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Analysis of the influence of work hardening on the residual stress state in welded high-alloy steels using diffraction methods

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Residual stresses can affect the behavior and performance of materials and components in many ways. While experimental methods can reliably yield the residual stress state resulting from welding, they are often costly and only deliver partial information. In contrast, numerical methods allow for an analysis at any specific point in space and time. However, the accuracy of such computations largely depends on the material model.

In welding simulation, modeling cyclic plasticity is of particular importance. Due to the inhomogeneous temperature field, the material near the molten zone experiences a plastic compression-tension cycle. Different assumptions on how to deal with the associated work hardening at reversal of loading significantly affect the numerical results, i.e. the local yield stress and thereby the distribution of the computed residual stresses. So far, comparisons of experimental and numerical analyses of residual stresses have yielded inconsistent results on the question which plasticity model should be used.

This work specifically addresses this deficit. Bead-on-plate weldments are analyzed by both in- and ex-situ diffraction methods. Thereby, not only the residual stresses are determined, but also microstructural hardening effects are characterized by diffraction line profile analysis. These results are used to evaluate different hardening models employed in finite element welding simulations.

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