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MEASUREMENT OF RESIDUAL STRESSES BY LOAD AND DEPTH SENSING SPHERICAL INDENTATION

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ABSTRACT

The finite element method was used to determine whether load and depth sensing indentation with spherical indenters may be useful in the measurement of residual stresses in materials. The spherical indentation process for a wide range of elastic/ideal-plastic materials to which compressive and tensile biaxial stresses were applied was simulated using standard finite element techniques. The elastic moduli and yield stresses of the materials were varied systematically to model the behavior of a wide variety of metals and ceramics. Elastic-ideal-plastic materials were considered, with the residual stress levels varied from zero up to the yield stress. All three indentation regimes - elastic, elastic-plastic, and plastic - were examined, with emphasis given to the elastic and the early part of the elastic-plastic regimes, where differences in the load-displacement characteristics caused by residual stress were found to have a particularly significant effect. Systematic examination of the relationships among residual stress, contact pressure, and elastic recovery revealed a simple, measurable indentation parameter which correlates well with the residual stress. Using this parameter, an experimental technique is proposed by which residual stresses can be estimated in the elastic-plastic regime from measurements of the indentation load, the yield stress, and the elastic modulus of the material, all of which can be determined by load and depth sensing indentation methods. Based on an critical examination of the technique by finite element simulation, the technique appears promising.

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