Liu, M., Wang, Y.-Y., Low-Constraint Back-Bend Test of High Strength Steels: Crack Driving Force Calibration, Proceedings of 6th International Pipeline Conference, Calgary, Alberta, Canada, September 25- 29, 2006, Paper no. IPC2006-10414

Abstract

It has been well-established that the experimentally measured toughness of materials depends on the crack-tip constraint levels. Accurate assessment of the integrity of real structures requires that the laboratory tests be conducted at similar constraint levels as those experienced by the structures. Conventional laboratory tests are usually designed at high constraint levels to obtain "conservative" toughness values. However, pipelines usually experience low-constraint loads; therefore the assessment results using the conventional laboratory test data can be overly conservative.

Back-bend specimen is designed as a low-constraint laboratory test. To obtain the fracture toughness from the test, it is necessary to develop a correlation between the crack driving force, i.e. the crack tip opening displacement (CTOD), and the overall load and displacement. A semi-analytical correlation equation for back-bend tests is presented in this paper. The equation is based on the slip-line theory which was originally developed for rigid–perfectly plastic materials under plane strain conditions. The equation has been extended to take account of the elasticity, yield strength, and strain hardening of the materials. The geometry factors such as the ligament thinning and finite thickness are also investigated. The predicted CTOD driving force by the correlation equation shows a good match with the finite element calculations for a wide range of material properties and specimen dimensions.

Keywords

Low-constraint, Back-bend, Slip-line fracture mechanics, CTOD