite with strain was determined for two types of tests (tension and compression) at quasi-static strain rate. Varying testing conditions elucidates the influence of the stress triaxiality on the rate of transformation of the retained austenite and will help determine the stress state parameters in the retained austenite transformation kinetic model being developed. This model will eventually be incorporated in a rate dependent plasticity constitutive model for predicting the mechanical response of automotive TRIP steels under physical conditions comparable to those experienced during car crash.

The results obtained in the first phase of this study are shown in Figure 1, and have also been presented at the SAE 2007 World Congress [1] and at the ASME Applied Mechanics and Materials Conference, McMat 2007.

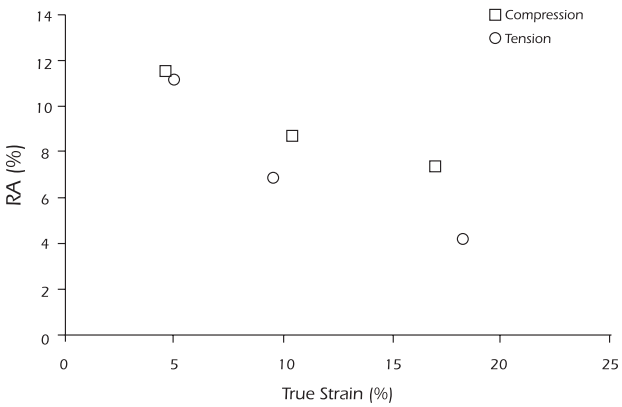

Fig. 1 *The variation of the retained austenite with strain under tension and compression loading conditions.*

References

[1] Wael Dabboussi, Jinbo Qu, James Nemes, Stephen Yue. Experimental Characterization of the Strain Rate and Stress State Effects on a TRIP Assisted Multiphase Steel. SAE World Congress & Exhibition, Detroit, MI, USA, April 2007. SAE 2007 Transactions: Journal of Materials and Manufacturing.