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應用時域模擬於固定式離岸風力機套管基礎之疲勞壽命分析
Fatigue Life Evaluation using Time-domain Simulation for Bottom-fixed Jacket Foundation of Offshore Wind Turbine

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摘要

本研究目標為以時域法分析套管式離岸風力機基礎結構的疲勞壽命。此風力機容量為 3.6 MW，設定場址位於福海離岸風場。海上環境量測及統計資料來源取自三年期的初期場址調查，得到風況及海況的機率散佈表和聯合機率表。海況以有義波高和零上切週期轉換成波浪頻譜模型，再由 HydroCRest 計算圓管構件之波浪負荷。風負荷分析方法使用 BEM 準穩態時域分析法，紊流模型採用 IEC 標準。本研究藉由有限元素分析結果推導接點公稱應力的閉合形式解，以縮短有限元素分析時間近千倍。熱點應力以接點公稱應力乘以應力集中係數計算。最後套用雨流計數法和查詢 S-N 曲線，得到接點疲勞壽命。結果顯示，數十日的模擬時間即能得到穩定且收斂的 20 年疲勞累積破壞值。

關鍵詞：離岸風力機，套管式基礎，疲勞分析，雨流計數法。

Abstract

This study evaluated the fatigue life of the jacket support structure of a 3.6 MW wind turbine operating in Fuhai Offshore Wind Farm by time-domain simulations. The long term statistical environment was based on a preliminary site survey that adequately served as the basis for a convergence study for an accurate fatigue life evaluation. The wave loads were determined by the Morison equation, executed via the in-house HydroCRest code, and the wind loads on the wind turbine rotor were calculated by an unsteady BEM method. The Finite Element model of the wind turbine was built using Beam elements. However, to reduce the time of computation, the hot spot stress evaluation approach combined FE-derived Closed-Form expressions of the nominal stress at the tubular joints and stress concentration factors. Finally, the fatigue damage was assessed using the Rainflow Cycle Counting scheme and adequate SN curves. The results showed that after a dozen days of simulated life time, the accumulated fatigue damage prediction converged to a stable 20-year fatigue damage.

Keywords: Offshore wind turbine, Jacket foundation, Fatigue analysis, Rainflow counting method.