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Using finite element modeling to predict stress concentration factors in tubular T, Y and K joints

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ABSTRACT

Tubular offshore structures are commonly assembled using welded joints, creating areas of stress concentration and potential fatigue failure. This study focuses on tubular T, Y and K joints, a common offshore structural component. Finite element modeling is used to predict stress concentration factors (K_t) for various loading conditions on the T, Y and K joints. The goal is to calculate K_t values and compare them to existing theoretical solutions from literature. Additionally, the influence of different loading modes (tension, bending) on the K_t values is investigated. By using advanced modeling techniques, this work aims to provide new insight into the behavior of tubular T, Y and K joints connections under realistic offshore loading conditions. The results can help improve design standards and fatigue life predictions for these critical structural joints.

1. Introduction

Tubes are a crucial semi-finished product in steel production (V.A. M Steel Statistical Yearbook 2017). When analyzing structures under repeated loads, existing methods consider the impact of stress concentration on the development of fatigue phenomena (Jukić et al., 2021). However, in tubular assemblies, geometric discontinuities arise due to construction requirements, leading to stress concentrations, particularly near weld beads. These zones pose the risk of initiating and propagating fatigue cracks (Alaoui, 2015). Various researchers have explored stress intensity factors and crack analysis in different contexts (Zhen et al., 2016). Wang and Lambert (2003) employed the weight function method to calculate stress intensity factors for surface cracks in T-plate joints under arbitrary mode I loads. Mansouri et al. (2022) identified distinct microstructures in steel pipe welded joints. El Fakkoussi et al. (2019) utilized finite element methods to compute stress intensity factor K_t in mode I for a longitudinal semi-elliptic crack on the outer surface of a tube. Krešimir et al. (2021) studied thermo-mechanical simulation of welding processes, stress mapping, and stress intensity factor (K_t) calculation. Yao et al. (2023) explored the effects of various influencing factors on stress intensity factors along the crack front, considering crack closure and different conditions under internal pressure. Wang (2016) applied fracture mechanics principles to quantitatively analyze propagating cracks, solving the crack problem in T-shaped welded tees in waste heat boilers. Fustar et al. (2018) presented a review of common fatigue assessment methods used for welded steel joints. OH et al. (2012) estimated stress intensity factors for circumferential cracked pipes under welding residual stress fields.

The primary goal of this study is to calculate stress concentration factors *Kt* in T, Y and K shaped tubular joints and compare them with existing theoretical solutions in the literature. Furthermore, the research aims to investigate the influence of loading modes (tension, bending) on K_t values. By examining these factors, the study seeks to gain valuable insights into the behavior and structural integrity of tubular joints, particularly in the three shaped configurations, which can aid in optimizing their design and performance.

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