Wang, B., Liu, B., Wang, Y.-Y., Wang, A., Rapp, S., 2020, Burst Pressure Prediction of Pipes with SCC Colonies with Intelligent Flaw Interaction Rules, Proceedings of the 13th International Pipeline Conference, Paper No. IPC2020-9693, September 28- October 1, 2020, Calgary, AB, Canada.

Abstract

Stress Corrosion Cracking (SCC) often occurs in clusters or colonies containing anywhere from a few cracks to thousands of individual cracks. Multiple closely spaced cracks may interact, resulting in a burst pressure lower than what might be expected from a single crack. Most existing flaw interaction rules account for these interactions by using a single interacting crack to represent multiple cracks when the separations between them are less than a critical spacing. The length of this interacting crack is usually the sum of the individual crack length plus the spacing between them. Using this interacting length and the maximum depth in the colony could produce overly conservative burst pressure predictions which can lead to unnecessary hydrotests and/or other remediation actions.

This paper covers the PRCI-funded work aimed at the development of intelligent flaw interaction rules (termed PRCI/CRES SIA-1-5 rules). These rules use the principles of equivalent impact among multiple interacting cracks and represent the magnitude of the impact by a single virtual crack. The new rules do not reply on a critical spacing to determine whether there is an interaction. The magnitude of the interaction is a continuous function of the size of adjacent cracks and the spacing between them.

A large number of FEA were conducted to examine the interaction among cracks for many crack configurations, including coplanar and noncoplanar cracks with different sizes and spacings. An analysis process was then developed to use the sizes and spacings of all cracks in an SCC colony to predict the equivalent virtual crack size and burst pressure.

The full-scale burst tests were conducted on the four test sections cut from the 20" and 18" OD pipe segments. The SCC colonies on the test sections were inspected using MPI, PAUT, ECA, and IWEX. The small-scale material tests were conducted to measure pipe tensile strength and Charpy impact energy. The four test sections were pressurized until they burst. The burst tests were recorded using multiple regular video cameras to capture the global behavior and detailed crack opening process at the burst locations. With the videos and the post-test metallurgical examination of the failure surfaces, the full-scale burst tests provide not only the burst pressure but also information for validation of the fundamental principles of the new interaction rules.

The modified Ln-sec method was used to predict the burst pressure using the equivalent crack size from different flaw interaction rules and the measured pipe material properties. The PRCI/CRES SIA-1-5 rules were found to provide the most accurate and precise burst pressure predictions.

Keywords

Stress-corrosion cracking, flaw interaction rules, burst pressure prediction, crack cluster, burst tests