SC D2- Information systems & telecommunication
PS1 The impact of emerging information and communication technologies on electric power utilities

Machine learning as an intelligent tool for long-term forecasting of power equipment technical state and lifecycle management

A. KHALYASMAA, S. EROSHENKO
Ural Federal University named after the first President of Russia B.N. Yeltsin
Russian Federation
a.i.khaliasmaa@urfu.ru

The paper provides an exhaustive analysis of long-term high-voltage equipment technical state forecasting approach and adaptive lifecycle management system implementation, based on machine learning approaches, taking into account the influence of adjacent power system operation modes on the functional state and residual life of the power equipment under consideration.

On the basis of the developed structure and algorithms of power equipment life cycle control and prediction system the paper describes practical experience of its application for 110 kV open switchgear, where machine learning approaches were used to identify and justify:

- the list of operating parameters of the power system that have the greatest impact on the functional state of the equipment under consideration;
- the effect of short circuits on the technical state of the power equipment in terms of dynamic and thermal effects on current-carrying parts, supporting structures and insulation;
- the influence of un-faulted operation conditions of the power system on the power equipment technical state based on the loading curves and operation mode parameters, such as voltage levels, frequency, etc.;
- the list of indicators and technical diagnostics parameters that have the greatest impact on the functional state of the equipment and on the structure of diagnostic models;
- the list of characteristics of materials and technological fluids of the most responsible nodes of power equipment units, which have the greatest impact on its functional state.
- power equipment technical state forecast for 5-year time period, including confidence limits identification.

Within the framework of the study, the basic requirements and criteria for power equipment functional state assessment were formulated taking into account the connectivity and topology of the power network, structure and composition of the operated power equipment, power system operation modes, etc. Presented architecture of the adaptive control and prediction system of power equipment life cycle as well as its hierarchical relations has been developed taking into account functional state analysis and long-term lifecycle management goals, based on machine learning approaches.

The application of machine learning algorithms is proved by the authors. Machine learning not only improves the accuracy of the power equipment state identification along with its defects (in case of sufficient training set), but also allows data processing by means of creation an additional superstructure above the existing database of equipment maintenance and repairs without the need of additional data entry, how it is typically implemented in existing data analytics systems for power equipment technical state assessment. This approach provides not just the improvement of power equipment operation reliability, but also enhances the intelligent level of the production asset management systems in general, which are typically based on power equipment technical state and operation risks estimates.

The influence of various operation modes of the power system on the power equipment technical state was analyzed by creating a model of the adjacent network in industrial power flow software package. The results of variative calculations of power flows along with retrospective metering data were introduced into the system to take into account the connectivity and topology of the power network, operation mode parameters and composition of the operated power equipment.

Technical state forecasting is carried out based on Strategic development plans of the Energy Sector of Russia, containing perspective data of power system operation conditions for 5 year-ahead period. The authors use gradient boosting decision trees to evaluate the functional state of the power equipment under consideration. In general, the algorithm improves itself by taking into account the errors of the previous decision tree compositions. The gradient boosting algorithm was implemented in the Python Jupiter software environment.