Experiences with depth of burial monitoring in the North Sea using Distributed Temperature Sensing

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ABSTRACT

Distributed Temperature Sensing (DTS) is a technique that uses an optical fiber to measure temperature along the length of a cable. Most submarine high voltage cables have integrated optical fibres which make it possible to measure the temperature inside the cable.

One of the challenges with submarine cables is that the original burial depth of the cable after installation might change. A calculation model has been developed to estimate the actual burial depth using DTS. In this paper, the results from the calculation model are discussed and a comparison is made with measured results.

KEYWORDS

Depth of Burial, Distributed Temperature Sensing, Wind Farm, North Sea , Maintenance, Submarine cable, Survey.

INTRODUCTION

Over last decade, a great number of wind farms have been constructed in the North Sea and even more wind farms are planned in the coming years. The wind farms are connected to the onshore grid via submarine high voltage cables. A change in burial depth of the cable can lead to a hotspot in the cable due to the large amount of soil insulating the cable, but it can also lead to an exposed cable in the seabed. An exposed cable can be a risk to the cable because it is more vulnerable for external damages such as anchor drops, fishing nets, etc. Also, local authorities often require a minimum burial depth that must be verified on a regular base. Therefore, wind farm and grid owners contract survey vessels to measure the actual depth of burial of these cables.

Distributed Temperature Sensing (DTS) is a technique that uses an optical fiber to measure temperature along the length of a cable. Most submarine high voltage cables have integrated optical fibers for communication between the offshore and onshore substations. The same fiber can be used for DTS, which makes it possible to measure the temperature inside the cable. Many wind farms nowadays have a DTS system to measure temperatures over the full length of the export and infield cables, to detect a possible hotspot in the cable connection. In theory, the temperatures measured by the DTS can also be used to calculate the actual burial depth of a cable. This is possible due to a change in the thermal response of the cable for different burial depths.

To verify whether it is possible to use the DTS temperature measurements to determine the actual burial depth, a calculation model has been developed that uses the thermal model of a cable and the seasonal influence of the surrounding soil to calculate the actual burial depth. This calculation model has been tested on different wind farm cable connections in the North Sea using data from (existing) DTS equipment, combined with SCADA data providing information about the load on the cable at both sides of the connection. A reliable estimation of the actual burial depth by DTS measurement can significantly reduce the need and frequency of surveys of the cable route to check the depth of burial.

To test whether it is possible to eliminate the need of a survey vessel by using a Depth Of Burial (DOB) model and temperature monitoring with DTS, a test has been performed on a submarine export cable of a wind farm in the North Sea.

THEORY

Temperature response cable

The temperature response of a cable can be calculated using the formulas described in the IEC 60853 standard. This standard is often used in Dynamic Cable Rating (DCR) software to determine the temperature response and overload capabilities of a cable. If DCR is used in an online monitoring system, it is normally referred as a Real Time Thermal Rating (RTTR) system. An RTTR system uses the actual load on the cable and measured temperature in the cable using the integrated optical fiber to determine the actual surrounding temperature and thermal resistivity of the soil.

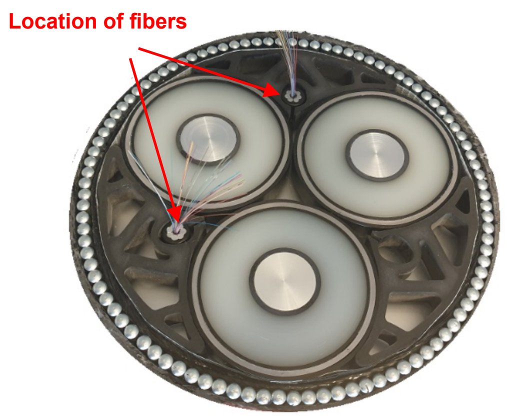

Fig. 1: Submarine cable with integrated fiber optic

The cable model as described in the IEC 60287 is used to model the cable and environment as a thermal network using thermal resistances and thermal capacitances.

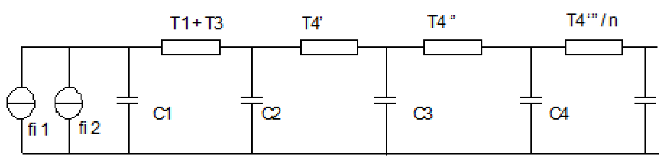

Fig. 2: Cable and environment model