INDUSTRIAL PILOT PROJECT

Non-destructive residual stress analysis on thick welds of Ti-6Al-4V plates for aerospace using neutron diffraction

THE INDUSTRIAL CHALLENGE

The aerospace industry tends to replace large casted structures with smaller free form sections which is assembled with welding. This approach increases the flexibility in manufacturing and reduce costs. However, it may introduce unfavourable residual stresses that could cause geometric distortions and out of tolerance problems. In order to supress the welding induced stresses, it is important to adjust the welding process. This can be accomplished using finite element (FE) simulation, but these numerical tools need to be experimentally verified.

WHY USING A LARGE SCALE FACILITY

The accuracy of FE-simulations can be verified in the surface region with X-ray diffraction measurements and deeper internal stresses by the contour method. X-ray diffraction measure the strains within the crystalline lattice while the contour method measure the relaxation of strains when the part is sectioned. Both methods are however destructive and in order to verify internal stresses of thick components non-destructive neutron diffraction (ND) is the only possibility.

HOW THE WORK WAS DONE

The project focused on the Electron Beam welding process. A sample was produced, with the dimension 400x100x55 mm. The sample was further prepared for ND by sectioning in order to access the stains in the centre of the sample which on the same time gave the input data to the contour measurement. The stresses were characterised with conventional lab-XRD and the Contour method. The neutron diffraction measurements were done remote at the beamline Engin-X at the ISIS Neutron and Muon Source in England. Beamline scientist Saurabh Kabra is acknowledged for the support.

THE RESULTS AND EXPECTED IMPACT

The selected samples size was really pushing the limit for ND but in discussion with the beamline we planned for strategies of how to as assess the most possible data. Even though these strategies were employed, the results showed that the sample thickness limited the amount of data that could be retrieved for this sample thickness. Unfortunately, a smaller sample geometry could not be used due to the welding process and it was not possible to make the sample smaller before measurements since this will influence on the internal stress state. The retrieved strain data was compared to FE-simulation and the other measurements, lab-XRD and contour method. The ND data showed similar strain-profiles but a large difference in magnitude compared to the strains measured with the contour method. Instead, the residual stresses measured with the contour method verified the FE-simulation and showed high correlation.

The project did verify the FE-simulation but could not retrieve enough strain data with ND to calculate the stresses which requires strain data in all three directions for each position in the sample. The project has gained important knowledge when planning for future ND studies where the sample size needs to be designed taking the maximum neutron traveling distance in mind. We also plan to perform future measurement using neutron imaging at ISIS which is a technique that measured large areas in the sample with very high spatial resolution.

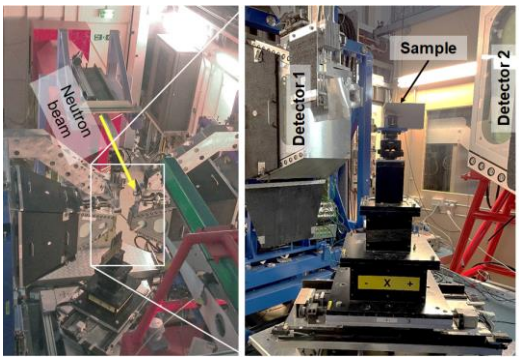

Figure. Sample setup at Engin-X showing the neutron beam entrance from the cut cross section setup (left)and the xyx-stage holding the sample between the two detectors.

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