Microscale mechanisms of plasticity and damage in advanced multi-phase steels

Varvara G. Kouznetsova*,†, Francesco Maresca‡, Lei Liu†,§, Johan P.M. Hoefnagels† and Marc G.D. Geers†

† Department of Mechanical Engineering
Eindhoven University of Technology
Eindhoven, The Netherlands
e-mail: v.g.kouznetsova@tue.nl

‡ Institute of Mechanical Engineering
École Polytechnique Fédérale de Lausanne
Lausanne, Switzerland

§ Materials innovation institute (M2i)
Delft, The Netherlands

ABSTRACT

Advanced high strength steels (AHSS), exhibiting excellent combination of strength and ductility, have complex multi-phase microstructure, where the behaviour of each constituent, as well their interaction through the interfaces, play crucial role.

This contribution will first focus on revealing the key microstructural features responsible for the observed apparent ductile behaviour of martensite in AHSS, which seemingly contradicts the common perception of steel martensite being strong, but brittle phase. A possible explanation has been shown to originate from the martensite fine scale hierarchical substructure consisting of martensite laths with thin (order of tens of nanometers) austenite layers in between them [1]. The results of crystal plasticity modelling of a martensite aggregate reveal that the austenite acts like a "greasy" plane on which the stiffer martensite laths can slide. The shearing mechanism is intrinsically related to the orientation relationship, which ensures that slip planes of the austenite are approximately parallel to the lath habit planes. It is shown that if the presence of interlath austenite is neglected, the observed experimental flow curves cannot be captured.

Next, the effect of the martensite substructure, including the greasy plane mechanism, on the behaviour of multi-phase AHSS is investigated. It has been shown that even negligible volume fraction of the interlath retained austenite can have a huge impact on both the local as well as global response of these materials [2].

Finally, the role played by the martensite-ferrite interface morphology, closely related to the martensite substructure, is investigated. Simulations indicate that the edge sharpness of martensite laths is an important factor in the plastic strain localization and damage initiation in multi-phase steel microstructures, which are additionally controlled by the loading mode and phase contrast. The results of this work can be used to guide the processing design for new generation AHSS.

REFERENCES

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