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Numerical investigation of the fatigue behavior of a Mn-TWIP steel

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ABSTRACT

Twinning Induced Plasticity (TWIP) steels are high manganese austenitic steels classified as the second generation of Advanced High Strength Steels (AHSS). Designed aiming at automotive applications, they exhibit a great potential for the lightweighting of vehicle parts due to the outstanding combination of high strength, toughness and formability [1], [2]. Well-suited for body and white (BiW) parts, they could also be applied to chassis components and suspension arms. In these cases, however, special attention should be attained to their fatigue behavior since these parts undergo cyclic loading during usage.

Automotive components subjected to cyclic loads are usually designed to withstand a large number of cycles (over 10^4 cycles) throughout their lifetime so that the availability of engineering data in the High Cycle Fatigue (HFC) domain is crucial for the efficient development of such components. Nonetheless, the generation of HCF data is commonly dependent on expensive and time-consuming test campaigns. For instance, the execution of a complete TWIP steel fatigue experiment employing the standardized staircase method [3] takes about two weeks and nineteen samples to be concluded using a high-frequency testing machine [2]. In order to provide faster and, yet, reliable data, rapid fatigue tests have been proposed in the recent years, such as that based on the sample stiffness degradation [2].

In this work, HCF finite element simulations are confronted with the experimental results presented by [2] for the rapid test based on stiffness evolution. The nonlinear HCF formulation proposed by [4] together with a new isotropic damage law was employed to properly capture the sample stiffness loss observed in the experiments. A calibration of the material parameters used as input in the simulations was carried out considering results of staircase tests. The entire fatigue load history is taken into account in the finite element analyses. For the sake of computational efficiency, the cycle-jump algorithm presented in [5] is used as advancing time strategy. The preliminary numerical results (expressed in terms of fatigue damage) show a good correlation with experimental measurements.

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