Reliability-based Design Optimization and Non-linear Finite Element Analysis of Pipeline Straightener in Reel-lay Installation

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Abstract

The main topic of this paper is reliability-based design of pipeline straightener in reel-lay installation. Theory of reliability engineering is extensively employed to make an optimal design, increasing the stability and rationality of pipeline straightener. Nonlinear finite element analysis of straightening has been successfully conducted by ABAQUS, which is of great value to the certification of reliability design.

The essence of pipeline straightening in reel-lay installation is anti-bending, simplified as three-points bending model. Basic hypothesis relating to material is that the steel analyzed is linear strengthen material. And plastic deformation does exist on the pipeline, making the reliability design more complicated. Plastic limit bending moment of pipeline, being regarded as strength criteria of reliability design, along with the expression of real bending moment, could be obtained analytically by plastic bending theory. Through Monte Carlo simulation, reliability indexes, corresponding with different parameters, say, rolling reduction, straightening force, position of straightener etc., are calculated. Accordingly, different relation curves between reliability indexes and parameters are drawn. Moreover, anti-bending procedure is simulated by ABAQUS with all the models being built in 3D space. Nonlinear finite element analysis is conducted based on the theory of elastoplasticity, which is also a good confirmation of reliability design.

In sum, reliability and nonlinear finite element analysis are two crucial ways to the optimal design of pipeline straightener in reel-lay installation. Both of them are adopted simultaneously in this paper, not only being a mutual authentication, but also providing some valuable design references to engineering.

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