DYNAMIC RATING OF TRANSMISSION CABLES

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ABSTRACT

Within the last two years the regional Danish transmission company SEAS-NVE has installed load management systems, in the form of dynamic current rating, on three new 145 kV cable systems. All three systems include both land and submarine cables.

The base technology and the expected benefit of these dynamic rating systems were explained in the Cigré paper B1-101/2010.

This paper describes in more detail the thermal modelling used for the calculation of the forecasted loading capabilities of a cable systems and present some results from the 132kV export cable system of Rødsand 2 offshore wind farm.

KEYWORDS

High voltage cables;Real-time thermal rating; Temperature monitoring; Adaptivemodelling;Grid management.

THE MODELING

The loading capability of a high voltage cable is usually limited by the maximum allowed conductor temperature. For a cable with XLPE-insulation the conductor should not exceed 90 C° as higher temperatures degrades the insulation.
In operation the cable temperature is determined by a number of parameters such as the cable construction, the grid configuration,the thermal properties of the cable itself and its surroundings, external heat and cooling sources, and both the past and present loading of thecircuit. Some of these are very well-defined or measured while others vary along the cable route or over time.

When engineering a cable circuit, one of the main focuses is to ensure that the cable is not exposed to critical temperatures. Therefore,some of the before mentioned parameters are traditionally chosen conservatively to take into account the worst case conditions expected.Typical parameters are the ground thermal resistivity and the effects of nearby installations.

Because the environmental conditions could change during the lifetime of a power cable system (for example new crossing roads or external heating sources) it is important to have a dynamic rating system.Based on temperature information of a DTS System and the current loading of the cable system the dynamic ratingsoftware is able to calculate the conductor temperature and enables evaluationsof the future loading capability.

With a thermal equivalent circuit the conductor temperature can be derived from the screen temperature. This can be done with a T-C network based on IEC60287, which describes the thermal conditions of a cable system. Each element of a cable system can be described by a thermal resistance and a thermal capacity.
Such an equivalent circuit can be determined using the IEC standard. Literature values define the thermal capacity and thermal conductivity for different materials. This model describes the cable quite accurately,but the T-C-elements for the cable surroundings areonly approximately correct and are rarely stationary. To calculate the elements, literature valuesare used, which describe the surroundings of the power cable only inaccurately because real values can be different from values for assumed environmental conditions. Some of them even change over time. E.g. the properties of the soil can change rapidly and differently along the cable installation. Accordingly the assumed IEC based T-C-network is not likely to reflect the real environmental conditions.

Alternatively FEM (Finite Element Method) simulationcan be used in order to get a more accurate calculation of the network.The simulated temperature curve is based on a daily load cycle as described in the VDE 95 norm. Different load factors are simulated for defined time periods to evaluate the expected development of cable temperatures which is useful information for improving the quality of the models but still the variation of surrounding parameters cannot be considered in the simulation.

By using an optimizer, the T-C-network is adapted until the calculated temperature curve matches the simulated curve, thus adjusting the models to the real environmental situation.

The determined T-C-network serves as a basic model for the calculation of the temperatures. For each calculation this model is adapted by the optimiser based on the measured temperature and current load of the monitored cable system where only the external elements of the T-C-network are optimised since the thermal properties of the cable don't change over time. With this process the variations along the cable route can be considered.

MODELING OF AN OFFSHORE WIND FARM EXPORT CABLE

The 132kV cable system N120 links the offshore wind farmRødsand 2with the main grid on land. The length of the system amounts 37 km and is divided in about 9 km submarine cable and 28 km land cable route. The submarine cable is a three-core800 mm² copper conductor, while the land cables are three single core 1600 mm² aluminium conductors. For technical reasons part of the land cable has alead sheath while the main part is with traditional copper wire screen.

For thermal modelling purposes, the total cable system N120 is subdivided into 75 different sections. In order to limit the amount of calculation power needed, these