Fatigue crack growth in pin loaded cold-worked holes

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An experimental program has been carried out for the evaluation of the fatigue crack growth in 2024-T351 aluminium alloy specimens, where a hole was present, subjected to the split sleeve expansion process. In previous ICAF Symposia, some information has been already given about the first part of the experimental activity (Helsinki, 2015) and about the development of a numerical analysis method (Nagoya, 2017). Both such preliminary papers referred to open hole specimens, always tested under Constant Amplitude loading, while in the last year a pin loaded configuration has been evaluated. The non-inspectability of the configuration required some particular experimental effort, in order to collect test results in terms of crack growth as a function of number of cycles. To this end, a marker load technique was adopted: a block of high R ratio cycles (R=0.9) was inserted in the R=0.1 sequence, with the aim of obtaining pictures of the crack front evolution at different number of cycles.
The three-dimensionality of the residual stress field required an EDM notch inserted on the mandrel entry side face; a 1 mm radius quarter-circular notch was introduced. Unfortunately, during the test program execution it was clear that sometimes the EDM notch had been introduced on the wrong side, and so natural cracks could nucleate on the entry side. It was therefore decided to include also mechanically milled notches, of similar dimensions, in order to guarantee that a crack initiated on the "right" side. This situation has sometimes generated almost contemporary crack growth at both notches, with a slight mutual influence. This situation has required more attention in the evaluation of the results.
Anyhow, the results show a rather regular front evolution (for instance, see Fig. 1), and have provided important material for the development of accurate numerical methods, based on the evaluation of the residual stress field and on the subsequent modification of the stress intensity factor distribution along the corner crack front.

Fig. 1 – Example of crack front evolution, from a mechanically milled notch.

The numerical analysis methodology is a specialization of the technique, already presented in the Nagoya Symposium, to the problem of single or double corner crack in a pin loaded hole. In particular, the strong three-dimensionality of the stress field poses a challenge to the block-by-block propagation analysis.

Keywords: Split sleeve cold working, pin loaded hole, corner crack