Study of Crack Propagation Through a Welded Pipeline Section

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The increasing demand for natural gas as an alternative energy source implies continued growth of gas pipeline installations. This trend compels the natural gas transmission industry to consider the construction of larger-diameter, higher-pressure pipelines (with operating pressures of more than 15 MPa). The application of high-strength steels in severe conditions will require reliable pipeline designs, as well as inspection and maintenance procedures that will prevent in-service failures. A difficult problem to be solved for the economic and safe operation of high pressure gas lines is the control of ductile fracture propagation. In this case, a safety factor has to be developed for fracture arrest. So, accurate prediction of the resistance to fracture for pressurized pipelines is one of the issues to be solved for the new pipeline designs

Crack tip opening angle (CTOA) which is based on the crack tip opening displacement (CTOD) ductile fracture criterion, is becoming one of the accepted properties for characterizing a materials resistance to crack growth. In particular, it is recognized as a measure of the resistance of a material to fracture, in cases where there is a large degree of stable-tearing crack extension during the fracture process. This type of steady-state fracture resistance takes place when the CTOA in a material reaches a critical value, as typically occurs in low-constraint configurations.

NIST has been studying the use of the CTOA test to develop such data. The test technique is still in development in ASTM (Task Group E08.08.06) and in ISO, and we will be feeding our data back to them to help in tuning the final standard. For example, we will describe the use of modified double cantilever beam (MDCB) specimen (with guide plate to prevent buckling) on very ductile materials, such as these new pipelines.

We have set up an optical data acquisition system and have used it to acquire crack tip opening angle during tests on a pipeline steel sample removed from a high strength pipeline (1.32 m in diameter with wall thicknesses near 20 mm). This pipe represents the current production of modern high strength pipeline steels (X100 steel).

We will present CTOA data on different specimen thicknesses (3 and 8 mm MDCB), and on crack growth orientations both parallel and perpendicular to welds. We will describe the change in CTOA when a running crack reaches a circumferential butt weld. This study will help the gas pipeline industry to better understand the effect of a running crack propagating through a weld.