ABSTRACT

This study extends a micromechanics approach based upon the computational cell methodology incorporating the Gurson model and a deformation-based approach using the CTOA criterion to describe ductile crack extension of longitudinal crack-like defects in high pressure pipeline steels. Laboratory testing of API 5L X60 and X70 steels at room temperature using standard, deeply cracked fracture specimens provides the data needed to measure the crack growth resistance curve and to calibrate the Gurson and the CTOA parameters for these materials. A central focus of the paper is the application of the cell methodology and the CTOA criterion to predict experimentally measured burst pressures for thin-walled gas pipeline containing longitudinal cracks. The experimental program includes precracked pipe specimens with 508 mm (20 inches) O.D. and 219 mm (8 5/8 inches) O.D. with varying crack depth to thickness ratios (at). Plane-strain and full 3D computations are conducted on detailed finite element models for the pipe specimens to describe crack extension with increased pressure. The numerical simulations demonstrate the effectiveness and limitations of both approaches to describe crack growth response and to predict the burst pressure for the tested pipes. While the CTOA criterion still appears to have limited applicability to predict ductile cracking behavior for the pipe specimens, the cell model predictions of the ductile response for the precracked pipes show good agreement with experimentally measured burst pressures.