SHEATH CIRCULATING CURRENT CALCULATIONS AND MEASUREMENTS OF UNDERGROUND POWER CABLES

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ABSTRACT

In this paper, a calculation method of the sheath circulating current is introduced, taking the different grounding types, laying environment, structural parameters of cables into account. Due to the parameters in practice, the circulating currents in sheath are calculated and measured under the conditions of single-point grounding and both-end crossbonded grounding. The possible causes, which lead to high circulating current, are discussed based on the calculation method.

KEYWORDS

Sheath circulating current; capacitance current; induced current

INTRODUCTION

With the development of high voltage and ultra-high voltage applications in power transmission systems in China, the single-core cables are usually used instead of three-core cables [1]. When the cables are in service, circulating currents flows in the sheaths. Large circulating current leads to the big loss in the sheaths and thus reduces the permissible current of the cables. Moreover, it will also enhance the danger in the cable maintenance and reduce the lifetime of the cables or cause the faults by the breakdown of insulation or cable jacket [2, 3]. Therefore, calculation on the sheath circulating currents and study on their characteristics are of importance for the maintenance of power cable system.

Under a common service condition, the sheath circulating current includes two parts: capacitance current and induced current. As the single-core cable is a cylindrical capacitance, the high-voltage side of the capacitance is the cable core, while the low-voltage side is the sheath of the cable. The current coupled by capacitance which is named capacitance current exists in the sheath, when AC load current flows in the cable core. The induced current appears in the sheath if there is induced voltage and the sheath is connected with the earth at more than one point, leading to a circuit loop for the induced current. The induced voltage is usually caused by the mixed laying method of the cables and different lengths between sections. It is also affected by the length of the cable, the layout type and the distance between cables. The several grounding points may be caused by the poor connection at the bonding point of lead sheaths, poor insulation of jackets, and so on.

The sheath of a long cable is divided into several sections, with the number of multiple times of three. And these sections are crossbonded together at each end of the cables to decrease the induced voltages and currents in the sheaths, shown in figure 1. In this condition, the phase difference of the induced voltages in each sheath section, such as A1B2C3, is 120°. Thus the total induced voltages in this circuit loop will be counteracted at the three sections, shown in Figure 2. The length of each section in figure 2 is same. But in practice, if the length of the sections is different, the induced current will increase obviously [4].

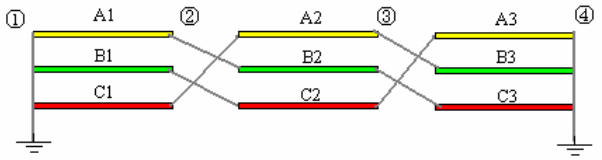

Figure 1: A schematic diagram of both-end crossbonded grouding three-phase cables

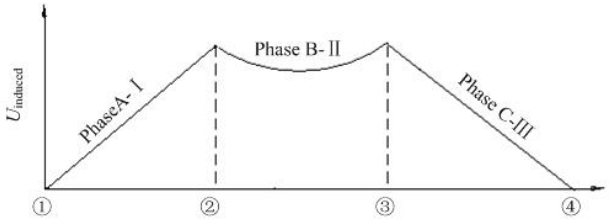

Figure 2: The induced voltage in the sheath marked A1B2C3 in figure 1

In this paper, we present the calculation method of capacitance current and induced current in sheath of the single-core cable. Especially, according to the flowing path of the capacitance current in the case of the crossbonded both-end grounding, we provide an equivalent circuit to calculate the current values flowing at every site along the cables. Based on the method, the sheath current of several cables in service are calculated and measured, and the calculation error and its influence factors are analyzed.

CALCULATION METHOD

Calculation method of capacitance current

The single-core cable can be looked as a cylindrical capacitance. Its capacitance per unit length is known as [5]:

$$C = \frac{55.7\varepsilon * 10^{-12}}{\ln \frac{D_c + 2\Delta}{D_c}} \text{ F/m} \qquad [1]$$