The Thermal Analysis Based on the Thermal Circuit Model and Thermal Field Calculation for 110kV Cables

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ABSTRACT

The heat dissipation problem is important in high voltage XLPE cables. In this paper, the thermal field model and the thermal circuit model are established. The temperature distribution of actual operating cable can be obtained through the thermal field model and the thermal circuit model. Thermal field model and thermal circuit model are compared and the results show that the thermal field model is more accurate. The suggestion for the optimization of cable structure has been done. If the thermal circuit model is corrected, it can be applied to the temperature measurement of the on-line cables.

KEYWORDS

high voltage XLPE cable; temperature distribution; thermal field model; thermal circuit model

INTRODUCTION

Power cables are widely used in the electric line of the city[1]. And because of its good heat resistance, good mechanical properties and large transmission capacity, so it is not only suitable for low and middle voltage power distribution system, but also can be applied to the high voltage and ultrahigh voltage system. But with the wide use of power cables, power system puts forward the higher requirements for the XLPE cables.

Previous studies on the thermal analysis of the cable have been done[2],[3], but accurate temperature calculation of the cable has not been done due to the rough thermal circuit model[4]. The thermal circuit model is not applied to calculate the temperature of each layer of the cable[5].

In this paper, a thermal field model and a thermal circuit model[6] were built, and the temperature distribution in cable was obtained. The thermal circuit model and the thermal field model have been compared to identify the reasons for the error. The thermal circuit model is modified to be used to calculate the temperature of the on-line cable.

MEASUREMENT OF THERMAL CONDUCTIVITY

Firstly the thermal conductivities of cable materials were measured by using the thermal analyzer LFA447 Nanoflash TM. The results of materials used in different cable structure layer, such as conductor, semiconductor, main insulation, water-resistant tape and sheath, are shown in Tab.1, in which it shows that the water blocking tape and air gap in the cable have a very low average thermal conductivities compared with the insulating layer and other layer in a cable.

Tab.1: Thermal conductivities of each layer of high voltage XLPE cables

Materials	Thermal conductivity（W/m·K）
copper conductor	401
inner shield	0.658
XLPE insulation	0.406
outer shield	0.608
water blocking tape	0.092
air gap	0.024
aluminum sheath	237
coating	2.28
sheath	0.41
PE sheath	0.42

THE STRUCTURE MODEL OF 110KV HIGH VOLTAGE XLPE CABLES

According to the structural characteristics of XLPE cable, if we do not consider the electric and thermal field and force field of terminals, the cable can be regarded as an infinitely long cable, therefore the plane simulation model will be established.

The axial model of 110kV XLPE cables is made mainly for the aluminum sheath with corrugated structure as shown in Fig.1. The axial model is including 10 layers, such as mainly conductor, shield, insulation, water blocking tape, air gap, aluminum sheath, etc. The structure size of each layer is shown in Tab.2. According to the results in Tab.1, the water blocking tape and air gap between insulation layer and sheath layer have the lowest thermal dissipation, so that it will be considered mainly in the following.

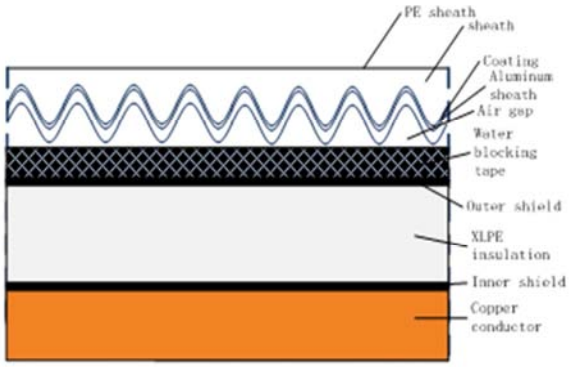

Fig.1: Axial model of 110kV XLPE cables

Tab.2: Structure size of cable of the conductor area of 800mm^2

Materials	Outer radius of each layer（mm）