Results and verifications from REE experience on monitoring insulated cables with DTS

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ABSTRACT

The ampacity of an insulated cable, for the transmission grid or for the distribution grid, is conditioned by the maximum temperature that its insulator could withstand (without compromising its life span). Due to the cyclic load regime, it is possible to exceed the steady state limit. Red Eléctrica de España (Spanish TSO) is analyzing some insulated cables with DTS technology (Distributed Temperature Sensing)

KEYWORDS

Ampacity, insulated cable, thermal inertia, Distributed Temperature Sensing (DTS), flexible and optimal operation.

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INTRODUCTION

The cable ampacity is related to the maximum current that the circuit could transmit in steady state. Red Eléctrica de España (Spanish Transmission System Operator) calculates the ampacity (current-carrying capacity of cables) under the hypothesis of steady state (Std. IEC 60287), as well as standard ground and environmental conditions. The Power Control Centre operates the insulated cables in such a way that their ampacity is not exceeded taking the appropriate measures for this purpose.

The load regime of all transmission circuits shows daily peaks, off – peaks and transitions between them, unique for each day, being far from constant or having a repetitive cyclic regime.

On the other hand, changes in the load regimen are not reflected instantaneously in the temperature of the insulated cable due basically to the heat storage capacity of the surrounding ground, and also the insulated cable, resulting in the concept of thermal inertia.

All this leads to the inference that the ampacity, under the hypothesis of steady state, may exceed the currently value, without reaching or exceeding the maximum insulated cable temperature, thus resulting in a more flexible and optimized system operation.

To verify this idea, REE has been monitoring real-time temperature in 220kV, 132kV and 66kV insulated cables with DTS technology (Distributed Temperature Sensing) since 2012, in the scope of different R&D projects. The DTS technology that is being used is based on Raman effect and all the results are fully satisfactory.

The distributed measure of temperature is taken in the sheath of the insulated cable, fiber optic cable with a stainless steel or plastic sheath was placed. This gives more accuracy in the calculation of conductor temperature than the usual installation of external optical fiber. The analyzed facilities include: shallow buried sections (in concrete ductbank), deeply buried sections (casing pipes) and, in the coming months, submarines sections (interconnection between islands) and aerial sections (ascend to towers).

Some of the objectives of this experience consist in the verification and quantification of thermal inertia, as well as quantification of maximum temperature peaks and their correlation with load regime and other parameters. Furthermore, thermodynamic models used in the simulations have been verified with FEM simulations based on the real data from DTS and current measurements.

These solid arguments can be applied to the development of new flexible and optimal procedures for the efficient and safe operation of insulated cable circuits under a more realistic approach to ampacity.

REE EXPIERENCE IN DTS MONITORING FOR 220KV CABLES TEMPERATURE

For a long time, REE has been installing temperature monitoring systems with the aim of thermal protection in very special facilities, like interconnections. This monitoring had the particularity that the measurement was outside the cable. For this reason it is necessary to do a complex correlation between the measurement and the conductor temperature.

Cable manufacturing processes has developed in the last years, allowing the approach of the measurement to the conductor, facilitating the introduction of the optical fiber with the sheath cooper wires. The optical fiber, either Raman effect or Brillouin , offers to the DTS systems the possibility of monitoring, in a distributed way, real- time temperature (see figure 1). The great advantage of measuring in the sheath is the simplification of the model and the decrease of the conductor temperature