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Measurement of residual stresses in the hole of railway axle

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Abstract. Values of the residual stress are very important for fatigue life of machinery components. It is likely to be the same for the railway wheelsets. In the most of the cases the pressure values of stress are required in proximity of the surface e.g. the standart EN 13 261 for railway axles allows the maximum value of stress +100MPa in the distance of 0,1mm under the surface. In many cases the hollow railway axles are used with the advantages of design motor axles. The determination of residual stress is not feasible with the regard to usual diameter of the hole from Ø30mm to Ø110mm. This thesis is focused on the possibility to determin of the values of the residual stress in the bore of railway axle by hole drilling method. The measuring was done with the use of hole drilling device RESTAN 3000. Measured values of residual stress in close proximity of the bore of axle were compared with the measurement of X-ray method.

Introduction

Measurement were done on surface of hardened railway axle from material of A4T quality. With regard to the Ø65mm axle bore diameter, the measurements had to be made in the journal area to allow the installation of the strain gauge RY61-1.5 / 120S.

Measurement by longer milling cutter. A Ø14 mm hole was made in the opposite axle wall against the selected measuring point in the bore. Subsequently, the center of the strain gauge rosette was focused using a laser cross, as shown in Fig. 1. Because of the access during installation, the strain gauge rose was located approximately 45 mm from the end of the hole in the journal of axle.

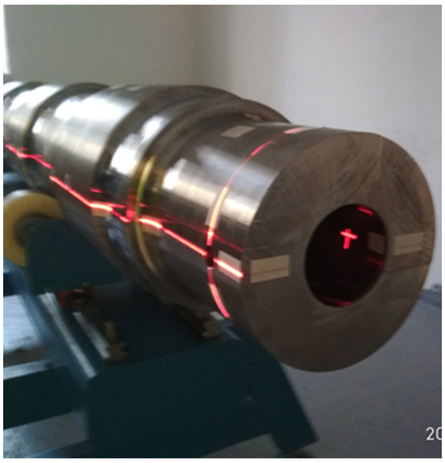

Fig 1: Measuring middle of the strain gauge rossete

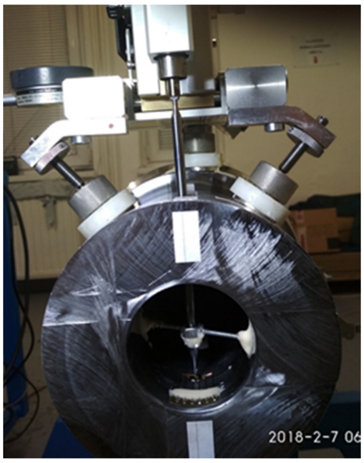

Fig 2: The test arrangement

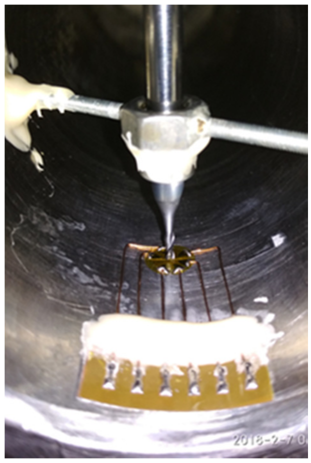

Fig 3: Drilling detail

After installation and connection of strain gauge type RY61-1,5 / 120S with drilled hole, which was done by drilling cutter. Subsequently, drilling was carried out with an extended length of 160mm, nominal Ø2mm to a depth of 1mm. As can be seen in Figs. 2 and 3, due to the limitation of the milling cutter, this was held inside the hole by a needle bearing. Due to the focal length of the distance microscope, the test arrangement does not allow a direct optical focus of the hole. A special touch probe with a Ø1mm end was used to read the diameter of the hole made by using the micrometric feed table of the RESTAN drill stand. When the probe is attached to the cutter drive with the side of the hole, the electric circuit closes and thus optical and audible signaling occurs. The method of measurement is shown in Fig. 4.

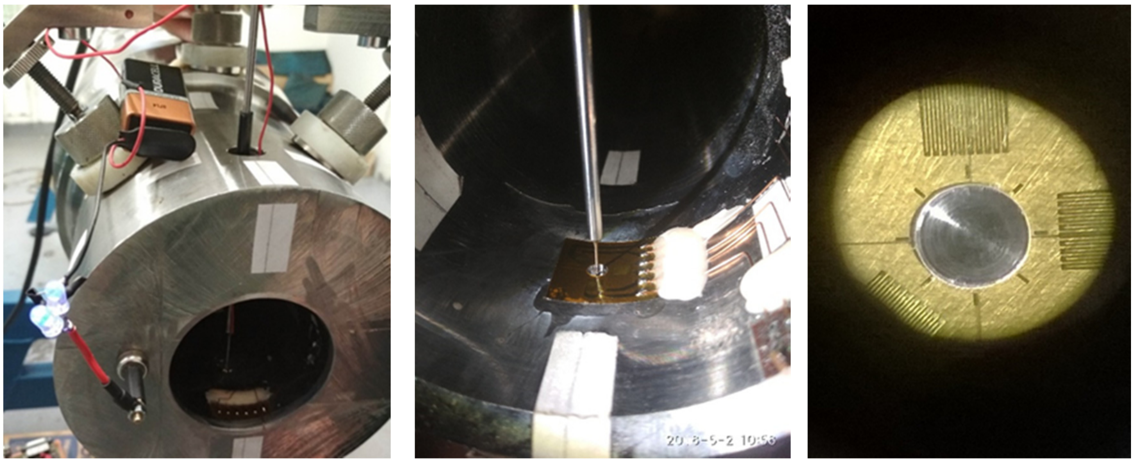

Fig 4: Measuring hole diameter, in the middle is probe in contact with the edge of the hole, on the right view of the drilling hole

Measurement were done by 20 steps of drillng to the 1,0mm depth. We used hole drilling RESTAN stand. We used strain gauge rossete HBM RY61-1.5/120S. Evaluation of the results was performed in the EVAL program using the E837-13 EXT Not Unif method. Depth profiles of directional stresses in the bore of axle are shown in the graph in the following Fig. 5.

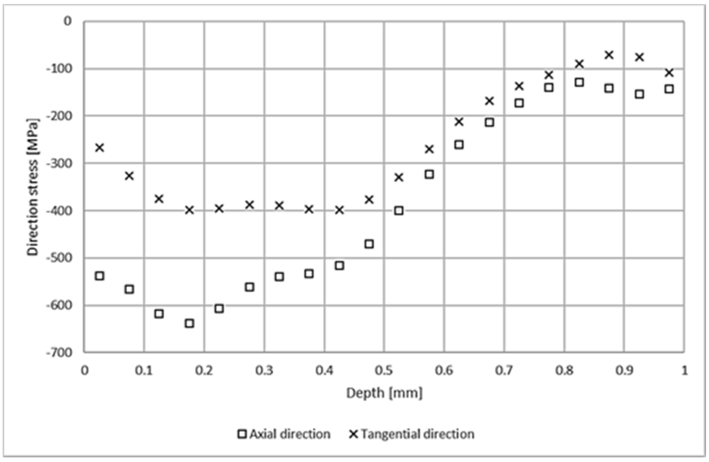

Fig 5: Depth profile of stresses in the bore of axle

Comparasion of results with X-Ray method. Measurement by X –Ray method were done on the small piece of axle. Measurement were done using the Stresstech ROBOT – see fig.6. Electrochemical etching to a depth of 0.2 mm below the surface was performed to obtain a depth stress profile. Calculations of stresses were performed in the XTronic program according to the European standard EN 15305. The determined stress profiles are shown in the graph in FIG.7

Fig 6: Measurement by X-Ray diffraction

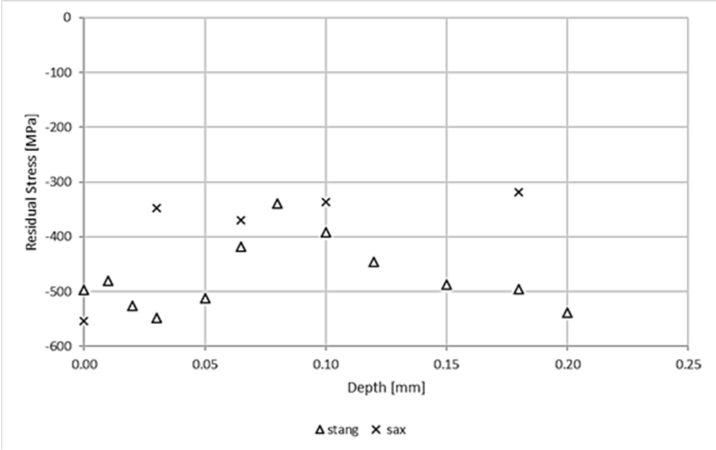

Fig 7: Depths profiles of stresses in the hole on the piece of axle

Conclusions

The use of an longer cutter allowed the determination of residual stress values in the bore of the railway axle without the need to cut the test piece. Strain gauge hole drilling method and X-Ray diffraction confirmed big compressive stresses on the surface of the hole and very near of the hole. During the measurement of longer cutter were residual stress in axial direction in distance 1 mm under the surface from -129 MPa to the-638 MPa, tangential from -71 MPa to the -398 MPa.
Measurement on the piece of axle using by X-Ray method confirmed occurence of compressive stresses. In axial direction were measured values from -319MPa to -554MPa and -339MPa to -549MPa in tangential direction.

References

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