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OC4 5MW 離岸參考風機 JACKET 型式支撐結構疲勞分析
A Study on the Fatigue Analysis of Jacket-Type Substructure for OC4 5MW Reference Offshore Wind Turbine

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摘要

本文基於應力壽命法，針對國際能源總署(IEA)所佈署的離岸風機研究計畫 OC4 (Offshore Code Comparison Collaboration Continuation)中之 Jacket 型式支撐結構進行疲勞評估，在同時考量伺服控制、風、波浪及海流等負載後，分別以整體分析(Global Analysis)及局部分析(Local Analysis)兩階段進行結構分析。整體分析使用 NREL FAST 風機動力分析軟體，本文先以 GL 設計標準之負載組合 DLC 1.1 為例，並配合國內本土參數進行疲勞分析。在分析得到風機塔架頂端剪力、軸力、彎矩與扭矩後，再輸入至 ANSYS APDL 分析軟體，對 Jacket 型式支撐結構進行局部動態歷時分析，在同一節點之斷面四個位置取動態應力值，經由雨流計次法(Rainflow Counting Algorithm)求得應力振幅值大小與對應的計次數，再利用 S-N 曲線及 Palmgren-Miner 線性累積損傷法則，求得節點的疲勞累積損傷值，並以使用年限 25 年檢核疲勞壽命的餘裕。結果顯示配合我國特定環境參數之 5MW Jacket 型式支撐結構滿足疲勞檢核，桁架式結構之頂部及底部位置有較高的疲勞損傷值，建議在此位置可局部環向補強，以控制疲勞損傷。

關鍵詞：離岸風機、桁架式支撐結構、疲勞評估、套管節點

Abstract

Base on stress-life approach, this study is focused on fatigue assessment of the Jacket-type substructure for 5MW referenced Offshore Wind Turbine (OWT) in the Offshore Code Comparison Collaboration Continuation Project (OC4) implemented by International Energy Agency (IEA). This work is to use two independent structural analyses: Global Analysis and Local Analysis, and is associated with considerations of the loadings from the server control, wind, wave and ocean current under Taiwan's environmental conditions. In global analysis, the NREL FAST software is employed to analyze the dynamic response of integrated offshore wind turbine and support structure under 324 design load cases defined by the GL guidelines. Then, the tower top shear, axial force and bending moment by FAST are calculated as the input to the ANSYS APDL software to conduct subsequent support structural fatigue analysis. Finally, the stress amplitude and its corresponding number of cycles can be obtained by the Rainflow-counting algorithm, and then the cumulative fatigue damage ratio can be thus calculated by S-N curve and Palmgren-Miner rule to evaluate the fatigue life under the consideration of 25 year lifetime. The present computed results show that the Jacket-type substructure for 5MW referenced Offshore Wind Turbine is in compliance with the fatigue life design under Taiwanese environmental conditions. Higher fatigue damage ratios at some locations close to tower top and bottom of jacket tubular structures can be found. It is also suggested that tubular joints close to above locations need to be reinforced.

Keywords: Offshore wind turbine, Jacket-type substructure, Fatigue evaluation, Tubular joint