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Residual stress determination in structural materials for fusion and fission reactors using neutron diffraction

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In structural integrity assessments of components residual stresses play a crucial role as they interact with load stresses during operation and thus directly affect the lifetime of the component. Therefore, reliable and accurate characterization of these stresses is of high relevance in the design of structural components for future fission or fusion reactors. In this respect, neutron diffraction methods have become a key technique for bulk and operando characterization given their unique combination of non-destructive nature and penetration power in comparison to other characterization methods.

The diffractometer STRESS-SPEC is the dedicated instrument for residual stress determination at the German neutron source Heinz Maier-Leibnitz (FRM II). In this contribution we will show two examples of measurements performed at STRESS-SPEC to demonstrate the capabilities of residual stress determination with neutron diffraction for components in nuclear applications. The first example elucidates the stress state in a W-monoblock plasma-facing component (PFC) under high heat-flux (HHF) loads [1], while in the second example the effect of welding in a stainless-steel material earmarked as possible structural material for future GEN-IV fission reactors is investigated [2].

[1] J.-H. You, H. Chae, R. Coppola, W. Gan, H. Greuner, M. Hofmann, S. Roccella, W. Woo, Neutron diffraction measurement of residual stresses in an ITER-like tungsten-monoblock type plasma-facing component, Fusion Engineering and Design 146 (2019) 701–704
[2] P.Agostini, R. Coppola, M. Hofmann, C. Ohms, K. Tucek, Stress distribution in a 316L(N) steel narrow gap TIG model weld for Gen IV nuclear applications, Nuclear Materials and Energy 32 (2022) 101203

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