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COMPARATIVE ANALYSIS OF METHODS FOR RESIDUAL LIFE OF CURRENT TRANSFORMERS PREDICTION

The demands of conserve resources and to decrease operating costs that are trending around the world in power electric energy branch causes increasing of usage of “aged” (according to calendar operation life) high voltage (HV) electric equipment. Operating of “aged” equipment demands the forecast of its residual life, that is why the problem discussed in this report is very actual. One of the most important element of all HV switchgears is a current transformer (CT). The analysis described in this report was based on the example of real case of failure (partial short circuiting of the main insulation) of the CT 330kV with OIP insulation and non-tight (open-breath) construction. This failure was diagnosed by Safe-TTM online monitoring system and due to professional actions of the personnel of the power company the CT was taken out of operation, without an accident in the power system.

Research results. Two prediction models were applied to this case. According to the first model, the resulting probability of non-failure operation was calculated by the diagnostic parameters – dielectric losses dissipation factor ($\text{tg}\delta_1$), change of $\text{tg}\delta_1$ value during operation life ($\Delta\text{tg}\delta_1$), velocity of change $\text{tg}\delta_1$ ($v_{\text{tg}\delta_1}$), calculated insulation moisture content (α) and base-function of non-failure operation ($S_0(t)$) (calculated according time of operation life for such type of CT):

$$S(t, (\text{tg}\delta_1, \Delta\text{tg}\delta_1, v_{\text{tg}\delta_1}, \alpha)) = S_0(t)^{\exp(b_1 \cdot \text{tg}\delta_1 + b_2 \cdot \Delta\text{tg}\delta_1 + b_3 \cdot v_{\text{tg}\delta_1} + b_4 \cdot \alpha)} \quad (1)$$

where b_1, b_2, b_3, b_4 – weights factors (quantitative assessment of the influence of diagnostic parameters).

Calculated probability of non-failure operation (0,4059) and residual life prediction were confirmed by the real case, predicted residual life of this CT in 2011 was between 0 and 6,5 years, which was confirmed by the failure, which occurred at the end of 2017 (6 years later after forecast was made).

According to the second model – using the fuzzy model according to the methods, the probability of failure (PF) and probability of non-failure operation were calculated according to the values of diagnostic parameters of the technical state (TS) (R_{isol} – insulation resistance, $\text{tg}\delta_1$ – insulation dissipation factor, C_X – capacitance,

Δt , °C – thermography data) at the two periods of operation – at the beginning of the forecast period and at the end (failure after 6,5 years).

The probabilities of failure were calculated according (2–7):

$$p(H_1) = \frac{F(t_2) - F(t_1)}{1 - F(t_1)}; \quad (2)$$

$$p(H_2) = 1 - p(H_1); \quad (3)$$

$$P = R \circ S; \quad (4)$$

where $\circ$ – mean max/min composition; S – technical state of the CT at the moment of calculation; R – matrix of cause – effect relationship.

$$y_{0P(Q)} = \frac{\sum_{j=1}^n P_{P(Q)_j} \cdot y_j}{\sum_{j=1}^n P_{P(Q)_j}}. \quad (5)$$

$$p(B/H_1) = y_{0P}; \quad (6)$$

$$p(B/H_2) = y_{0Q}. \quad (7)$$

Summary and conclusions. Two models of residual life prediction based on example of current transformer were analyzed. Both model used values of diagnostic parameters reflecting technical condition of CT. The first method gave a more accurate forecast over a longer interval (6,5 years), while the disadvantage of this method is the too wide range of predicted failure time (uncertainty about the occurrence of the event). The second model showed a tendency of an increasing in the probability of failure over the interval (7 years).

At the same time, the second model gave a high forecast accuracy over a short interval (1 year) and well reflected trends in the probability of an event. In operation, it is recommended to carry out calculations using both methods using automated online monitoring systems to predict the period of possible equipment failure, which will make it possible to schedule repairs and replacements of equipment, to avoid accidents, as well as to optimized distribution of financial assets of energy companies.