ESRF	**Experiment title:** MICROBEAM X-RAY DIFFRACTION APPLIED TO A NICKEL-BASE SUPERALLOY TURBINE BLADE	**Experiment number:** HC-495
Beamline: D5-BL10	**Date of Experiment:** from: 12.4.1996 to: 15.4.1996	**Date of Report:** 6.11.1996
Shifts: 9	**Local contact(s):** A. Snigirev, M. Kocsis	*Received at ESRF :* 5 DEC. 1996

Names and affiliations of applicants (*indicates experimentalists):

H. Biermann*, B. v. Großmann*, S. Mechsner*, H. Mughrabi and T. Ungár*‡

Institut für Werkstoffwissenschaften, Lehrstuhl I, Universität Erlangen-Nürnberg

Martensstrasse 5, D-91058 Erlangen, Fed. Rep. Germany

‡Institute for General Physics, Eötvös University Budapest, Muzeum krt. 6-8, P.O. Box 323,

H-1445 Budapest VIII, Hungary

Report:

In modern aircraft engines nickel-base superalloys are used as monocrystalline turbine blades of the first stages. X-ray diffraction peak profiles of creep-deformed nickel-base superalloys were shown to be characteristically asymmetric due to long-range internal stresses induced i) partly by plastic deformation of the heterogeneous γ/γ' structure and ii) partly by the difference in the thermal expansion coefficients of these two phases. These internal stresses lead to counteracting tetragonal lattice distortions, cf. [l]. In turbine blades subjected to service, changes of the microstructure and a build-up of internal stresses can be observed [2]. Since temperature gradients cause strong inhomogeneities in the local thermal and mechanical loads, an investigation of the local variations of the internal stresses near the surfaces of turbine blades requires a high lateral resolution which can only be achieved by special techniques. In the present work, measurements of peak profiles were performed with a new technique, using the advantages of synchrotron radiation of the European Synchrotron Radiation Facility (ESRF) applying the Bragg-Fresnel focusing optics [3].

The experiments were performed at the optics beam line BL 10 at a bending magnet. The (Ill) Si single crystal, linear phase-Bragg-Fresnel lens (BFL), cf. [3], and the sample were arranged in a double-crystal diffractometer mode. The BFL was used both to monochromatize the synchrotron radiation and to focus the X-ray beam. The BFL with a focusing distance of 0.6 m was adjusted for the energy of 18.006 keV, determined by the absorption edge of Zr. With a slit system, a spot of 2 μm height and 30 μm and 50 μm length, respectively, was adjusted for the experiments in the present case. The sample-to-detector distance was selected to be 0.82 m, in order to have a sufficiently high angular resolution for the peak profile measurements. A linear position-sensitive proportional counter (OED-50, Braun, Munich) with a spatial resolution of about 80 μm has been used for the measurement of the peak profiles of the (400) and/or (004) Bragg reflections. The samples were mounted on a high precision goniometer with an x-y-z three-dimensional translation stage.

A turbine blade of the nickel-base superalloy CMSX-6 which was subjected to service in an accelerated mission test for several hundred hours was investigated at different positions along several (100) and (001) sections. From the locally measured (004) and (400) profiles the local lattice parameters of the γ and γ' phases were determined. The analysis of the data shows that in the region near the surfaces i) a changed stress state exists near to the surfaces compared to the bulk material and ii) the higher Al content in this region measured by energy dispersive analysis causes an increase of the net lattice constant. In the bulk of the material a homogeneous stress state exists which is comparable with the results obtained in the home laboratory.

1. H.-A. Kuhn, H. Biermann, T. Ungar and H. Mughrabi, Acta metall. mater. 39,2783 (1991).
2. H. Biermann, S. Spangel and H. Mughrabi, Z. Metallkd. 87,403 (1996).
3. V. V. Aristov, A. Snigirev, Yu. A. Basov and A. Yu. Nikulin, AIP Conf. Proc. 147, 253 (1986).

This work was supported financially by Volkswagen-Stiftung (Az. I/69362).