COMPARASION OF ARMOR LOSSES ON DIFFERENT THREE-CORE SUBMARINE CABLES THROUGH MEASUREMENT AND CALCULATION

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ABSTRACT

To have a better understanding of the submarine cable design and selection for typical windfarm project, it is driven to make a direct comparison on the amor losses between different kinds of armor design. The measurement and calculation are made on three cables with same construction, except the change of armor design. It is found that the measurement of armor losses is different although the difference is not so big on different armor design. Besides, for the cable with full galvanized steel wire armor design and mixed armor, the armor losses obtained from measurement and calculation through FEM (3D model) are much lower than the one calculated according to IEC60287 and CIGRE TB880. It is worth to take these into considerations for the engineers when they make the cable design and selection for windfarm projects.

KEYWORDS

Armor Losses, Measurement, 3D, FEM, IEC60287, CIGRE TB880

INTRODUCTION

With the continuous development offshore wind farms industry in recent years, more and more engineers in the field of submarine cables started to pay attention to the design of submarine cables and the focus is on the armor design of the submarine cable. Usually, armor is mainly considered more related to the mechanical performance for submarine cables. However, in actual operation, due to the alternating magnetic flux induced by the alternating current in the conductor, voltage will be subsequently induced on armor material. Due to the long length of the submarine cable, grounded at both ends is chosen in the most of case, which will form a loop and generate circulating current losses. Except the circulating current loss, eddy current loss and hysteresis loss will always there no matter which grounding method is applied. For three core submarine cables, due to the geometric feature [7], even if both ends are grounded, there will be no circulating current losses. In conclusion, for the armor layer of three core submarine cables, eddy current and hysteresis losses will play the main role of the total losses in the armor.

After understanding these characteristics, engineers started to consider how to reduce losses on the armor and improve the transmission capacity of submarine cables by selecting different armor materials and adjusting the armor design. A common choice is to use stainless steel wire armor instead of galvanized steel wire, although the price of stainless steel wire is many times that of galvanized steel wire. In addition, there is other application of mixed armor, which uses circular PE wires instead of galvanized steel wire, which can also reduce the weight of submarine cables. On the other hand, for traditional galvanized steel wire, calculations are generally carried out according to IEC60287. Engineers have also found the calculation results according to this method are too conservative, which may result in redundant selection of submarine cable sections. For this topic discussed in recent years, this paper also made some analysis between IEC and FEM calculations and experiments to propose some of its own views on the selection and design of submarine cables.

PARAMETERS

This paper mainly discusses three common designs of submarine cables, full galvanized steel wire, stainless steel wire, and mixed armor (galvanized steel wire and PE wire mixed with a ratio 1:1). The three designs of submarine cable are almost the same except for the design of the armor layer. Their parameters used for calculation are provided in the table below:

Table 1 Cable parameters

Cable type	Full galvanized steel wire	Mixed armor	Stainless steel wire
Conductor cross-section (mm²)	2000	2000	2000
Material of conductor	Aluminium	Aluminium	Aluminium
Diameter (mm)	261	261	261
Lead alloy sheath thickness (mm)	2.0	2.0	2.0
Diameter over cable core (mm)	109.6	109.6	109.6
No of armor wire	118	59/59	118
Outer diameter of cable (mm)	261	261	261
Crossing pitch [4] (mm)	4800	4800	4800
Electrical resistance of conductor @ 20℃	1.49×10^{-5}	1.49×10^{-5}	1.49×10^{-5}
Electrical resistivity of lead alloy (ohm/m)	21.4×10^{-8}	21.4×10^{-8}	21.4×10^{-8}
Electrical resistivity of armor (ohm/m)	13.8×10^{-8}	13.8×10^{-8}	70×10^{-8}
Relative magnetic permeability of armor [4]	600-350j		1