Investigation of Residual Stress Distribution of Wheel Rims using Neutron Diffraction

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Introduction

Damage accumulation due to fatigue significantly reduces the safety of railway vehicles. The large stress, perhaps due to wheel/rail impact or material discontinuity, is responsible for the initiation of shattered rims (Fig. 1). The 'new' wheels have a better resistance to the shattered rim failure, due to the fact that the circumferential residual stress on tread of a new wheel must be compressive and compliant with requirements of International standard EN 13262.

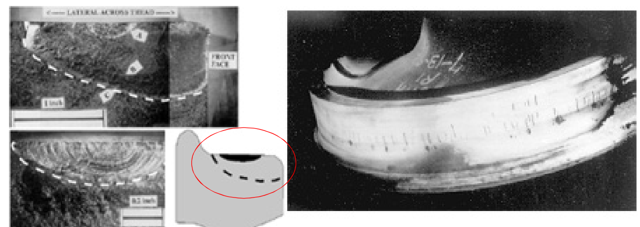


Figure 1.The wheel cracks within the critical region in red [VOLPE National Transportation System Center]

This may not necessarily apply for millions of 'old' wheels that are still in use. At the moment the residual stress measurements are carried out using destructive method but due to the challenging size (diameter over 1m) and weight (500kg) of the high speed wheel, neutron diffraction is the only non-destructive method suitable to provide information about the residual stress profile within the bulk.

Neutron Diffraction Measurements Method

ENGIN-X beamline at ISIS Rutherford-Appleton Laboratory was used to investigate the residual stress distribution on the rim of a new (as manufactured) wheel from a Tenitalia ETR-500 high-speed train. Such manipulation of heavy and bulky engineering samples in the vicinity of delicate instrumentation is not trivial, and has traditionally been performed manually. The unique virtual laboratory available on Engin-X (use strain scanning software SScanSS) was used to prepare and optimized the measurements. The preparation and measurements procedure is shown on Fig. 2.

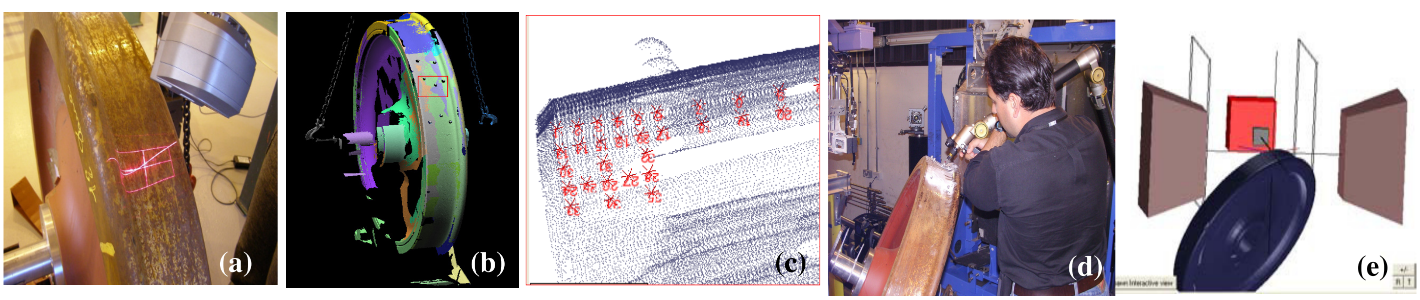
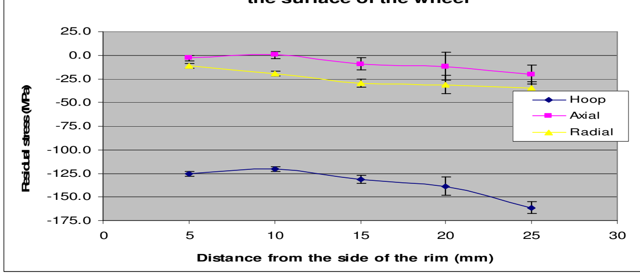


Figure 2. The measurement procedure: (a) laser scanning, (b) model preparation from the point cloud, (red square represents the are of interest) (c) specifying the measurements within the SScanSS software prior to experiment, (d) touch probe measurement during alignment set up of the wheel for the hoop measurements on the Engin-X positioner and (e) simulation of the measurements within the SScanSS.

Results and discussion

This pilot study has demonstrated the possibility of using neutron diffraction as a method for quantitative 3D residual stress analysis of large and heavy samples such as a train wheel. Fig. 3 show the typical residual stress distribution of the new wheel where we can clearly see desirable compressive stresses in the hoop (circumferential) direction. This investigation provided valuable feedback to the FEM modellers of the wheel manufacturing processes.

Figure 3. The residual stress distribution 5 mm below the surface of the wheel



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