ESRF	**Experiment title:** Investigation of Residual Stresses in 12Cr Steel Used in Stationary Steam Turbine Blades and Their Modification by Shot Peening and Fatigue Cycling	**Experiment number**: MA-326
Beamline: ID31	**Date of experiment**: from: 1/10/05 to: 5/10/05 and: 30/11/05 to: 5/12/05	**Date of report**: 17 October 2007
Shifts: 12	**Local contact(s)**: Dr Alex Evans	*Received at ESRF:*

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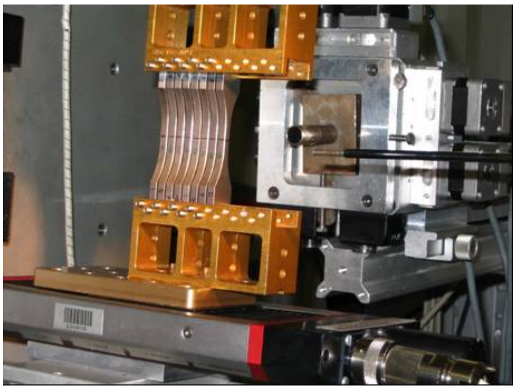
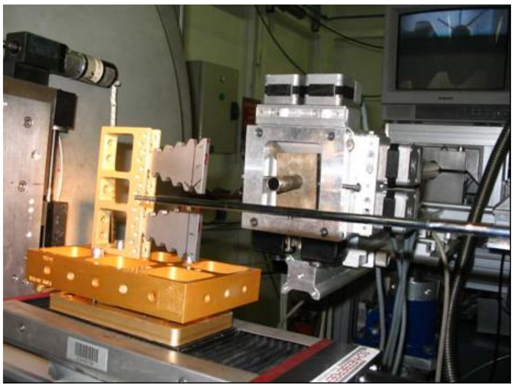
Report:

The work in this experiment focused on the generation of representative data for a range of shot peening and blade operating conditions, interpretation of the new data, its synthesis into a predictive model and the development of this model into a tool to relate fatigue performance of turbine blades to material condition and shot peening parameters [1, 2]. This represents a fundamental advance in knowledge in an area critical to efficient and safe power generation.

Samples cut from turbine blade steel were exposed to controlled shot peening conditions that simulate variations on industrial practice. Residual strains were measured in the samples simultaneously in two orthogonal directions in the as-peened condition and after subjecting the samples to a controlled fatigue loading and number of cycles. The samples were mounted in order; 1, 2, 4, 5, 7, 8, 10 & 11. The view in figures below shows the target line on the centre. The left hand side of each specimen was the outside surface on which the shot peening was done.





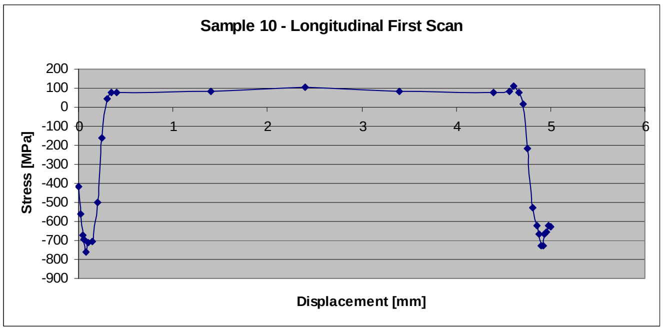
Test matrix:

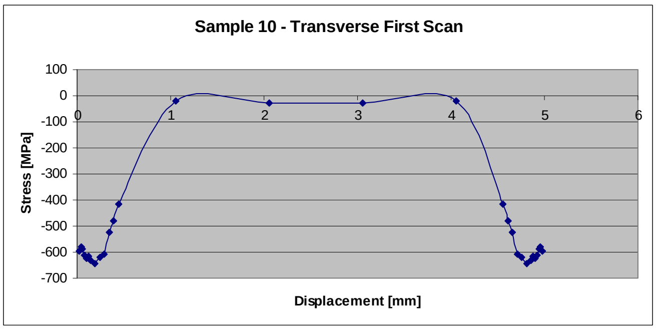
SAMPLE	LETTER	SHOTPEENING	FIRST LOAD	SECOND LOAD	COMMENT
1	A	75%	868MPa or 0,2%	910MPa or 0,5% strain	None
2	B	75%	600MPa	868MPa mean with 20MPa range for 100000 cycles	None
3		75%			Not measured. Was used to check grips in Instron, load of approx 20 kN applied. Cannot be used for further analysis
4	C	100%	868MPa or 0,2%	910MPa or 0,5% strain	None
5	D	100%	600MPa	868MPa mean with 20MPa range for 100000 cycles	None
6		100%			Not measured
7	E	150%	868MPa or 0,2%	910MPa or 0,5% strain	None

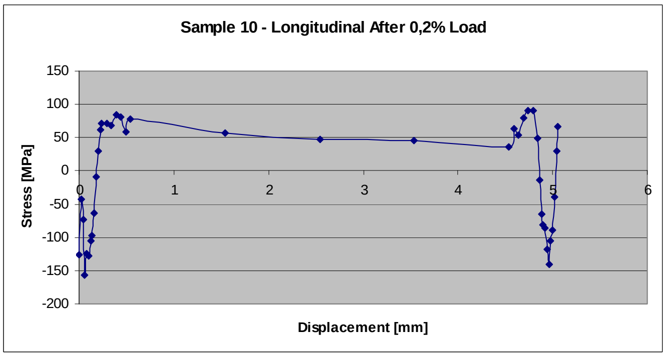
8	F	150%	600MPa	868MPa mean with 20MPa range for 100000 cycles	None
9		150%			Not measured
10	G	200%	868MPa or 0,2%	910MPa or 0,5% strain	None
11	H	200%	600MPa	868MPa mean with 20MPa range for 100000 cycles	None
12		200%			Not measured
Firtree 1		200%			Measured on one side of first serration - beam entering from top face
Firtree 2		200%			Measured on both sides of first serration, beam entered from top then bottom. On bottom face also measured on two locations approx 45 deg each way. Also measured on second serration, beam entering from top.

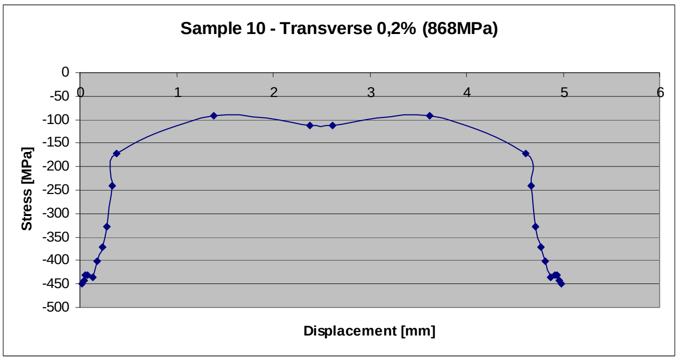
When the samples were orientated horizontally, and the translation was in the Y direction, the beam attenuation was too high at the bottom surface and the data is questionable. With the flat samples a mirror image can be used but on the firtree samples this is not possible. The data for the firtree samples where the beam entered from the bottom did not yielded good results. Re-measurement will have to be considered as it is important because the two profiles that were done away from the bottom of the serration are affected. The alignment for these profiles was done manually, using the video cross.

Results indicate the range of peening conditions necessary to achieve high compressive residual stresses and adequate depth of peened layer to resist relaxation during fatigue cycling. These results will be compared with the residual stresses measured in ex-service blades with known fatigue performance. FE modelling will be used to develop a predictive tool that links shot peening conditions to fatigue life via the residual stress distribution. The graphs give an indication of some of the data obtained during this experiment.









References

1. M N James, D J Hughes, Z Chen, H Lombard, D G Hattingh, D Asquith, J R Yates and P J Webster (2006), *Residual stresses and fatigue performance*, accepted by Engineering Failure Analysis ISSN 1350-6307.
2. M N James, D G Hattingh, D J Hughes, L-W Wei, E A Patterson and J Fonseca (2004), *Synchrotron diffraction investigation of the distribution and influence of residual stresses in fatigue*, Fatigue and Fracture of Engineering Materials and Structures, 27 pp.609-622 ISSN 0160-4112.