Analysis of Electric Field Distribution in XLPE Insulation of DC Submarine Cable

Yadong **FAN** (1), Jianguo **WANG**(2), Zejun **HONG**(3), Qiyao **QIN**(4), Mi **ZHOU** (5), Li **CAI**(6)
1-Wuhan University, Wuhan, China, ydfan@whu.edu.cn
2- Wuhan University, Wuhan, China, wjg@whu.edu.cn(2), 397896229@qq.com(3), qinqiyao@hotmail.com(4), zhoumi927@whu.edu.cn (5), cail@ whu.edu.cn(6)

ABSTRACT

Temperature field distribution of DC submarine XLPE cables operating at rated load, overload and under-load were simulated by using ANSYS finite element software in this paper. Based on the simulation results and conductivity measurement under different temperature by test, properties of electric intensity in insulation material (XLPE) of the cable were got, The results show that the maximum electric field strength generally appears in the outer insulation under full load and overload, while appears in the vicinity of the core of conduct wire under no-load, the maximum value can reach 100 kV/mm.

KEYWORDS

DC XLPE submarine cable; temperature field; resistivity; insulation resistance; electric intensity

1 INTRODUCTION

With the continuous development and expansion of the power system, DC transmission technology attracted renewed attention with its advantages long-distance power transmission capacity and flexible power system interconnection. Power interconnection establishment between island and mainland as well as between islands needs to be solved by submarine cables [1]. In 2013, China laid ±160kv DC submarine cables in Nanao waters near Shantou, which is the first DC submarine cable enduring 160kv DC voltage of in China [2].

Different from the AC cable electric field capacitive distribution, the XLPE insulation of DC submarine cable is highly related to its conductivity. The electric field distribution is increased with the volume resistivity. However, the conductivity has a close relationship with electric field and temperature, whose change would cause a change of the conductivity distribution of XLPE insulation, as well as the electric field. The relationship mentioned above indicates the difficulties in the study of field distribution in XLPE insulation of DC submarine cables.

Zhan Ping did the theoretical analysis upon the characteristics of distribution and insulation [4], Wang Ya did a detailed theoretical analysis upon the effects of space charge towards DC cable electric field distribution [5], considering the effects of both conductivity and space charge towards electric field intensity, Gu Jin and Duan Shaohui established an intact analysis and experience equation [6-7]; Using iteration method, Qu Shiguang proposed a precise and convenient calculation method of electric field of DC submarine cables [8]; Wan Shude conducted experiments on polarity reversal of DC submarine cables and endurance test of superimposed impulse [9]; Liu Dazhong, Yu Sulian and Wang Zhenguo calculated the cable electric field distribution under three circumstances, constant voltage, impulsive voltage and polarity reversal, respectively [10]. Till now the analysis of temperature and electric distribution of DC submarine cables mainly focused on the simplified analytical method and experience equations. No precise electric field distribution solution has been proposed.

In this paper, we proposed using finite element method ANSYS to simulate the temperature field in XLPE insulation of DC submarine cable under overloading, full-loading and no-loading conditions. Comparing with the test results we obtain different conductivity in different radial directions under several operating conditions, based on which we calculate the electric intensity along radial direction of XLPE insulation layer.

2 SIMULATION MODEL OF XLPE INSULATION DC SUBMARINE CABLE AND PARAMETER SETTING

Computational Model

Using a DC200kv submarine cable as a simulation example, which cross section is shown in Fig.1, with a single core, 117.3mm nominal external diameter, 26.6mm nominal external diameter of conductor layer, 1.7mm thickness of the insulation layer. To simplify the model, we regard the size of the conductor shielding layer as part of the conductor core layer, ignoring the shielding size of the external semi-conductor. This model could be classified from inside to the outside as: Copper (external diameter 15.0mm), XLPE, PE shield, steel wire, pitch and PP rope. The size of each material could be described as Tab. 1

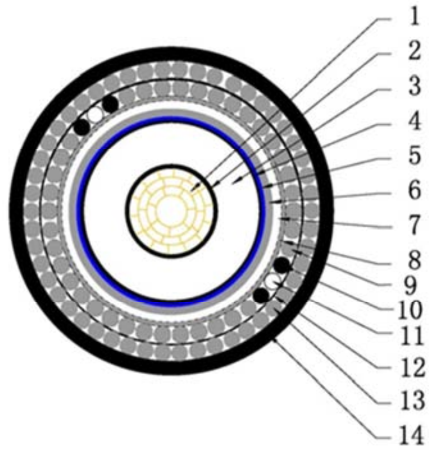

Fig. 1 The cable transverse profile