EFFECT OF THE BOTTOM-HOLE FILLET RADIUS ON THE RESIDUAL STRESS ANALYSIS BY THE HOLE DRILLING METHOD

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In the residual stresses analysis by the hole drilling method, the evaluation of the residual stresses is performed by using influence functions determined numerically by considering a perfect cylindrical hole. Unfortunately, due to various experimental influence parameters the hole shape is different from the considered one in the numerical simulations. One of the most important deviations is constituted by the the bottom-hole fillet radius.

In this work the effects of the bottom-hole fillet radius in the relaxed strains measured on surface in presence of a uniform residual stress distribution, have been analysed by systematic numerical simulations carried out by a BEM code. Consequently, a closed-form expression that allows the user the evaluation of strain deviation $sd_{\%}$ has been found by a least square procedure:

$$sd_{\%} = 100\frac{\varepsilon_\rho - \varepsilon_0}{\varepsilon_0} = \sum_{i=1}^{3}\sum_{j=0}^{5}\left[\left(c_{0ij} + c_{1ij}d + c_{2ij}d^2\right)(\rho)^i h^j \log h\right], \tag{1}$$

In eq.(1) ε_ρ and ε_0 are respectively the strains relaxed in presence and in absence of the fillet radius, $h=z/R$ is the ratio between the hole-depth z and the rosette average radius R, $\rho=r/D_0$ is the ratio between the bottom-hole fillet radius r and the hole diameter D_0, $d=D_0/D$ the ratio between the hole diameter D_0 and the average diameter D of the rosette. The c_{sij} coefficients (s=0÷2; i=1÷3; j=0÷5) are the parameters provided by the least square method; these coefficients depend on the rosette geometry and on the Poisson ratio.

The micrographic analysis of the section of holes drilled by several procedures, has shown that the bottom-hole fillet radius can reach $\rho = 0.30$ for EDM, whereas the use of an inverted cone tungsten carbide end-mill can lead a bottom-hole fillet radius with ρ=0.10. Especially for small hole-depth, as confirmed also by several experimental tests, these ρ values lead to $sd_{\%}$ greater than 20% and, consequently, wrong non-uniformity test results and wrong residual stresses are evaluated by the ASTM E837 Standard Test procedure.

In the present work a simple procedure to evaluate the effect of the bottom-hole fillet radius as well as the relative stress uncertainty due to the fillet radius estimation, is proposed.