Experimental report

06/09/2022

Proposal: 1-02-277 **Council:** 4/2019

Title: Residual stress analysis for materials with depth gradients of the strain free / independent lattice parameter d0

Research area: Methods and instrumentation

This proposal is a new proposal

Main proposer: Jens GIBMEIER

Experimental team: Joana REBELO KORNMEIER
Samuel PULVERMACHER
Jens GIBMEIER

Local contacts: Thilo PIRLING
Sandra CABEZA

Samples: 20MnCr5

Instrument	Requested days	Allocated days	From	To
SALSA	3	3	23/09/2019	26/09/2019

Abstract:

Within this project a basic understanding on the effect of chemical gradients on the local strain free or strain independent lattice parameter will be gained. The systematic experimental approach will be the basis to extend the numerical approaches to correct for the surface effect for through surface strain scanning to material states with gradients in the chemical composition, i.e. we aim at providing an approach for the reliable modelling of the surface effects for materials states with chemical gradients in the near surface region, corporately a measuring and evaluation strategy for non-destructive analysis of near surface residual stress gradients for problematic material states will be developed. As model material the case hardening steel 20MnCr5 will be used. Two different carburization processes will be carried out to maximum carbon contents of 0.7% and 0.9%, respectively. CHD will be around 1 mm. Through surface strain scanning will be carried out at the SALSA instrument for all three principal directions.

Experimental Report – Proposal No. 1-02-277

Residual stress analysis for multiphase materials with depth gradients of the strain free / independent lattice parameter d_0

J. Gibmeier[1], J. Rebelo-Kornmeier[2], M. Hofmann[2], S. Pulvermacher[1], J. Šaroun[3]

[1] KIT – Karlsruhe Institute of Technology, IAM, D-76131 Karlsruhe, Germany

[2] TU München, ZWE-FRM II, D-85747 Garching, Germany

[3] Nuclear Physics Institute of the ASCR, Řež, Czech Republic

Abstract/Aim

Within this project a basic understanding on the effect of chemical gradients on the local strain free or strain independent lattice parameter should be gained. Our systematic experimental approach forms the basis to extend the numerical approaches to correct for the surface effect for through surface strain scanning to material states with gradients in the chemical composition, i.e. we aim at providing an approach for the reliable modelling of the surface effects for materials states with chemical gradients in the near surface region, corporately a measuring and evaluation strategy for non-destructive analysis of near surface residual stress gradients for problematic material states will be developed. As model material the case hardening steel 20MnCr5 is used. The samples are rings with an outer diameter of 33 mm and an inner diameter of 15 mm. The height of the rings is 15 mm (cf. Fig. 1). The case hardening depth CHD is around 1 mm and 1.5 mm, i.e. two states were considered. Through surface strain scanning was carried out at the SALSA instrument for all three principal directions.

Measurement setup:

The used wavelength was 1.704 Å. In the ferrite phase , the {211} lattice plane was investigated. No neutronographic measurements were performed in the austenite phase, since higher amount of retained austenite are localized to very small information depths of only some tenths of a millimetre, which is not assessable for neutron diffraction. The neutronographic measurements were performed with a nominal measurement volume of $0.6 \times 0.6 \times 2$ mm³ defined by radial collimators in the primary and the secondary beam path. The sample was a close-to-reality gear replacement geometry made of 20MnCr5. The chemical gradients resulting from the carburization process can be seen together with the geometry of the rings in Fig. 1 a) and b).

Preliminary results

For the carburized gear replacement geometry with a CHD value of 1.5 mm, the line position of the investigated ferrite {211} lattice plane in all three principal stress directions were investigated. In the region of the inner surface, no more robust data could be acquired. With regard to a D_0-strategy, two pins with different diameters were investigated. Here, results could be determined over the full component height. The resulting strains in the gear replacement geometry are displayed in Fig. 1 c).

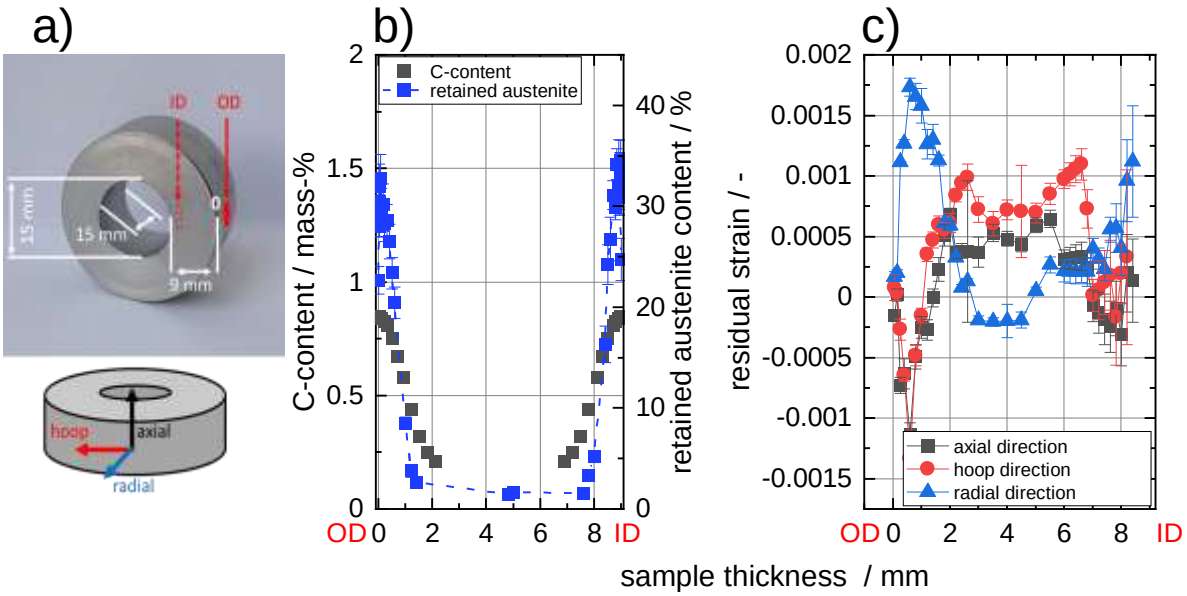

Figure 1: In a) the geometric dimensions of the gear replacement geometry including the used coordinate system. In b) the chemical gradients of the bulk sample are shown. In c) the preliminary results of the strain evaluation are plotted.

Currently, the data is being finally evaluated. Together with the results of the accompanying investigations (metallography, retained austenite measurements (by XRD) and mechanical methods for stress analysis as e.g. Sachs boring), the results are prepared for publication in renowned journals. Furthermore, the results will we inserted and discussed in the PhD thesis of Samuel Pulvermacher.

We would like to thank the ILL for granting the experiment and the staff for their excellent and helpful support, which guaranteed the successful beamtime.