DEVELOPMENT AND EFFICACY OF SHEATH CURRENT REDUCTION DEVICES ON UNDERGROUND POWER CABLE SYSTEMS

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ABSTRACT

In underground power cable systems, high sheath current is usually caused by mixed cable burying formation and different lengths between sections. It can cause sheath loss and reduce the permissible current of cables. Previous research results indicated that the designed current reduction device could effectively reduce the sheath circulating current.

This paper presents a new device to reduce the sheath circulating current by installing a reactor possessing transient protection functions to the cross-bonding lead where the current has increased and describes its efficacy. The newly designed device is applied in an actual underground transmission system for more than 1 year in South Korea.

KEYWORDS

Sheath circuiting current, Sheath current reduction, Underground power cable

INTRODUCTION

Nowadays underground power cables are expanding throughout cities due to large electric energy demand. For high voltage power transmission systems, three separate single-core cables are usually used instead of three-core cables. This leads to high induced voltages in the sheaths owing to unequal spacing between the sheaths relative to any one conductor [1].

In practice, the sheaths are cross-bonded at each end of the cable to suppress the induced voltages. The details of cross-bonding can be referred to IEEE guide [2]. The cross-bonding of the sheaths provides a returning path for the induced current from other phase cables. This current is known as “sheath circulating current” which results in “sheath circulating loss”. According to IEC std. 287[3], the high sheath circulating loss has an influence on the permissible current of AC cable. It causes sheath temperature increase and the total thermal resistance of the cable. Thus it reduces the permissible current and must be reduced to a reasonable level.

To prevent the flow of sheath circulating currents, one obvious way is to eliminate cross-bonding and earthing. Such a practice would allow, however, large standing voltages to be present on the sheath which forms a considerable hazard to life as well as the possibility of arcing and consequent deterioration of the cable.

According to the studies of induced voltage in sheaths [1, 4], another possible practice to reduce the sheath circulating current is to increase the spacing of the cables and keep them balanced. However, the increase of cable spacing will increase the size of cable channels, which is not cost effective.

A practical measure, which is widely used in the UK, is to transpose the cable once per section length as well as sheath cross-bonding. Further practice is to bond the sheaths at some intermediate points rather than at joints [4], but this increases the cost and is difficult to maintain.

In practice, because of geometric limitations and planning problems, some transmission cable systems are buried in different formations and at different lengths in each section. An example of such a system is described in the next chapter. This kind of unbalanced arrangement leads to a huge circulating current in the sheaths, and general sheath reduction methods are not enough to reduce the current to a reasonable level [5].

So, in the previous papers [6, 7], the characteristics of sheath current and the causes of current increase were extensively analyzed. Further, in order to reduce the sheath current, the reduction devices of resistors and reactors were developed and installed at the joints. The results indicated that the designed current reduction device could effectively reduce the sheath circulating current.

This paper presented a new device to reduce the sheath circulating current by installing a reactor possessing transient protection functions to the cross-bonding lead where the current has increased. The newly designed device has been in operation for more than 1 year in a South Korean underground transmission system.

CORRELATION OF THE SHEATH CURRENT AND PERMISSIBLE CURRENT

While the underground power transmission cable is in operation, the sheaths are cross-bonded at each end of the cable to suppress the induced voltages in the sheath. The cross-bonding of the sheaths produces a returning path of the induced current from other phase cables. This current is known as “sheath circulating current” which results in “sheath circulating loss”. According to IEC std. 287[3], the permissible current of an AC cable is written as Equation [1] in buried cables where drying out of the soil does not occur or cables installed in air.

$$I = \sqrt{\frac{\Delta\theta - W_d[0.5T_1 + n(T_2 + T_3 + T_4)}{RT_1 + nR(1+\lambda_1)T_2 + nR(1+\lambda_1+\lambda_2)(T_3+T_4)}} \qquad [1]$$

T_1 to T_4 means the internal and external thermal resistances of cables. λ_1 is the ratio of losses in the sheath to total losses in all conductors is that cable. λ_2 is the ratio of losses in the armouring to total losses in all