A Comparison Of Finite Element Based ECA Approaches For Pipeline Girth Weld During Reeling-Lay

Daowu Zhou, Xiaowei Wang, T. Sriskandarajah
Subsea 7
Sutton, UK

ABSTRACT

Three dimensional finite element based ECA is needed for non over-matching welds during reel-lay. Two procedures are presented. One procedure is based on a tearing-low cycle fatigue concept which is included in BS7910. The other procedure disregards low cycle fatigue but treats the blunting as part of tearing. This procedure is described in DNV-RP-F108. This paper compares reeling crack growth between the two approaches using an 18” diameter alloy overlay pipe. The comparison reveals that both methods give comparable crack growth. Detailed comparisons on safety margin are discussed. This work helps industry to appreciate the confidence level in reeling FE based ECA.

KEY WORDS: reeling ECA; girth weld; clad pipe; Finite element analysis; tearing; low cycle fatigue.

NOMENCLATURE

2c  flaw length
Δat  crack growth due to fatigue
Δat  crack growth due to tearing
Δatot  total crack growth due to fatigue and tearing
J0.2V  blunting limit taken at 0.2mm extension vertical crossing in a J-R curve
J0.2BL  blunting limit taken at 0.2mm extension offset crossing in a J-R curve
ν  Poisson ratio

INTRODUCTION

Offshore pipeline typically requires an over-matching girth weld. However, the increasing selection of high strength steel and corrosion resistant alloy (CRA) clad lined pipes has created the need to address the issue of partially over-matching or fully under-matching girth welds. During reel-lay, strain concentration occurs in the weld region with the weld partial over-matching or full under-matching. The fracture integrity of the weld cannot be addressed through the typical failure-based diagram (FAD) based engineering critical assessment (ECA). 3D finite element (FE) analyses are required in this scenario.

Two distinct ECA procedures based on 3D FE analyses for reel-lay are presented in the public literature. One procedure is based on a tearing-low cycle fatigue concept in BS7910 (BSI, 2019). Tearing is calculated when the crack driving force exceeds the blunting limit (crack initiation) and the low cycle fatigue mechanism is used to account for the crack growth between multiple reeling cycles. The total crack growth is the summation of the tearing and low cycle fatigue. In contrast, the other procedure disregards the low cycle fatigue due to multiple reeling cycle but treats the blunting as part of tearing. This procedure is followed in DNV-RP-F108 (DNV, 2021). Both methods have been widely used in the industry.

The purpose of this paper is to present the FE based ECA procedure in the reeling installation phase. A CRA pipe of 18” diameter subjected to reel-lay from a recent project is used in this study. The FE study includes all the essential parameters (such as geometry mismatch, material