EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Process and Performance Optimisation for Friction Welding of Thin Walled Zr tubes.	**Experiment number**: ME1355
Beamline: ID15A	**Date of experiment**: from: 10/9/2014 to: 13/9/2014	**Date of report**: 17/2/2015
Shifts: 9	**Local contact(s)**: Thomas Buslaps	*Received at ESRF:*
Names and affiliations of applicants (* indicates experimentalists):		

Axel Steuwer, Lund University, Sweden & NMMU Port Elizabeth, South Africa

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Report:

Aim of the Experiment:

The aim of this experiment was to characterise the residual stresses in Friction Processed thin-walled Zircaloy-4 tubes to a 6mm thick Zircaloy-4 base components, in order to evaluate the feasibility or potential of an alternative joining technology for nuclear applications. Figure 1 shows an illustration of the thin walled-friction welded tubes and the area of interest for this study as well as the welded tubes and lastly the set-up on the beam line.

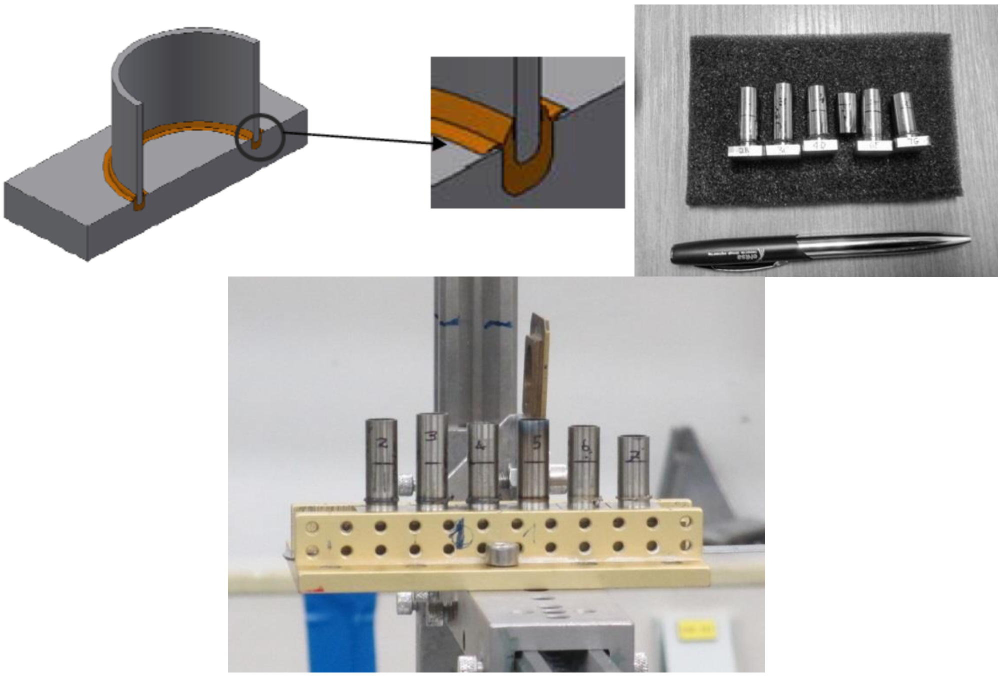

Figure 1: Illustration of the set-up (top left) and the actualy welded samples (bottom right) with the set-up on beam line shown at bottom.

Test matrix process parameters:

Weld Nr	Platform	Down force [kN]	Spindle speed [rpm]	Upset distance [mm]	Forge force [kN]	Forging time [s]	Weld completed
Zr-1	**Weldcore III**	1.5	1500	0.5	2.0	5	Yes
Zr-2	**Weldcore III**	1.5	3000	0.5	2.0	5	Yes
Zr-3	**Weldcore III**	1.5	1500	0.75	2.0	5	Yes
Zr-4	**Weldcore III**	1.5	3000	0.75	2.0	5	Yes
Zr-5	**Weldcore III**	1.5	1000	0.5	2.0	5	Yes
Zr-6	**Weldcore III**	1.0	1500	0.5	2.0	5	Yes
Zr-7	**Weldcore III**	1.5	1500	0.5	2.0	5	Yes

Note: sample Zr-1 was used for Dzero measurements.

The Experiment:
After setting up the two energy dispersive detectors, we mounted a set of tubes in the beam and acquired the diffraction patterns in radial, hoop and axial position with respect to the tube axis with beam sizes of the order of tens of microns.
We scanned at different position in the tubes, and through the wall thickness. Figure 2 shows a typical diffraction patternn of the hexagonal alpha-Zr phase fitted with GSAS after conversion to virtual angle-dispersive diffraction. This allows us to access more peak profile functions.
The peaks are clearly separated and easy to fit. We are now processing the strain-maps obtained from the measurements in order to calculate the residual stresses induced by the Friction processing.

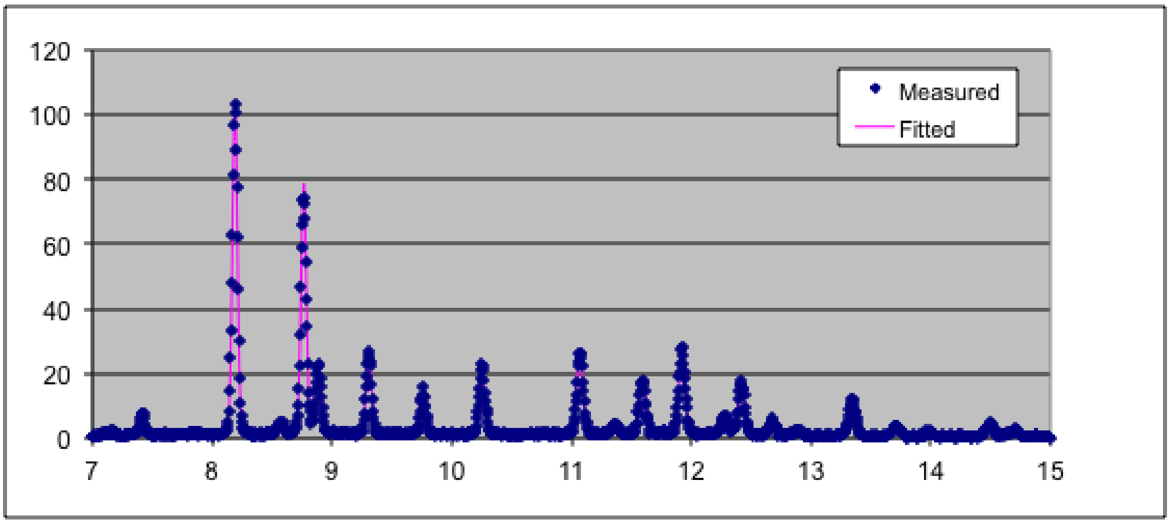

Fig 2: Typical energy dispersive spectrum of hexagonal alpha-Zr tube material fitted with GSAS after conversion to virtual two-theta.

The further evaluation of all the data obtained has been the subject of a Masters, forming the primary contribution of experimental work. It is also anticipated that the analysed data will be published following the acceptance of the Masters dissertation.