Liu, M., Wang, Y.-Y., Significance of Biaxial Stress on the Strain Concentration and Crack Driving Force in Pipeline Girth Welds with Softened HAZ, Proceedings of the 26th International Conference on Offshore Mechanics and Arctic Engineering, June 10-15, 2007, San Diego, California, USA, Paper no. OMAE2007-29415

Abstract

The effect of the biaxial stress and HAZ softening on the crack driving force of girth weld defects was investigated using finite element analyses (FEA). The defects were of elliptic shape and located on the inner surface of the pipe. The crack driving force is represented by the crack tip opening displacement (CTOD) normal to the cracked plane (Mode I). The effect of hoop stress on a homogeneous pipe was revisited at first. It was found that the application of hoop stress tends to increase the crack driving force. However, in the practical range of longitudinal strains (≤4.0%), the effects of hoop stress is not monotonic. For example, at a constant longitudinal strain, as the pre-existing hoop stress increases, the driving force may firstly increase then decrease. The combined effect of HAZ softening and biaxial stress was then studied. With the application of hoop stress, the increase of the crack drive force due to HAZ softening was amplified. It was found that the crack driving force can be closely correlated with the surface strain measured over a structurally significant scale right above the defect. In addition, the effects of loading sequence and material anisotropy on the crack driving force were also briefly examined. The increase of the crack driving force from the hoop stress is more pronounced when it is applied prior to the application of longitudinal strains than the reverse loading sequence. The material anisotropy was found to further increase the crack driving force and therefore representative material models are necessary to analyze the anisotropy effects.

Keywords

Heat-affected zone (HAZ), HAZ softening, Girth weld integrity, Crack driving force, Tensile strain limit (capacity), Strain-based design (SBD), Bi-axial stress, Material anisotropy, Pipeline