Predicted rating system for directly buried cables

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ABSTRACT

In recent years, increasing attention has been placed on cable dynamic rating systems to increase asset utilization and decrease constraint costs. However, the variations in dynamic ratings makes them difficult to plan with. In this work, a novel cable rating concept, Predicted Cable Rating, is introduced. This concept integrates a day-ahead load forecasting system into the dynamic rating system to provide the time-limited emergency rating calculated forward from any point within the next 24 hours.

KEYWORDS

Dynamic cable rating; Load prediction; Online monitoring; Predicted cable rating; Support Vector Machine; Finite Difference Method.

INTRODUCTION

System operators need to be confident in the ratings of the circuits in order to make effective plans, particularly where generation and circuit configuration may lead to high power flows being transported via particular circuits. As a result, it is beneficial to the system operators to examine new cable rating methods to assess the real-time thermal condition of the cable and optimize asset utilization, but with minimum risk.

The majority of high voltage cables are sized and operated based on a continuous, current rating. In most cases, the load on the cables themselves will not match these assumptions and may vary significantly depending upon the time of day, day of the week and season. Given the relatively short durations of peak loads and the comparatively long thermal time constants of high voltage cables, it is often possible to load cables beyond their continuous current rating without the cable exceeding its operating temperature limit. Many utilities are now beginning to use dynamic ratings to use this additional capacity safely [1-3], however this data is not available at the day ahead planning stage, which would be very valuable to network operators.

To solve this problem, it is necessary to employ a predictive rating method [4], capable of providing network operators with accurate short term current ratings at the day ahead stage. This has the double benefit of reducing variations in dynamic ratings (which makes them difficult to plan with), while reducing the risk of thermally overloading the cable.

In this paper, a novel cable rating concept, Predicted Cable Rating, is introduced. This concept integrates a day-ahead load forecasting system into the dynamic rating system to provide the time-limited emergency rating calculated forward from any point within the next 24 hours. A dynamic thermal model for a buried cable installation is built by using the finite difference method (FDM). The real-time load current is used to calculate the heat losses in the conductor and sheath of the cable. The day-ahead load forecasting is achieved by using the Support Vector Regression (SVR) method. Time-limited short-term ratings can then be calculated 24hrs ahead, based on the predicted load data. In addition, an error estimation system based on the exponentially weighted moving average (EWMA) equation and multiple linear regression (MLR) is used to estimate the predicted conductor temperature error quickly.

PREDICTED CABLE RATING

Based on the dynamic thermal model, day-ahead prediction system and error estimation system, the predicted rating system can be implemented by the structure shown in Fig. 1.

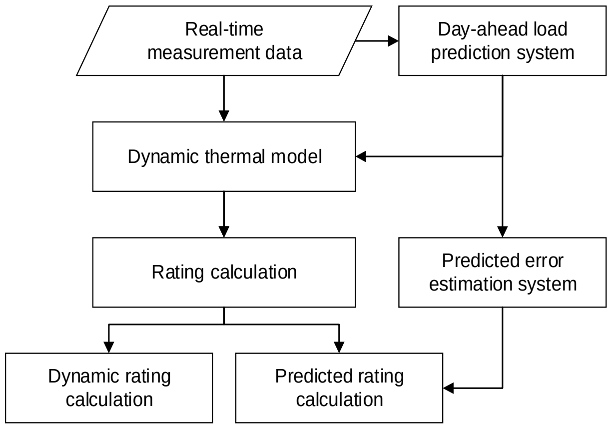

Fig. 1: Structure of predicted rating system

The real-time load and environment data are measured and used in the dynamic thermal model to update the thermal parameters and heat losses which are essential to calculate the temperature response of the cable in each step. With these real-time temperature and historical load information, the normal dynamic rating can be obtained. In order to predict the cable rating 24 hours ahead, the day-ahead ambient temperature and load information are needed at each time step. In this work, the ambient temperature forecast data is assumed to be available and perfect. A load prediction system in [4], based on the Support Vector Regression (SVR) technique to forecast next 24hours' load at each step, is used.

Based on the real-time cable temperature results from the thermal model, these day-ahead prediction data are used to estimate the cable temperature 24 hours ahead. Thus, the predicted rating which provides the time-limited emergency rating calculated forward from any point within the next 24 hours can be performed. At the same time, a rating error estimation system based on the exponentially weighted moving average (EWMA) equation and multiple linear regression (MLR) techniques can estimate the prediction rating error without using the dynamic thermal