RESIDUAL STRESS REDISTRIBUTION IN A WHEEL/AXLE ASSEMBLY DUE TO CYCLIC LOADING

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Introduction

With increasing speed of the trains, fail safe design of the wheelset assembly has become of key interest. In some cases micro-cracks can be initiated close to the ends of the wheelset overhang. Fretting fatigue is usually associated with this crack initiation process. The present study is a contribution to a larger program devoted to safety assessment of the wheelset assembly. The aim of this work is to have a better knowledge of the in service evolution of the residual stresses in the structure.

Because of the very low penetration power of the X-rays, neutron diffraction experiments were conducted to characterise the stress state evolution at the interface between axle and wheel. Two reduced scale assemblies (1:3) have been tested before and after low cycle fatigue (1000 cycles) in rotary three point bending. In order to limit the neutron path, drilling holes access was performed according to the criteria established by a previous study (E. LABBE et al., Neutron diffraction residual stresses evaluation in railway wheels, Journal of Neutron Research (2001), vol 9, pp. 393-397).

Experiments

A three-dimensional modelling of the assembly has been performed to simulate the press fitting process and the cyclic loading. Numerical results are compared with experimental ones.

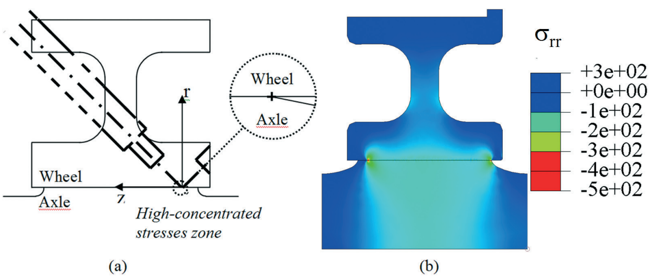

Figure 1. (a) Drilling orientation: radial strain measurement. (b) 2D axisymmetric press fitting simulation : high stress level zone.

These results have already been presented *(Labbé et al.)*. The grid spacing is 1 mm. The shortest path for the neutrons gives the maximum of intensity, this maximum is around 3 mm above the interface (the dash pots line on the maps, figure 2) :

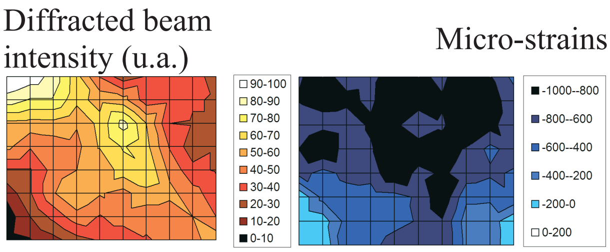

Figure 2. Radial strain measurement in a press fitted assembly after press fitting.

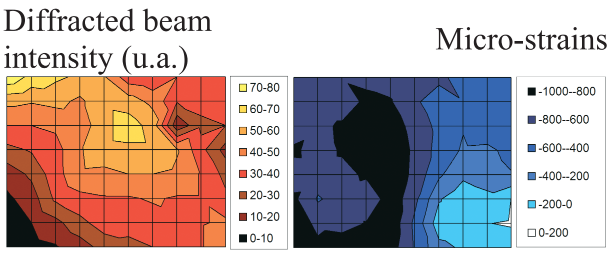

Figure 3. : Strain measurement in a press fitted assembly after press fitting and fatigue test.

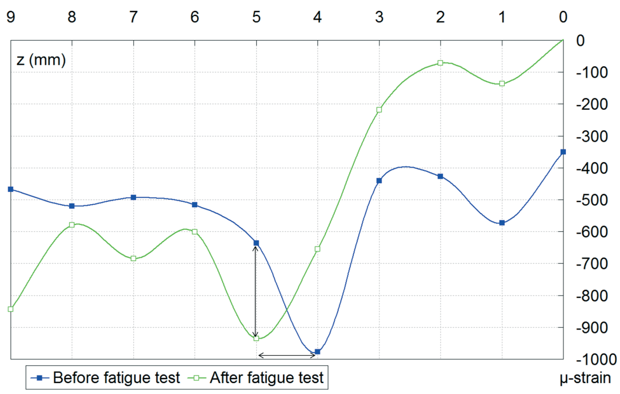

Figure 4: Experimental radial micro-strains along interface after press fitting and fatigue test.

The loss of clamp can be seen through the decrease of the micro-strain, Δ≈300 micro-strains. The peak shift is equal to 1 mm. During the fatigue test cycles, the wheelseat extremities (and of course the geometrical singularity) were first deformed plastically and rapidly the contact between the wheel and the axle in this zone is lost.

Submodelling and loading :

To run a submodel is first to perform the complete analysis on the global structure, and then, from the result (displacement of the nodes), to "drive" in displacement the boundary of a substructure (zone of interest). The submodelling is very useful, because of the large dimensions of the assembly. In our case the substructure is the part of the assembly close to the interface.

Results

The submodelling gives the following results (figure 7) :

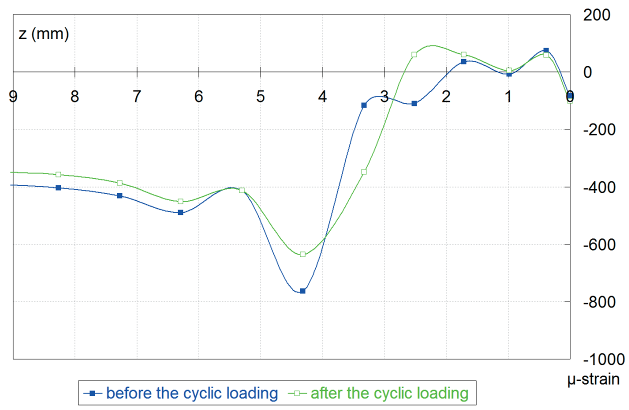

Figure 5 : Numerical radial micro-strains along interface after press fitting and cyclic loading.

A decrease of the compressive is observed, but no shift : 5 cycles is enough to initiate the plastic deformation of the geometrical singularity, but this loading can't produce a loss of contact at the extremity of the wheelseat.

The decrease is important and surely surestimated, this can be due to parameters of the model (σ_0=199 MPa).

Conclusion

Due to a penetration power, higher than the X-rays one, neutrons permit strain measurements inner an industrial assembly. The technique was very useful for the calibration of the numerical parameter for the simulation of fatigue process.

Neutron diffraction technique gives a precise description of the residual radial stress field induced by press fitting process in an industrial assembly. We have a very good agreement with the numerical modelling for the initial mechanical state.

In more, in a fatigue tested assembly, neutron measurements highlighted the loss of clamp between the two pieces. This decrease directly affects the mechanical integrity of the railway assembly. A local loss of clamp and the subsequent local loss of contact could lead to fretting fatigue crack to occur.

Presently, the numerical model doesn't show the peak shift, increase the cycle number in the model must improve results. Nevertheless, with only 5 cycles, the model is able to reproduce the decrease of the peak, provided a precise description of the constitutive equation of the material.

Ce travail a donné lieu à une publication dans Neutron Research, dont les références sont :

Residual Stress Redistribution due to Cyclic Loading in a Railway Wheel/Axle Assembly
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