ONLINE AMPACITY DETERMINATION OF A 220-KV CABLE USING AN OPTICAL FIBRE BASED MONITORING SYSTEM

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ABSTRACT

A dynamic rating system to increase the ampacity of a 220-kV power cable is described. The advantage of the used system is the ability to online calculate the ampacity and therewith to use short term ampacity increases in the operation of the grid. Measurement results are analysed and interpreted. Compared to the formerly installed static rating of the cable the use of the new monitoring system delivers additional ampacity depending on the current load and the soil temperature. Additionally the condition of the cable concerning cable temperature hot spots is monitored continuously.

KEYWORDS

Online monitoring, dynamic rating, ampacity, 220-kV underground cable, cable temperature

BACKGROUND AND MOTIVATION

The ampacity of underground cables is limited by the maximum allowable temperature at the surface between conductor and insulation (90°C for the 220-kV cable Siems-Luebeck). The cable heats up due to the losses (electric and dielectric) occurring during operation. The preload has significant effect on the temperature because of the cable's high heat capacity.

The foundation of the cable has to ensure an effective heat transfer between the cable and the surrounding soil. A desiccation of the soil has to be avoided, even in unfavourable conditions. During project planning conservative assumptions related to soil desiccation were taken. The ampacity of the cable is obtained considering the earth desiccation assumptions.

According to this the ampacity of an underground cable depends on the internal temperature of the cable (conductor temperature). The maximum allowable temperature of 90°C is indicated by the manufacturer. According to manufacturer's information this temperature is reached with a current load of 850 A. This corresponds to a planned cable power of approximately 350 MVA, which is based on conservative picked data for soil desiccation and the thermal conductivity of soils.

During operation the soil will periodically be more humid than assumed and therewith the heat transfer in average will be more efficient than designed. This leads to periodically higher ampacities than planned. Using a cable monitoring system the cable sheath temperature is recorded in regular time frames. The data is used for online calculation of the additional ampacity potential.

In the upper phase of the cable system optical fibre cables are integrated in the cable sheath to measure the temperature (Fig. 1).

In the past a Distributed Temperature Sensing (DTS) Monitoring System without online ampacity determination (dynamic rating) was used. Current and temperature data has been evaluated periodically to avoid a long term rise of the temperature level and to identify further increase possibilities of the cable ampacity. It has been shown that the ampacity of the monitored 220-kV cable could be increased from 850 A to 950 A as a static rating. This corresponds to 38 MVA or respectively an increase of 12 % [1].

Currently a DTS Monitoring System by AP Sensing is used. In combination with a dynamic real time temperature rating (RTTR) software, which is embedded in a visualization and communication software by OSSCAD, the ampacity is calculated online depending on actual load and surrounding conditions. The dynamic rating software is based on the IEC 60853. The additional ampacity obtained with the real time rating, the integration into the control centre and the calculation of the ampacity will be explained and presented in this paper.

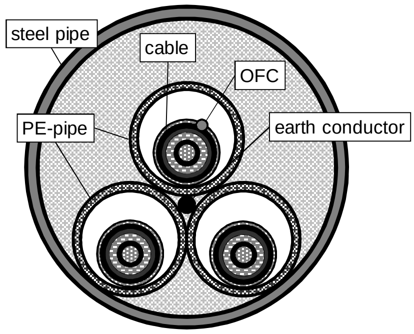

Fig. 1: Arrangement of cables in a steel pipe and optical fibre cable (OFC) in the sheath

DTS TECHNOLOGY

DTS technology has been introduced to the market place in the early nineties. A technique span-off from the academic research utilizing the optical time domain reflectometry (OTDR) combined with measurement of diminutive RAMAN Stokes and Antistokes light [3]. As a result a spatially distributed temperature profile over several kilometres length is obtained by using a simple fibre optical cable. This and the high electromagnetic interference resistance make it very attractive to monitor the temperature of underground power cables.

The DTS technology evolved quickly overcoming technical problems which are linked to conventional DTS systems and defining the difference between a laboratory apparatus and a robust industrial product. The diminutive Stokes and Antistokes signal challenge the instrument design providing sufficient signal-to-noise ratio (SNR) to