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RESIDUAL STRESSES - NEUTRON DIFFRACTOMETERS STRESS-SPEC @ FRM II

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ABSTRACT

Diffraction is a powerful tool for analyzing residual stresses as well as applied stresses. Both x-ray and neutron diffraction can be used for this purpose. The interest in neutron stress analysis stems from the high penetrating power of neutrons when compared to laboratory x-ray sources, i.e. several cm instead of a few tens of μm. This contribution will focus on some recent experiments on residual strain, texture and phase analysis to highlight the capabilities of a modern neutron diffractometer. In addition an overview on current instrumental and methodical developments for non-destructive through surface strain measurements, which bridges the gap between X-rays and bulk neutrons, will be shown.

Keywords: STRESS-SPEC, residual stresses, neutron diffraction, spurious strains.

INTRODUCTION

Neutron diffraction opens up the possibility to analyze residual stresses in the interior of technical components rather than just at the surface. With the advent of second and third generation synchrotron sources, hard x-rays have become a powerful competitor for stress analysis in bulk solids. One might have thought that due to the high penetrating power of hard x-rays and the very high brilliance of synchrotron sources neutrons would have be driven out of business. However, this has not happened and neutron instruments dedicated to stress analysis have not become short of users. As a consequence, new instruments for neutron stress analysis have been commissioned or are under construction to this very day. The neutron diffractometer STRESS-SPEC located at Germany's neutron source "Forschungsneutronenquelle Heinz Maier-Leibnitz" (FRM II) in Garching is such a dedicated instrument for engineering and materials science applications.

RESULTS AND CONCLUSIONS

This contribution will focus on some recent experiments on residual strain, texture and phase analysis to highlight the capabilities of a modern neutron diffractometer. In addition an overview on current instrumental and methodical developments through surface strain measurements will be given bridging the gap between X-rays and bulk neutrons. Thanks to the high flux reactor FRM II and the latest improvements of STRESS-SPEC, measurements from the surface into the bulk, has seen an increased demand. Whenever the gauge volume is not totally immersed in the sample the measured strain must be corrected for the respective

spurious strain. A new analytical model is now a routine tool for corrections of strain measurements close to the surface at STRESS-SPEC. An example for a deep rolled sample is shown in Figure 1. A recent further development of the analytical method for treatment of pseudo strains arising near surfaces as well as due to strain gradients is verified by a 4-point bending experiment with a ferritic steel sample of a fine grained construction steel type S690QL. It provides a general framework for treatment of spatial resolution effects, including both pseudo strains and smearing of measured strain distribution due to the finite gauge volume, Figure 2. Finally, a double radial collimator for the primary side has been simulated and is under construction which will reduce considerably the spurious strains enabling flexible sample positioning due to higher focus distance compared to usual slit systems.

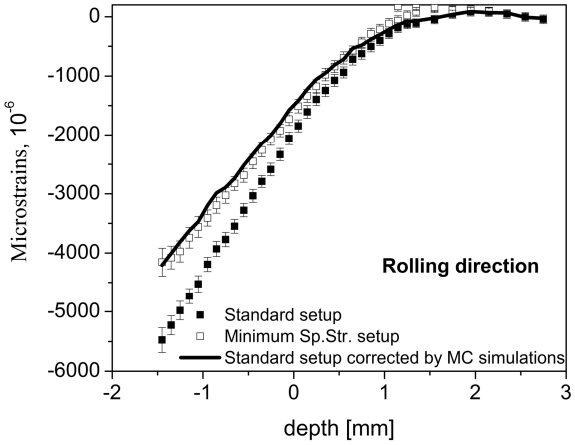

Fig. 1 - Example of spurious strains corrections for a deep rolled sample

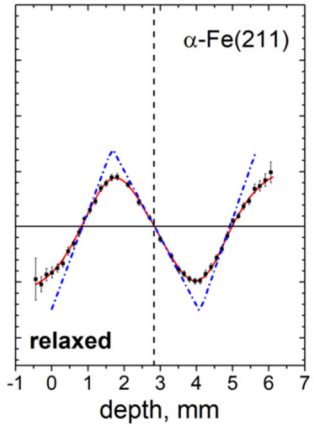

Fig. 2 - Example of spurious strains and smearing corrections for a 4-point bending steel sample

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