Study of the precision and accuracy of the acoustic birefringence for evaluation of residual and applied stresses

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Keywords: acoustic birefringence; stress; precision; accuracy

This work presents a numerical procedure for estimation of the precision and accuracy of the acoustic birefringence technique as used in the Nuclear Engineering Institute (IEN) for evaluation of residual and applied stresses in structures [1, 2]. This procedure shall be incorporated later to the signal processing module of ultrasonic system used at IEN's Ultrasonic Laboratory to account in an automatic and systematic way for the uncertainties in the input data and their propagation throughout the calculations.
The acoustic birefringence is generally defined from the speeds of two mutually orthogonal volumetric waves of normal incidence, but it can also be defined directly from the time-of-flight of the waves since they travel the same physical space. The times-of-flight of the waves can thus be regarded as the primary variables of interest. They are estimated by coupling the mathematical techniques of cross correlation and data interpolation, whereas the material's acoustoelastic constant is determined via a weighted linear regression. By means of the acoustoelasticity, it is possible to relate the acoustic birefringence with the stresses acting in the material exploring the fact that the velocity of the ultrasonic wave is changed by the existence of a stress field (a phenomenon called acoustoelastic effect) [2].
An Excel spreadsheet performs all calculations taking into account the uncertainties in the input data, their propagation throughout the calculations and the number of significant digits in the results. As an example of the procedure developed, the estimation of the precision and accuracy in the evaluation of the stresses acting in a beam under bending is presented. The analytical solution derived from the strength of materials theory was used as the reference value for accuracy estimation purpose [3-5].

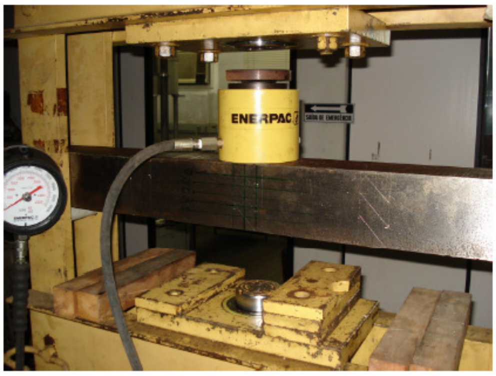

Figure - Flection test of the steel 20 MnMoNi 55

The results indicated a reasonable precision, with a relative error less than 8%, and a poor accuracy, with less than 57% at the points of the beam subjected to the maximum and minimum principal bending stresses.

References

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