Modelling of temperature distribution of underground medium voltage cable as a tool for positioning temperature sensors

Pedro-José **NAVARRETE-RAJADEL;** Navarrete Ingenieros, (Spain), pedro@navarreteingenieros.com

Pedro **LLOVERA-SEGOVIA,** Instituto de Tecnología Eléctrica, Universitat Politècnica de València, Instituto Tecnológico de Energía, (Spain), pedro.llovera@ite.es

Vicente **FUSTER-ROIG**, Instituto de Tecnología Eléctrica, Universitat Politècnica de València, Instituto Tecnológico de Energía, (Spain), vicente.fuster@ite.es

Marcos **DOMÍNGUEZ-LAGUNILLA**, Instituto Tecnológico de Energía, (Spain), marcos.dominguez@ite.es

ABSTRACT

Underground medium voltage cable temperature is an important variable for cable maintenance and operation. However, it is difficult to install distributed temperature sensing systems in the distribution network. Instead some localized temperature measurements could be installed in cables, but then the measurement points have to be carefully selected. 3D thermal simulations of an underground medium voltage cable and its transition from the secondary substation to the ground have been carried out to analyze the temperature distribution and the best position for thermal sensors installation.

KEYWORDS

Thermal modelling, temperature sensing, finite elements, dynamic rating, asset management.

INTRODUCTION

Temperature assessment of undergound medium voltage cables in the distribution network is a complex task because of the spreading and complexity of the network. Moreover, installing temperature sensors in existing cables is costly and hardly feasible. However, with the current development of communications and intelligent secondary power substations, the information about cables temperature may become an important variable.

Cable temperature information is important for 1) network operation and design and 2) for asset management. In the first case, for ampacity calculations [1]-[4] and dynamic rating, an accurate determination of temperature, such as measurement made with distributed temperature sensing (DTS), would be needed but is economically out of reach at present. It has been proposed to use localized temperature sensing (LTS) [5] as a feasible alternative to DTS. In the second case (asset management and cable life estimation), accuracy on cable temperature is somehow less critical since life models have already large uncertainties. But knowledge of real cable temperature will provide very valuable information in order to establish a Health Index coefficient based on real data instead of estimations. In fact, Health Index of underground power cables require different information such as statistical data (characteristics of the cable or failure data), utilization data (cable load) and condition data (state of the cable according to diagnostic tests). Gathering the condition and usage data may be difficult for medium voltage underground network and, very often, only an incomplete set of data is available. One way to improve it, could be to have real temperature data in some points of the cables since temperature is a fundamental variable in cable life models.

Thus, as well for ampacity or dynamic rating as for health index, temperature of medium voltage underground cables is a critical variable, easy to transfer to control center via existing communication networks. But some cost-difficulties remain on having a costly-effective solution to measure it.

One realistic possibility to obtain a better estimation of the cable temperature may be based on reducing the sensing number of points to some few points per cable. The question is then how many sensors should be installed and where.

In this work, we will focus on the determination of the most representative temperature measurement point of existing underground cable installed in ducts. Because of the twisting of cables during laying process, it is generally difficult to install a temperature sensor at more than 10 m away from the end of the duct after the cable has been laid. A key point, in this sense, is to determine what is the minimum distance from the end of the duct where a temperature sensor can be installed in a position representing the general state of the cable. We have modelled a 15-meter-long underground medium voltage cables in ducts, including the secondary substation. 3D finite element modelling instead of 2D modelling has been carried out to determine the temperature profile of the cable. Different situations have been represented obtaining the minimun distance with stable temperature to place sensors.

MODELLING OF THE PROBLEM

For the purpose of the study, a common situation has been modelled: a 3-phase cable installed in a single duct, exiting from a secondary power substation in an homogenous ground (Figure 1). The transition from the inner volume of the secondary substation to the underground duct has also been represented. The sealing of the duct, typically with a polyurethane foam, has been represented by a high thermal resistivity element. The simulated cable corresponds to a commercial 18/30 kV, 400 mm^2 of aluminium. Cable characteristics for the thermal simulation are described in Table 1.

The following parameters have been considered in the model:

- Ground dimensions are 8 m wide, 8 m deep and 15 m long.
- External ambient temperature is 20ºC.