Numerical analysis on the thermal insulating role of biofouling on dynamic subsea power cables

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ABSTRACT

The objective of this paper is to numerically assess the impact of biofouling on the 2D thermal fields of a dynamic subsea power cable. An experimental campaign gave inputs as for the properties to be considered for modelling the biofouling. The inter-array cable considered is meshed with Salomé_Méca, and the non-linear thermal equations are solved using Code_Aster. A sensitivity study is conducted on convection factor and biofouling thickness. 2D temperature fields are found to be sensitive to biofouling thickness and to low values of convection factor. Overall temperatures rise up to an order of magnitude of some degrees.

KEYWORDS

Submarine power cable; thermics; marine growth.

INTRODUCTION

How biofouling will affect the dynamic cables used for connecting Floating Offshore Wind Turbines (FOWTs) is a major unknown, regarding several aspects. One of the main impacts is mechanical, through the weight added to the structure and through the increase of hydromechanical loads. The second aspect is thermal, through the addition of a potentially insulating layer encapsulating the cable. Even though the thermal insulation role played by the biofouling is unlikely to affect cable thermal ratings, it may generate hotspots [1]. As temperature largely impacts the global mechanical behaviour of the cable (mainly bending stiffness, [2]), local hotspots can however generate local stiffness variations along the cable. These local stiffness variations may affect the global curvature distribution and accelerate mechanical fatigue. Hence the need to identify representative values for assessing the thermal role played by a layer of biofouling grown on the outer face of a cable immersed in the water.

The characteristics of a biofouling layer developing on an offshore structure can be extremely complex and varied (in terms of species, thicknesses, colonization density), ([3], [4]). Biofouling characteristics are highly dependent on numerous parameters: geographical location, depth, currents, turbidity, salinity, temperature [5].

CONTEXT

ABIOP+ project

Biofouling affects all types of offshore structures, and is not fully understood, especially considering the very dynamic and shallow sites characteristic of ORE systems siting areas. The ABIOP+ project highlights that biofouling is a critical problem for mooring lines and dynamic cables. The general objective of the project is to characterize biofouling qualitatively and quantitatively, according to the sites and components concerned using innovative, inexpensive and globally applicable protocols. This objective was achieved through four main axes:

- Multi-scale characterization of biofouling,
- Improvement of biofouling characterisation protocols on standardisation, operability and cost aspects,
- Development of a quantitative image analysis method,
- Evaluation of existing solutions to manage biofouling.

This study is part of the multi-scale characterization of biofouling.

Objectives and perimeter of the study

This study is composed of an experimental campaign and a numerical campaign, and this paper is more focused on the numerical part.

The objective of the experimental study was to identify relevant values for taking the role of an added outer layer of biofouling into account for thermal models of dynamic cables. To narrow the perimeter of this study, the biofouling to be considered had to be as representative as possible of a type of biofouling expected at cable deployment sites.

The general objective of the 2D numerical study was to assess the impact of the colonization obtained within the experimental campaign on the thermal fields obtained numerically. The conclusions of the numerical part are hence applicable to this type of biofouling distribution only. However, knowing this limited perimeter, the study helps to:

- evaluate the impact of colonization on thermal regimes of cables;
- estimate the temperature of the cable's outer sheath that may influence biofouling growth kinetics;
- estimate cable local bending stiffness losses due to local hotspots.

EXPERIMENTAL CAMPAIGN

Thermal and biofouling characterization protocol

PVC pipes were immersed at sea in the Atlantic Ocean near Brest and Lorient, for natural biofouling to grow on the outer surface. Pipes were immersed at sea for nine months, on locations relatively representative of cable deployment conditions. The biofouling grown on the outer face was then characterized following a protocol developed within the ABIOP+ project and dedicated to this experiment, to measure parameters useful for engineering parameterization. In particular, biofouling thickness was estimated based on three different measurements: local thickness (thickness of the biofouling organisms found at random places), overall diameters and circumferences of colonized pipes.