Displacement based calculation of fracture toughness for cracked pipes using R6 method

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Displacement based calculation of fracture toughness for cracked pipes using R6 method

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Abstract

Determination of fracture toughness, J-R curve from experimental test results requires certain geometry factors such as η and γ. These expressions of geometry factors are available for standard geometries and loading configurations. However, these expressions are not available in open literature for complex geometries and loading configurations. R6 Failure Assessment Diagram (FAD) methodology is used for assessment of failure in the failure regime of cleavage fracture, ductile crack initiation and plastic collapse. Recently, one load based approach was proposed for calculation of fracture toughness by R6 using experimental load vs. crack extension data. On comparison with already reported J-R curves calculated using conventional η-factor approach, predicted results were showing good match for some cases while for few cases it became significantly non-conservative. In this paper, the load based approach is modified to displacement based approach and instead of load vs. crack extension data, displacement vs. crack extension data is used for calculation. The calculated fracture properties using displacement based approach show a marked improvement over results using load based approach while comparing with the conventionally calculated J-R curves. The problem of non-conservatism of predicted fracture properties by load based approach is also resolved by the proposed displacement based approach.

Keywords: fracture toughness property; R6; failure assessment; fracture; J-R curve; cracked pipe.

Nomenclature

a =initial crack size
Δa=crack growth
c=half crack length
D_o =outer diameter of pipe
E= Young's modulus
$E' = E/(1-\nu^2)$
F_b = geometry factor for determination of crack driving force, K_I
I = moment of inertia of the cross section with respect to the neutral axis in beam theory
J = total J-integral (summation of elastic and plastic)
$J_{0.2}$= crack initiation toughness
J_e= Elastic J-integral
J_{mat}= material fracture toughness in plastically deformed regime

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