Experimental Report

12/05/2014

Proposal: **1-02-141** **Council:** 10/2012

Title: Measurement of residual stresses in the turbine housings of turbochargers

This proposal is a new proposal

Researh Area: Materials

Main proposer: **KILCOYNE SUSAN**

Experimental Team: KILCOYNE SUSAN
GANNON Katy

Local Contact: PIRLING Thilo

Samples: Fe alloy (>95% Fe)

Instrument	Req. Days	All. Days	From	To
SALSA	4	5	13/05/2013	18/05/2013

Abstract:

Emission regulations in Europe are extremely stringent and only turbocharged and charged-air-cooled engines are able to comply with current requirements. To meet these performance, durability and legislative conditions, a turbine housing must be capable of operating in harsh environments where vibration is always present and exhaust temperatures can reach 800°C, however many turbine housings are at the limits of operation with regard to strength and durability under these conditions, and failures are recorded on accelerated durability tests. It is now of great importance to understand the fatigue performance of these components and the conditions that determine this performance. In this experiment residual stress measurements will be made of three turbine housings in areas where cracks are commonly observed. We estimate that 4 days of beam time will be required.

Introduction

Thermo-mechanical stresses generated during service within the turbine housing component of a turbo charger can be predicted using Finite Element Analysis (FEA) software, however this does not take into account residual stresses. Residual stresses are known to cause unexpected failures as they can combine with service stresses reducing a components life. On occasion FEA simulations have been unable to accurately predict fracture locations and perhaps this is due to the presence of residual stresses. In order to quantify the effect of residual stresses on crack initiation and propagation within the turbine housing it is necessary to know their magnitude and distribution.

Due to the complex shape of the turbine housing and the variable thickness of the internal sections, the residual stresses in the area of interest are difficult to measure by other means hence the need for neutron diffraction. The effect of heat treatment on residual stresses is also a focus of this experiment, as such heat treated and un-heat treated parts have also been studied to determined, gathered stress measurements will then be compared with FEA predictions.

Method

Tri-axial (hoop, axial and radial direction) measurements were taken through the divider wall of the turbine housing from the outer wall inwards on an annealed turbine housing and also a housing without heat treatment using a gauge volume of 2x2x2. Measurements were taken at different points through the housing (Fig. 1) line A, +10mm, +20mm and -10mm in increments of 3mm from the outer wall inwards.

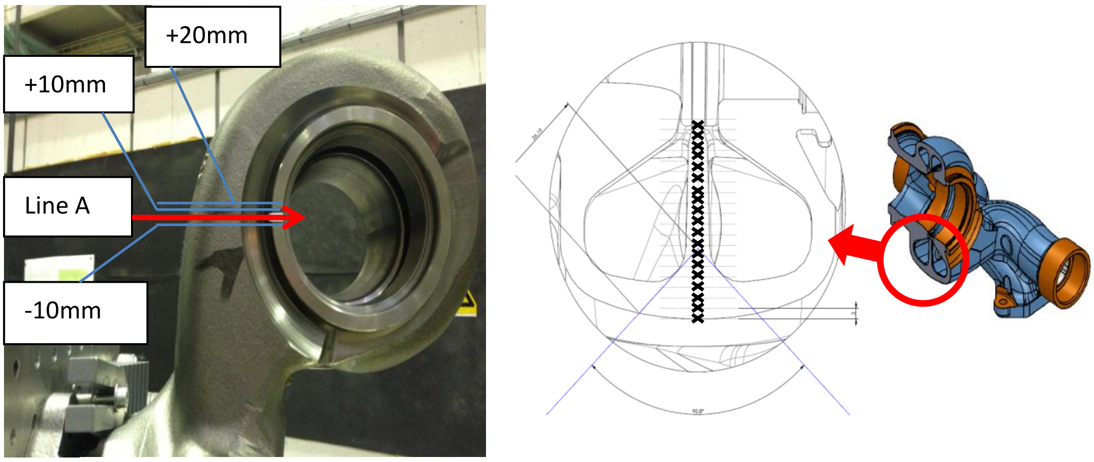

Figure 1. Strain measurement locations

Preliminary Results

Unfortunately the experiment took longer than initially planned and subsequent measurements were required for full analysis. Preliminary analysis (Fig. 2-5) shows the 2 ϴ (Deg) measurement as the distance from the outer wall increases, results appear to show that heat treatment may have little effect on the residual strain in the radial and axial directions however once the d0 values are taken into account this could change. Correct hoop measurements have since been made (Feb 14) as well as measurements of the unstrained lattice parameter (d0) and a full analysis of this data is currently under way.

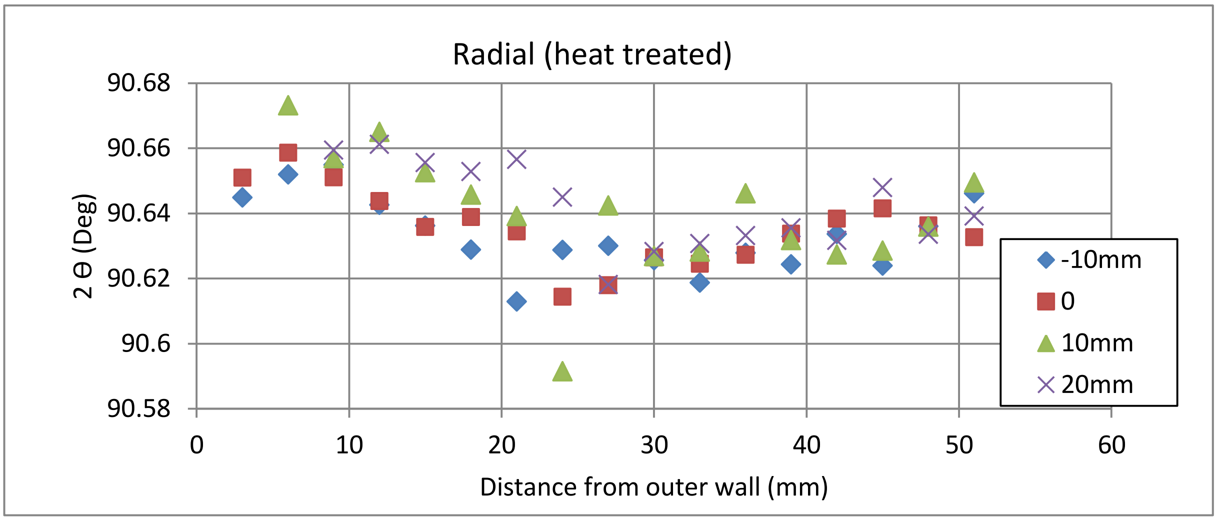

Figure 2. 2 ϴ (Deg) neutron diffraction measurements in the radial direction on the heat treated housing.

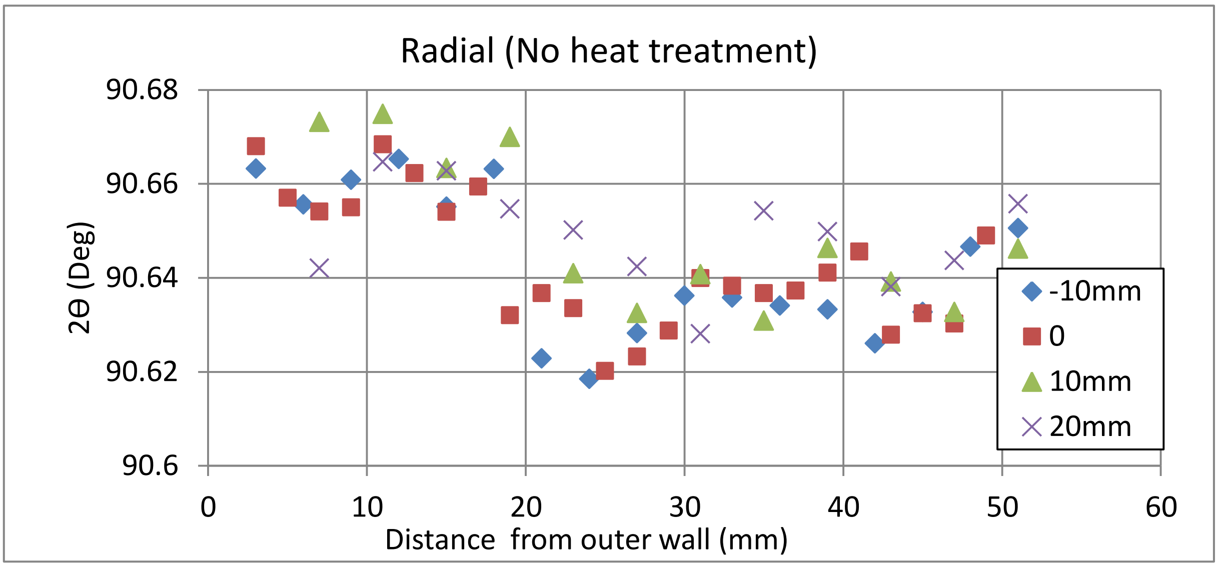

Figure 3. 2 ϴ (Deg) measurements in the radial direction on the housing with no heat treatment

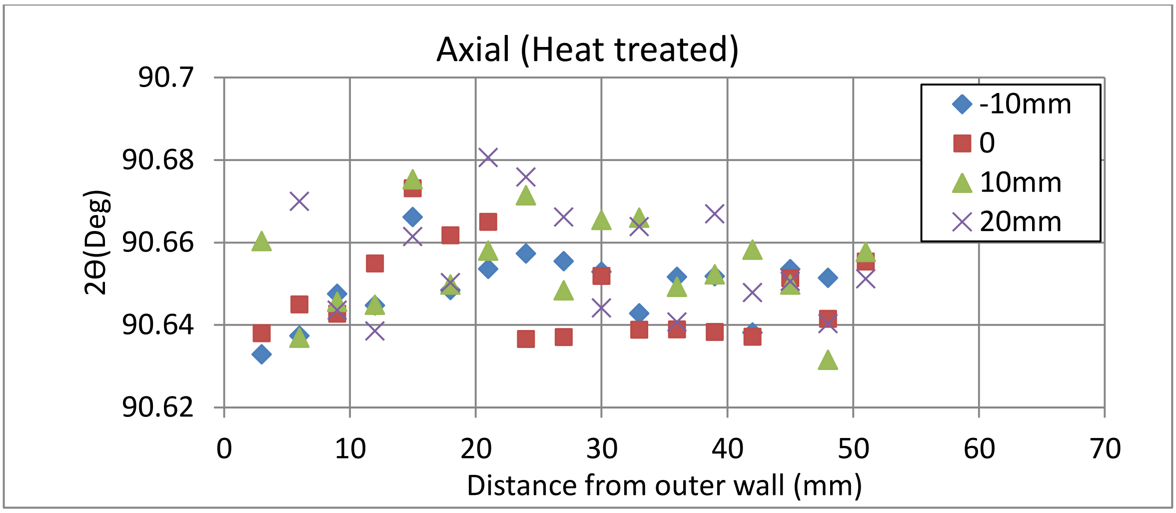

Figure 4. 2 Θ (Deg) measurements in the axial direction on the housing with heat treatment

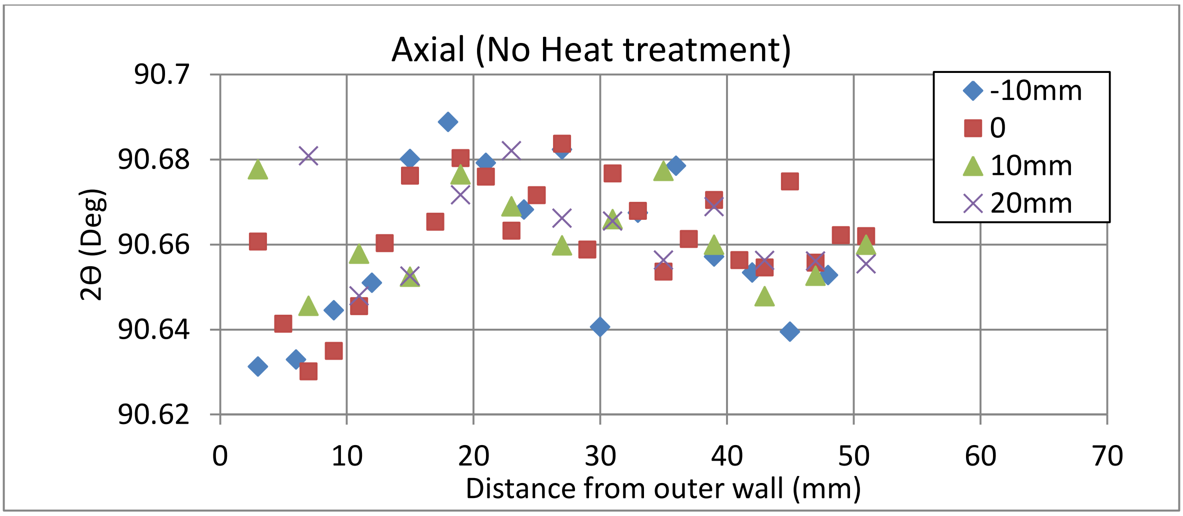

Figure 5. 2 Θ (Deg) measurements in the axial direction on the housing with no heat treatment

References

1. Withers, P. J., & Bhadeshia, H. K. (2001). Residual Stress: Part 1- Measurement Techniques. *Material Science and Technology, 17*, 355-365.

2. Webster, G. A., & Wimpory, R. C. (2001). Non-Destructive measurement of residual stress by neutron diffraction. *Journal of Materials Processing Technology, 117*, 395-399.

3. Shin, M. W., Jang, J. K., Kim, H. Y., & Jang, H. (2013). The Effect of Residual Stress on the Distortion of Gray Iron Brake Disks. *Journal of Materials Engineering and Performance, 22*(4), 1129-1135.