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Comparison between hot surface stress and effective stress acting at notch-like defect tip in a pressure vessel

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ABSTRACT

In this study, we have compared effective stress obtained by the Volumetric Method (VM) and hot surface stress (HS) obtained by linear or quadratic extrapolations for a longitudinal or transversal surface defect stress distribution in a pressure vessel.

It appears clearly that the definition of hot surface stress through linear extrapolation characterises the gross stress distribution affected by stress concentration.

It has been found that effective stress and hot surface stress are close. This is due to the fact that the tested pressure vessel is made with a thin pipe of ductile material where plastic relaxation induced a smooth peak stress distribution.

Prediction of stress distribution at the deepest point of a surface defect from stress distribution at surface tip of the defect exhibits some difficulties due to modification of stress intensity and stress gradient.

1. Introduction

Most gas pipe defects are due to external interferences according to [1]. An example of such defects is given in Fig. 1 where a series of parallel and inclined gouges provoked by an excavator are seen. Such gouge defects are considered notches and characterised by their length $2c$, depth a, orientation θ along the pipe longitudinal direction and the notch radius ρ.

A notch acts as a stress concentrator. It has been proved that fracture is not ruled by the maximum stress but an acting lower stress. The main argument is the fact that it is possible to find two different situations (fracture or no fracture) with the same maximum stress but with different loading conditions e.g. tension or bending. This proves also the influence of the stress gradient which plays an essential role in notch effect. In order to obtain an acting stress inferior to the maximum stress, several methods have been proposed in literature. Neuber [2] increases fictiously the notch radius by a value of ρ' (Neuber's Constant) and this which gives a new maximum stress inferior to the real one. Peterson [3] takes the stress value at some distance in stress distribution (Point Method, PM). Taylor and Wang [4] uses the average value over a characteristic distance (Line Method, LM). Pluvinage [5] determines the mean value within the volume of the fracture process zone (Volumetric Method, VM). A specific procedure [5] has been proposed in order to determine this fracture process zone. For symmetrical loading, the Volumetric Method is reduced to line method and fracture process volume is practically cylindrical with a diameter called the effective distance.

The second fact which is not often pointed out is when crack initiation emanating from notches is different in fatigue and fracture. Elastoplastic fracture initiation emanating from notch is localised at some distance from the notch tip. This can be clearly seen on the fracture surface of a Charpy *V* specimen exhibiting a mixed fracture appearance, a ductile fracture extension is followed by a brittle fracture surface at a little distance from the notch tip aspect. Another example is given in [5]

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