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On the reliability of phase-specific residual stress analyses on textured, multiphase materials using diffraction methods - Example: Duplex stainless steels

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Process-induced residual stresses (RS), which are induced as a result of plastic deformation, can lead to plastic anisotropy effects caused by intergranular strains. The strict application of diffraction elastic constants (DEC) to calculate phase-specific RS, as tabulated for many material phases in literature, can lead to arguably erroneous RS calculations. These plastic anisotropy effects can be numerically calculated taking into account phase-specific textures, e.g. by means of EPSC modelling (elasto-plastic self-consistent modelling).
EPSC simulations were carried out for the two duplex stainless steels X2CrNiMoN22-5-3 and X3CrNiMoN27-5-2, which differ in their ratio of ferrite to austenite and in the phase-specific textures. A distinction is made between the cases with and without texture and the corresponding deviations were determined and discussed. The numerically determined results are compared with results from in situ neutron diffraction experiments determined for uniaxially loaded tensile specimens at different neutron diffraction experiments (MLZ, ILL, ISIS). Finally, a practical application of the findings to the neutronographic determination of the RS depth distribution is carried out on the deep-rolled duplex steel X2CrNiMoN22-5-3. In the discussion of the results, a comparison is made with results from complementary RS analyses using the incremental hole drilling method and from X-ray RS analysis according to the well-known sin²968;-method.

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