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APPLICATION OF STRAIN GAGE HOLE DRILLING METHOD AS A TOOL FOR MONITORING INFLUENCE OF TECHONOLOGIES ON TOTAL STRESS STATE IN HIGH STRESSED STRUCTURES

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Summary: *The paper deals with an application of drilling method in order to determine the residual stresses in big forgings for turbine rotors and railway axles. Residual stress was measured on two forgings of both cases having different heat treatment. Both pieces were identically heat treated by hardening and tempering. Then one piece from both cases was annealed in order to eliminate residual stress. The measuring procedure and the experiment results is described in the contribution. The reason for these experiments was evaluation of impact of different treatment on the level of the induced residual stresses.*

1. Introduction

Contemporary requirements for higher outputs and simultaneous demands for higher reliability of structures compel application not only of better materials and modern means of analysis on a higher level during design but more precise technologies. Any failure of highly stressed parts in operation has to bring catastrophic accidents as we know from aviation, high-speed train traffic or big energetic machinery. Railway axles or turbine rotors belong to the group of extremely dynamically loaded parts. That is why high attention is given to these parts during all steps from design over producing to operation [L1].

The paper deals with determination of residual stresses in the surface layer of turbine rotor and railway axle after forging, heat treatment and turning. The aim of all activities is to assure the limits of residual stresses induced into the above mentioned parts during above mentioned technologic operations and to give some recommendation from the point of residual stresses.

Methodology for evaluating and determining of residual stresses in structures is given by the ASTM Standard E 837 [L2]. This measuring procedure, when all requirements and conditions are satisfied, ensure repeatability $\pm 5\%$. Verification of this limits was carried out before [L3], [L4]. Thus the residual stress determination became one of the inspectional procedures during producing turbine axles [L5], [L6].

2. Practical application at the turbine rotor

The client asked to examine the residual stress state on the maximum of the examined surface. Time and financial conditions badly keep down the total number of measured points.

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It was concluded to measure the stress state in five cross sections, where two points are located on the diameter. To cover the maximum of the surface the cross sections were turned each other by 120^o.

The rotor was made of steel ČSN 16536 (R_m = 980 MPa, $R_{p\ 0,2}$ = 670 ÷ 830 MPa) and the so called safe limit of residual stresses was taken as $0{,}1.R_{p\ 0,2}$. The measuring should reliably fix the quality of examined structure as to residual stresses. If the rotors had not satisfied the residual stress limits then the heat treatment should have been repeated under stiffened and more accurate conditions. In such a way the experimental method became a control one in the technology.

Material constants were determined by measuring the sample of the used material for the rotor. From the measured deformation during drilling the determined hole and with the use of constant respecting rosette geometry, diameter and the depth of the drilled hole were taken from TN 505-3 of Vishay Co. [L7].

The results of the determined residual stresses along the depth of the drilled hole [L8]. In three sections with two measured points situated opposite will be shown. In all points residual stresses in the surface layer were in pressure, as it was required, and their protracted and unruffled course proves homogeneity of the residual stress state and maximal values do not exceed the prescribed limits. Also the orientation of the main stresses proved good homogeneity of the stress state and consequently the good quality of heat treatment and at the end good quality of the product.

After residual stress measurement fine turning took off the layer containing the holes.

3. Conclusion

The paper briefly presents the results of residual stress measurement on the turbine rotor and railway axle. Simultaneously it proves applicability of the standard hole drilling method as inspectional method for heat treatment [L9].

4. Acknowledgements

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