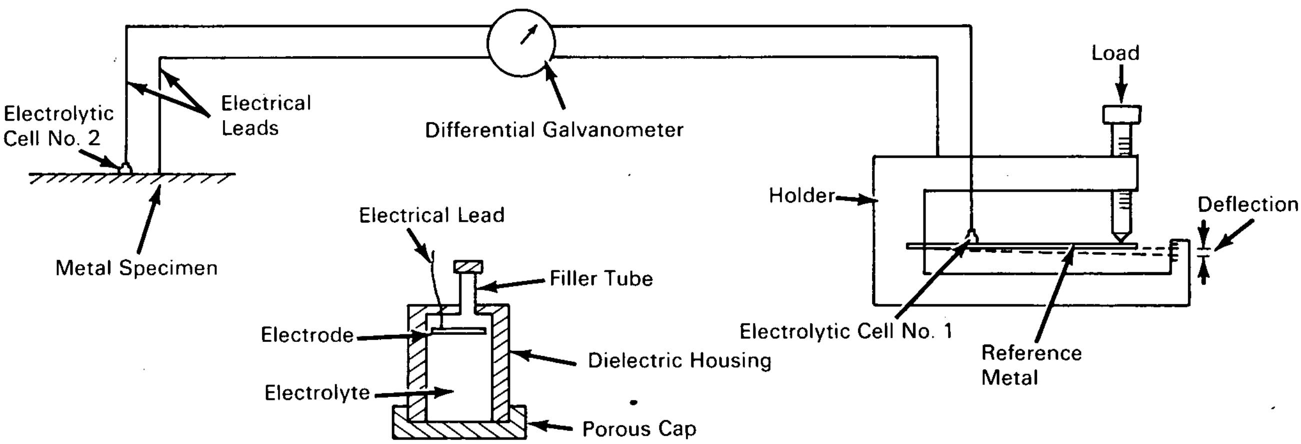
NASA TECH BRIEF

Nondestructive Method for Measuring Residual Stresses in Metals, a Concept



CROSS SECTION OF ELECTROLYTIC CELL

A nondestructive method has been conceived to provide direct measurements of residual surface stresses in metals. Such stresses can exist in a body in the absence of external forces and occur, for example, after shot peening and other surface treatments. The proposed method is based in principle on the empirical fact that a metal under stress has a different electrochemical solution potential than in the unstressed condition. The method would use two matched electrolytic cells to cancel all extraneous effects on the actual solution potential of the metal specimen.

The illustration shows an apparatus for measuring the residual stress on a metal specimen. This specimen is placed in contact (through a porous cap) with one of the electrolytic cells. A reference strip of metal, which has the same chemical composition as the test specimen but which has not been subjected to shot peening, forming, or any other treatment or deformation applied to the test specimen, is mounted at one end in a holder. The holder provides a cantilever support for the reference metal and allows the application of known loads to the free end of the reference metal. A second electrolytic cell, identical to the first cell, is placed in contact with the reference metal at a known distance from the point of application of predetermined loads. Electrical leads connect both electrolytic cells to a differential galvanometer.

The deflection of the galvanometer needle will indicate the net potential difference between the test specimen and the reference metal. The direction of the deflection will depend on the orientation of the residual stress at the surface of the test specimen. With the arrangement shown, if the galvanometer indicates compressive stress, the holder should be inverted and cell No. 1 placed on the opposite side of the reference metal. A load is gradually applied to

(continued overleaf)

the free end of the reference metal, stressing the surface of this metal. When the galvanometer reads zero, the stresses in the test specimen and reference metal are of the same magnitude. Having matched stresses, the stress in the reference metal can be determined accurately from the measured deflection of the cantilever strip (reference metal) and its known modulus of elasticity. The residual stress in the test specimen is then of the same magnitude as the calculated stress in the reference metal.

The walls of the electrolytic cells (cross sectional detail) are made from a dielectric material. An electrode is mounted at one end of the cell, and a porous cap is placed on the opposite end. The electrode should be constructed from the same kind of metal as that under test to avoid swamping the galvanometer with large voltages. It is important that the two cells be matched in potential as closely as possible. Matching can be accomplished by nulling the two cells on the same piece of metal when the cells are fabricated and filled with electrolyte (such as dilute sulfuric acid). The cells should normally remain matched during the life of the apparatus.

Notes:

1. This method is in the conceptual stage as of the date of this Tech Brief; only a simple prototype of the apparatus has been constructed to demonstrate feasibility.
2. It is believed that this concept can be developed for the nondestructive measurement of residual stresses as an aid in metal fatigue studies and the evaluation of the effectiveness of shot peening and other surface treatments.

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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