FRACTURE OF LONGITUDINALLY CRACKED DUCTILE TUBES

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SUMMARY

In the frame of safety studies undertaken on LMFBR's structures, burst tests of longitudinally through-cracked tubes of ductile steel (AISI 304) have been run. In this work, an attempt is made to get a reasonable ascertainment of the degree of safety that is insured using methods that are not always conventional.

The present paper deals with through-cracks and in particular discusses the fields of application of some theoretical or semi-empirical criteria. A first F.M. approach that is taken into consideration in this paper is related to crack's initiation of propagation where the load carrying capacity increases to a maximum, while the crack's original length remains unaltered. A theoretical approach as suggested by ERDOGAN has been taken into consideration. In this paper a formula is proposed that is based on the known logsec expression by Burdekin and Stone for the crack opening stretch in which however the hoop stress value is magnified by the shape factor M. Then, by calculating the locus of the points corresponding to the same slope (high, value, arbitrarily chosen) in a set of curves: COD vs. nominal hoop stress, for various shell parameters λ a new correlation follows between shell parameter λ and hoop stress. The concept of ultimate collapse of a cracked tube, based on the original shape and size of the structure has been investigated and results are given of lower bound failure predictions. The results are somewhat overconservative. On the other hand the simple application of the known EIBER rule where the tube is treated like a plate (equal thickness and stress field) but where the loads are magnified by the factor M yields good results for the small λ values but is non-conservative for the larger values. The utmost importance of being able to relate M vs λ in the most accurate way has led us to consider the utilization in this paper of Krenk's theoretical approach concerning a 10th order shell theory which accounts for transverse shear deformation as against 8th order theory generally used so far.

Along a same line of thoughts, the paper will deal with an evaluation of the bulging of cracked tubes by means of FEM using the 1/4 point singularity element of the 3D quadratic isoparametric wedge family. A study based on or Hahn, Sarrate, Rosenfield work concerning stress intensity factor evaluation at onset of unstable crack growth has been carried out.

The experimental results that will be given in the paper concern three tube dimensions for a total of about 18 burst tests, λ values ranging from 0.5 to 9. The obvious difficulty in these tests lies in the necessity of introducing rather heavy patches. Specific tests have been run in order to evaluate the weights this may have on burst results and conclusions will be given in the paper. A tentative simulation of the patch stiffness and its structural interaction with the cracked tube is foreseen in the frame of the above mentioned FEM computations.