Refining the accuracy of power cable's pulling forces estimations

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ABSTRACT

Due to the deployment of larger projects such as in offshore environment, the stresses undergone by cables during the installation are rising. In order to avoid damaging the cable during its installation and to set the qualification testing parameters, a precise methodology is needed to anticipate the forces that the cable will be subjected to.

It appears that the historical analytical method has shown some limits for larger offshore projects due to the increased bending stiffness and cable mass. These issues tend to occur especially when the cable is pulled in convex curves – a case often encountered at landfall pullings. This point has been highlighted specifically by offshore projects studies.

The paper will discuss about on the accuracy of this theory in light of RTE recent developments and propose a new analytical methodology of calculation with improved accuracy.

KEYWORDS

Submarine cables; offshore; pulling; winch; ducts; friction; capstan; reverse engineering; measurement

INTRODUCTION

Pushed by wider objectives of the energy transition, a string of large projects involving submarine cables have been launched in France in the last few years.

As a TSO, RTE oversees the connection of the marine wind farms from the offshore substation to the land grid. In order to enhance the performance of the European network, new interconnectors with neighbouring countries are in development.

These new assets gradually change the nature of the transmission network and push its boundaries offshore. Beyond the sole connection of production site or interconnecting separate networks, these new lines can become the backbone of a real meshed network where offshore assets play a larger role in grid performance.

Multiplication of project goes along with a diversity of pulling configurations including large foreshores, floating turbines, OSS installation in deeper seas, etc. It becomes necessary to expand the mechanical limits of power cables and also improve the reliability of pulling predictions.
These operations in marine environment are critical. There are several issues about environment, meteorological phenomena that require large installation means. Due to these numerous constraints, a great vigilance is given to the execution of cable pulling at landfall and at platform.

In the case of this paper, we will only deal with the pulling at landfall case. Indeed, from an analytical point of view, it covers most of the cases that the cable could encounter during its installation and the stresses tend to be higher.

Practically, the prediction work is done at two stages: first during the settling of qualification tests parameters, and then – using more detailed data and more complex simulation tools – before cable installation.

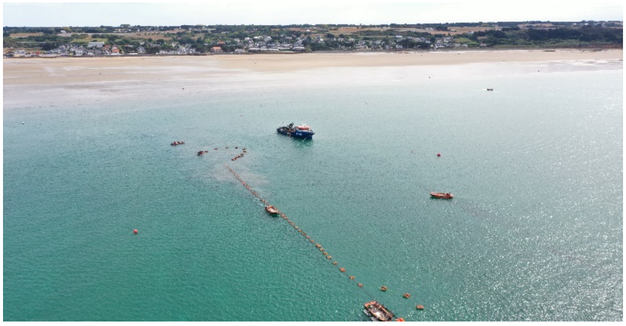

Fig. 1 Aerial view of an export cable landfall pulling

As illustrated in Fig. 1 above, installation at landfall require a large spread of marine means and a precise organisation.

I. THEORY

In the following section, only the overall mechanics of the cable will be reported. The latter will be considered as a uniform beam. Due to the dimensions, the relative displacements of the cable's constituent layers are not relevant for the discussion.
Considering the dimensions, the cable will be considered as a beam and its global mechanical properties (E, G, ν, R_m, *etc.*) will be assimilated to the mean intrinsic properties the different constituent unit materials weighted by the geometries of each of them.

The final purpose is to determine with precision the applied forces on the cable according to the route design.

1. Historical method (*Rifenburg et al.*)

The mechanical study of a cable pulled through ducts relies on an analytical methodology established by Rifenburg *et al.* in 1957 [1] and slightly refined by Smith *et al.* in 1981 [2]. This method published by the IEEE and referred by the CIGRE TB 194 [3], unchanged in 2023 [4], is a reference widely used for decades.

The method consists in modelling the pulling operation as a static loading of a set of elementary sections of cables, laid with uniform geometries and friction parameters. It can be seen as a more elaborate version of the Euler-Eytelwein model, also known as "capstan effect", that results from the assumption of a cable comparable to a rope without additional dimensions and without mass because considered to have a negligible impact. It is based on Coulomb's theory of friction, which establishes a proportional relationship between the frictional force