A critical assessment of martensitic variant selection criteria in martensitic steels: statistical evaluation through microtexture evaluation

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Abstract

The austenite-to-martensite phase transformation in steels has been a subject of active research because of its unique crystallographic signatures, which include the formation of equivalent but crystallographically distinct variants. Generation of distinct variants can alter the resulting properties of the steel. The favorable alteration of texture through deformation of the parent austenite is an ongoing research goal.
Various theories have been proposed to explain the observed preference for certain variants in steel. These theories include the interaction between externally applied stresses and the stress associated with martensitic transformation, the autocatalytic formation of certain variants to lower strain energy, the presence of twin-related regions in the austenite crystal, and the consequent lowering of interfacial energy by preserving twin boundaries. Despite extensive research on the subject, these existing theories are yet to be widely accepted.
To bridge this knowledge gap and develop controllable paths to develop preferred textures in martensitic steels, a critical assessment of variant selection criteria is carried out through detailed experimental examination of a hot-deformed 9%Cr steel. Starting from first-principles, the study makes minimal assumptions about the mechanisms involved, seeking instead to infer these from the statistically observed phenomena. For the first time, a pixel-by-pixel study is performed, where every measured crystallite is individually examined for its transformation characteristics, selection of martensitic variant, and deviation from ideal orientation relationship. Through these observations, a set of unifying observations are made, necessitating a re-evaluation of various commonly made assumptions. In particular, it is shown that the assumption of equiprobable variants requires rigorous scrutiny. Furthermore, a demonstrable method for predicting the transformation texture is developed. The merits of this method are its computational simplicity, widespread applicability, and fundamentally quantitative nature. Initial experimentation on other materials appears to show that the proposed method is also valid for other lath martensitic microstructures.

Keywords: martensite, variant selection, EBSD, austenite reconstruction

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