Fatigue Life Assessment of Tubular Joints for Jacket Platforms Considering Corrosion

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ABSTRACT
The effect of corrosion on the fatigue life of tubular joints is studied by numerical simulation method based on the linear cumulative damage law. In this study, the plate thickness wastage and elastic modulus reduction are considered as the dynamic variables during corrosion procedure. The finite element model (FEM) of a jacket structure is established by using the finite element software SESAM and the structure parameters are adjusted relatively according to the residual wall thickness and elastic modulus. The results show that plate thickness wastage has more significant influence on the fatigue life of tubular joints compared with elastic modulus reduction. Meanwhile, the relative variation ratio curves of hot-spot stresses are nonlinear and can be expressed by the function of time (year). In addition, the tubular joint may be damaged when the service time is 13 ~ 20 years if considering the influence of plate thickness wastage and elastic modulus reduction simultaneously.

KEY WORDS: Fatigue life assessment; Tubular joints; Linear cumulative damage; Plate thickness wastage; Elastic modulus reduction;

INTRODUCTION
Steel jacket platforms are widely used in offshore oil industry and offshore wind industry. Jacket platforms experience the combined actions due to environmental loads and corrosion damage during their service period. Generally, the splash zone of jacket platforms suffers the most severe corrosion, especially when the coating is disappeared. Therefore, corrosion damage cannot be ignored when conducting the fatigue life assessment of tubular joints for jacket platforms, especially for aged jacket platforms.

Plate thickness wastage is the main form of corrosion damage and some related studies had been conducted. Dong et al. (2012) analyzed the fatigue reliability of welded tubular joint based on a fixed annual thickness reduction rate due to corrosion during the service life. It was found that the effects of corrosion on the hot-spot stress and material degradation would reduce the reliability index. Ji et al. (2016) conducted an experimental and numerical study on the ultimate strength of offshore jacket considering the effects of corrosion and crack based on the nonlinear plate thickness wastage model and Paris equations. The results indicated that the ultimate strength of an aged jacket with 50 years-service life was decreased about 27% and 30% due to the thickness wastage and crack respectively.

On the other hand, the SN curve of metal material can be changed in corrosive environment. DNV-RP-C203 (2010) and DNVGL-RP-C203 (2016) issued some SN curves of high-strength steel in sea water with or without cathodic protection. In addition, Adasooriya et al. (2019) and Zheng et al. (2020) conducted some studies on the SN curve and fatigue performance of high-strength steel under different corrosive environment. The results indicated that the fatigue endurance limit of high-strength steel would be decreased greatly due to the corrosion and the fatigue performance was also degenerated.

In recent years, many researches indicated that the mechanical properties (such as elastic modulus, yield strength and ductility etc.) of material would also be changed during corrosion procedure in addition to the plate thickness and SN curve. Ou et al. (2016) conducted a tensile testing of corroded steel bars with naturally and artificial corrosion, which indicated that the cross-sectional area, strength and deformation capacities of steel bars were decreased with increasing corrosion. Qin et al. (2016) investigated the degradation laws of mechanical properties of Q235 steel plate under the condition of accelerated corrosion with artificial salt spray. The results showed that the yield plateaus would be shortened greatly and all mechanical property indexes were also decreased significantly when the corrosion rate is over 15%. Jia et al. (2019) studied the mechanical properties of marine high performance steel NVD36 under the condition of corrosion damage. The results indicated that the influence of corrosion damage cannot be evaluated by section reduction simply. Furthermore, the elastic modulus and yield strength were also decreased due to corrosion damage.

In this study, the plate thickness wastage and elastic modulus reduction are considered as the dynamic variables during corrosion procedure. Based on the linear cumulative damage law, the effects of these two variables on fatigue life of tubular joints are analyzed by using the deterministic fatigue analysis method with the aid of finite element software SESAM. Besides, the environmental conditions are simulated based on the data of South China Sea.