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Determination of cable dynamic rating from distributed temperature sensing and hotspot temperature analysis

SU Q., LI H.J., TAN K.C., Singapore PowerGrid, Singapore

Abstract: Accurate assessment of cable ampacity is crucial for a utility to fully utilise the capacity of its underground cables. Based on distributed temperature sensing (DTS) and hotspot temperature analysis, the real-time conductor temperature and cable dynamic ampacity are determined more accurately than the conventional methods which mainly rely on modelling and calculations.

Keywords: Cable, ampacity, DTS, Finite Element Method

Mots clés: DTS, FEM

1. Introduction

The ampacity (current carrying capacity) of a cable circuit is affected by many factors, such as the cable structure, thermal conductivity of surrounding soil, ambient temperature and sheath bonding. Since the ambient temperature and the thermal properties of soil change with time depending on weather in different seasons, the ampacity of a cable circuit could change significantly from time to time. For example, a long time of dry and hot weather can dry out the soil, resulting in a high thermal resistivity up to 2-3 °C m/W, while a short time rainfall can reduce the soil thermal resistivity to as low as 0.2-0.4°C m/W. Therefore, it is important to determine the dynamic rating of a cable circuit so that its full capacity could be utilized all year around.

Since the last decade, many utilities have recognized that cable-rating management is actually temperature management at hotspots. There could be several hotspots in a cable circuit which act as bottlenecks to limit the load-carry capacity. It is vital for a utility to locate and rectify all hotspots in a cable circuit so that it could be driven to its rating limit comfortably. Location of all hotspots in a cable circuit is possible using fiber-optic temperature sensing technology to detect cable surface temperatures along the complete length of cable. In this paper, is presented a technique to accurately locate hotspots in a cable circuit using a DTS instrument. The analysis of hotspots helps to better understand the causes of overheating in certain cable sections. The most suitable methods are then used to rectify the hotspots and increase the cable capacity. The DTS data can also be collected by a computer network and analysed with a Finite Element Method (FEM) to determine the conductor temperature and dynamic rating. The information can be provided to the network operator for reliable operation of a cable network under dynamic and emergency loads.

2. Cable hotspots

There is no doubt that the hotspots along a cable, acting as bottlenecks, inhibit its current carrying capacity. Hotspot investigation based on cable route survey, thermal resistivity measurement at roads and simulated ampacity calculation could give some useful information such as the estimation of maximum allowed rating. However, estimations are not conclusive on some critical hotspots in the analysis and are usually conservative. DTS has made the temperature profile along the complete cable path available at real time, which can be readily used to determine all hotspots. Based on cable surface temperatures at hotspots and their variation with time, the conductor temperature could be accurately determined and forms the basis of a real-time dynamic rating management system,

2.1 Hotspot identification with DTS

In PowerGrid, all 400kV and a number of 230kV cables are installed with optic fibres for temperature sensing. Two DTS detectors are installed in terminal substations to monitor the cable surface temperature. Each DTS detector has six channels which can separately monitor up to six cables. With these DTS detectors, the cable temperature is