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Intelligent life cycle management system model for the power network equipment

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Currently in Russia as well as in all the world there is much concern about life-cycle management of high-voltage equipment of power plants and substations. Such trends result from the necessity of power network equipment operational reliability improvement under the conditions of high wear rates and the needs for power equipment maintenance optimization to minimize technical risks and provide effective asset management and investment programs development of grid companies and large industrial enterprises. Moreover, given the big amounts of multidimensional and different-type data, gathered from various control systems and sensors, technical diagnostics and testing protocols of power equipment, it is practically impossible to provide effective manual supervision of complex technical system like a substation. In its turn, the problem of complex technical system management and control presupposes the identification of its current state in general, the states of all sub-systems and elements separately and the forecast for subsequent states. In other words, the life cycle management problem for the substation should be considered from the point of the object in general as well as from the point of separate power equipment units and its main components. High-voltage power equipment life cycle management among other tasks requires power equipment remaining lifetime forecasting to provide minimal technical risks and optimal strategy of maintenance and operation.

Nowadays there are lots of systems, providing solution for abovementioned problems: different systems of technical state estimation of separate types of power equipment, for example oil-filled or SF6-filled power equipment units, and complex solutions such as integral asset management systems of industrial enterprises. However, the majority of the listed systems provide purely technical or economic solutions. It should be noted, that asset management systems are often based on the results of technical state assessment activities, so the accuracy and reliability of the information, collected from the latter one influence the results of the former one greatly.

Afore-mentioned problems cannot be solved by means of technical state assessment systems development for separate types of power network equipment. Principally new complex decision-support systems are needed – intelligent one, providing adequate analysis of big amounts of aggregated data for different types of power equipment as well as nontrivial useful knowledge discovery in the databases for its application in industrial operational activities. Such approach gives the possibility to retrieve and organize the factors of mutual influence of power network equipment parameters, its operational conditions, structure and functional states as well as to build and store knowledge databases, containing information about effective operational conditions in the form of formalized expert knowledge.

The authors offer a model of intelligent information-analytical system to provide reliable estimation of power equipment functional state based on the technologies of Knowledge Discovery in Databases. Neuro-fuzzy inference was taken as Data Mining methodology, giving the possibility to build effective technical maintenance and repair programs. Within the scope of the research work methodological, mathematical and algorithmic bases of the intelligent information-analytical system were developed, taking into account functional state and material composition of power network equipment. The

proposed model was verified by functional state assessment of power equipment of the real electric network fragment for the period from 2005 and up to the present day. New correlations and regular principles of different parameters variations, including power equipment operational modes, functional states, configuration, state of technological liquids were identified and classified. Using gained knowledge, new approaches of power equipment functional state assessment were introduced to improve the accuracy, reliability and transparency of the decision-making process. In the proposed system, the results of power equipment technical state assessment are formulated using stochastic operators to provide subsequent technical risks estimation and finally to develop ranked strategy of maintenance and repair on the basis of stochastic rules as well. Modelling and verification of the proposed model was carried out in MATLAB software package, which resulted in appropriate accuracy of power equipment state identification – 91%. The reference states of the power equipment under consideration correspond to the inspection reports, made by diagnostic laboratories.

The developed model can be used as an independent tool – the model of automated power network equipment integral assessment system, or can be implemented as a sub-system for existing enterprise resource planning software packages of power industry utilities. New developed approaches for power network control based on artificial intelligence methods, which take into account the coupling of power system elements, give the possibility to use the proposed system as an integral information-analytical tool of industrial scale, providing knowledge about latent regularities and correlations in statistical data. The proposed system gives the possibility not only to optimize operational and technological control of the power equipment, but to build and adjust investment strategies, energy- and resource saving plans on its basis and to improve tariff setting rules in the power industry, which result from power supply reliability improvement in dynamic external conditions and provide social and economic development of the regions.