LOAD AND FATIGUE EVALUATION FOR 66KV FLOATING OFFSHORE WIND SUBMARINE DYNAMIC POWER CABLE

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ABSTRACT

Floating Offshore Wind technology has seen a number of prototype deployments around the world in recent years. One of the critical components that must maintain the highest possible integrity is the dynamic power cable. This paper presents the approach and applied methods for the design work that informs the development and qualification of a 66kV submarine dynamic power cable. The design envelope is quantified through coupled aero-hydrodynamic modelling, determining the ultimate load conditions for different cable configurations. The model sensitivity and convergence for an OC4 floating design are explored regarding metocean conditions, computational parameters. A lowered Lazy Wave cable configuration is chosen as most suitable design, providing a compromise between hang-off tensions and induced bending stresses. The numerical results form the basis for subsequent physical cable demonstration and validation tests.

KEYWORD

Dynamic Submarine Power Cable, Floating Offshore Wind, Coupled Analysis; Reliability, Fatigue Evaluation.

1 INTRODUCTION

Floating Offshore Wind technology has matured to a feasible technical solution, with a number of prototype deployments around. Whilst the floating platform type has been variable, all deployments have opted for a horizontal-axis, three-bladed wind turbine. The floating platform types, which have seen full-scale demonstration deployments, include the Spar-buoy, barge and semi-submersible concepts [1].

One of the critical components that must maintain the highest possible integrity to ensure uninterrupted power generation is the dynamic power cable. These dynamic submarine power cables will have to cross the water column, as they typically connect to a subsea connector that provides the link to the static inter-array / export cable.

Floating offshore wind turbines constitute a complex coupled system, comprising of:

- the aerodynamic and structural properties of the turbine blades, nacelle and tower
- the control characteristics of the drivetrain/generator
- the hydrodynamic properties of the floating platform, expressed as Response Amplitude Operators (RAOs)
- the mooring properties and power cable dynamics

It is important to note that each sub-system influences the response of the other sub-system and the overall system response. The dominating aspects are the aerodynamic and hydrodynamic properties, together with the mooring characteristics. The dynamic power cable is designed to avoid an active coupling with the floating platform, thus it will only alter the system behaviour slightly through its additional weight and drag, which are small in comparison to the size and mass of the floater.

The power cable design should be carried out to match the envisaged turbine/platform/mooring arrangement for a specific installation site. Offshore engineering Design standards [2] stipulate a mechanical design assessment that considers the metocean conditions for the Ultimate Limit State (ULS), the Accidental Limit State (ALS) and the Fatigue Limit State (FLS). The work presented here focusses on the ULS condition.

This paper will present the rationale and design work that informs the development and qualification of a 66kV dynamic submarine power cable for Floating Offshore Wind turbines. The paper is structured as follows: First, an overview to the modelling methods and parameters is presented. Second, the results section summarises the numerical convergence and sensitivity, together with the key design drivers and outcomes regarding ULS. The findings are discussed in regarding ongoing and planned development work and related industry developments for floating offshore wind installations.

2 COUPLED NUMERICAL MODELLING

The mechanical load analysis for dynamic submarine power cables is commonly carried out in two distinctive steps:

- A global load analysis that establishes the forces and motions acting on the power cable, induced through the combined effect of the metocean environment and the aero-hydrodynamic response of the floating structure.
- A local analysis that seeks to determine the local stresses (within the cross-section) of the cable, e.g. the stress the armoring or the conductor will have to withstand in operation.

This paper is primarily concerned with the global load analysis. The results thus require a local stress model for the cable in order to estimate the stress acting on each cable layer.

The floating offshore wind turbine assembly, including the turbine, the floating platform, the moorings and the dynamic power cable are modelled using the aerodynamic-hydrodynamic coupling described in [3,4]. This method has been applied for the modelling of non-linear mooring systems [5], as well as the optimization of mooring configurations [6] showing that it provides suitable results in the time-domain [7]. In the following the main features and parameters of each model is briefly outlined.

2.1 Aerodynamic model setup

The aerodynamic model employs the widely-used open access code FAST. A suite of sub-models represents the aerodynamic and structural properties of the wind turbine