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Micro-Scale Digital Image Correlation-Driven Finite Element Simulations of Deformation and Damage Initiation in Advanced High Strength Steels

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Abstract : The development of next-generation advanced high strength steels (AHSS) used in the automotive industry requires a better understanding of local deformation and damage development at the scale of their microstructures. This work is focused on dual-phase DP1000 steels and involves micro-mechanical tensile testing inside a scanning electron microscope (SEM) combined with digital image correlation (DIC) to quantify the heterogeneity of deformation in both ferrite and martensite and its evolution up to fracture. Natural features of the microstructure are used for the correlation carried out using Davis LaVision software. Strain localization is observed in both phases with tensile strain values up to 130% and 110% recorded in ferrite and martensite respectively just before final fracture. Damage initiation sites have been observed during deformation in martensite but could not be correlated to local strain values. A finite element (FE) model of the microstructure has then been developed using Abaqus to map stress distributions over representative areas of the microstructure by forcing the model to deform as in the experiment using DIC-measured displacement maps as boundary conditions. A MATLAB code has been developed to automatically mesh the microstructure from SEM images and to map displacement vectors from DIC onto the FE mesh. Results show a correlation of damage initiation at the interface between ferrite and martensite with local principal stress values of about 1700MPa in the martensite phase. Damage in ferrite is now being investigated, and results are expected to bring new insight into damage development in DP steels.

Keywords : advanced high strength steels, digital image correlation, finite element modelling, micro-mechanical testing
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