Rudland, D., Wilkowski, G., **Wang, Y.-Y.,** Horsley, D., Rothwell, B., and, Glover, A., Investigation into the Use of a Single Specimen for the Determination of Dynamic Steady State Propagation Resistance in High Toughness Line-Pipe Steels, Proceedings of 4th International Pipeline Conference, 2002, Calgary, Alberta, Canada, Paper No. IPC2002-27029

Abstract

This paper summarizes efforts funded by TransCanada PipeLine Limited on improving the methodology for predicting a true measure of the dynamic steady-state fracture toughness of line-pipe steels using a single mill test specimen. In the past, ductile fracture methodologies generally involved using the Charpy V-notch test to empirically quantify the material dynamic ductile fracture propagation resistance. However, due to its geometry, the use of the Charpy test has proven to be unreliable for high-toughness materials, for materials that have rising-shelf energies, and for higher-grade steels (relative to those for which correlations were originally established). An improved methodology for characterizing the dynamic ductile fracture resistance is to utilize the energy from a full-thickness impact specimen, of which the Drop-Weight Tear

Test (DWTT) specimen is the most frequently used type. It has been demonstrated that the total energy from a DWTT-type specimen includes; (1) the energy associated with initiation of the crack (including indentation energy and yielding of the specimen), (2) the energy for transient crack growth from initiation to reaching steady-state fracture, (3) steady-state fracture energy, and (4) a non-steady-state fracture energy region at the end of the test. During the steady-state fracture region it was observed that both the crack velocity and constant crack-tip-opening angle (CTOA) remained constant. This paper presents the results of an investigation aimed at identifying a single specimen that will capture only the steady-state fracture energy present in standard DWTT specimens. Detailed experiments and three-dimensional finite element analyses were used to verify various procedures for eliminating the initiation energy and the residual energy at the end of the tests. A non-instrumented modified specimen, the back-slotted, static-precracked DWTT (BS-SPC-DWTT) specimen, has been developed from the results of these analyses. Energy results from this specimen, for a variety of line-pipe steels, are presented. A correlation between these energies and the propagation energy from standard DWTT specimen is presented. This correlation will aid in the methodology for predicting axial crack arrest in line-pipe steels having higher toughness, a rising upper shelf, or a higher grade.

Keywords

Pipeline, Fracture arrest, Crack propagation