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Photoelastic Tomography with Linear and Non-linear Algorithms

Photoelastic tomography is a non-destructive method of 3D stress measurement. If birefringence is weak or rotation of the principal stress directions is small (the linear approximation), it is based on two integrals of the stress components, which can be measured on every light ray by tomographic scanning of the specimen. In the general 3D case the normal stress distribution in an arbitrary section can be determined.

In the axisymmetric case, besides the axial stress distribution also the shear stress can be determined. The other stress components are calculated with hybrid mechanics algorithms.

For the axisymmetric case also a non-linear algorithm of photoelastic tomography has been elaborated. It is based on the method of differential evolution. Experimentally the characteristic parameters are measured on many light rays. A population of possible stress fields is generated. This population is iteratively modified with a genetic algorithm so that the measured and calculated characteristic parameters over all the measurement points are possibly close to each other.

The paper is illustrated by several examples of residual stress measurement in glass articles.

DSc. Hillar Aben was born in Tartu, Estonia, in 1929. He graduated from the Tallinn University of Technology in 1953. He obtained the DSc degree from the Estonian Academy of Sciences in 1966. His main research area has been integrated photoelasticity – a nondestructive method for the measurement of 3D stress fields. Theoretical foundations of integrated photoelasticity are presented in his book “Integrated Photoelasticity,” published in 1979 by McGraw-Hill, NY. Integrated photoelasticity is mostly used for residual stress measurement in glass articles of complicated form. On this topic he has written together with C. Guillemet the book “Photoelasticity of Glass” (Springer-Verlag, 1993, Berlin).