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Abstract

Curved wide plate (CWP) testing in tension, on API 5L X100 pipes of 36-inch (916-mm) diameter and 0.75-inch (19-mm) wall thickness, has been initiated in support of strain-based design using high strength steel for oil and gas pipeline applications. The CWP tests are being used to optimize and validate welding procedures and to determine the defect tolerance within the girth welds. A traditional pre-requisite for fracture mechanics testing is a final extension of a crack via fatigue pre-cracking to produce a representative flaw. A method of fatigue pre-cracking CWP specimens for final notch preparation in bending was developed to meet ASTM guidelines for fracture mechanics testing. Fatigue pre-cracking for the present specimen geometry was possible in bending due to lower requisite force capacity equipment which allowed for greater cyclic loading frequencies. In order to achieve sufficient stress levels for fatigue crack growth in the curved plate, a stress field analysis was performed to optimize the loading support configuration in four-point bending. In addition to the stress field analysis, a 3-D finite element model of the CWP specimen was generated to analyze the notched CWP specimen in four-point bending. Finite element analysis (FEA) results and experimental data were used to confirm the hypothesis that, under the proposed loading arrangement, the closed-form solutions for stress-intensity (K) of flat plates in bending can be used to approximate the K for CWP specimens in bending. Validation of a solution for stress-intensity factor subsequently allowed the determination of force amplitude levels for fatigue crack growth. Force and crack mouth opening displacement (CMOD) data were analyzed to correlate compliance with crack length measurements. From experimental results, a method was developed that enable the repeatable and well characterized extension of surface flaws by fatigue pre-cracking in curved wide plate specimens in bending.

Keywords

Pipeline, Curved wide plate, Large-scale testing, Surface notch, Fatigue pre-cracking