Calculation of output voltage values of a transformer subjected to asymmetric load

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Abstract **The paper presents the formulae necessary for calculating the output voltage values in power transformers subject to asymmetric loads, with the use of MCAD software.**

Keywords **Electrical machines, power transformers.**

I. INTRODUCTION

The power transformers, referred to as circuit-separation transformers, are used for transforming the medium to low voltage. They operate without voltage adjustment. These transformers are usually provided with three taps adjusted under potential-free state. The circuit-separation transformers are adequate to single-phase asymmetric loads in result of the use of the connection arrangement unaffected by such load types.

Under symmetric load the voltage drop value may be calculated using a simple relationship (1):

$$\Delta U(I,\alpha) = I(R\cos(\alpha) + X\sin(\alpha))$$

Analysis of the output voltage values under asymmetric load is more complex. The method of symmetrical components is a convenient tool for this purpose. Application of the method allows easily to calculate the coefficients of output voltage asymmetry, that significantly affect the assessment of the mains operating conditions. The coefficients of voltage asymmetry were calculated as the ratio of the negative to positive-sequence symmetric voltage. Legal regulations require checking the value of a so-called asymmetry index, defined as the ratio of negative to positive-sequence voltage. The value of the coefficient must not exceed 0.02. Exceedance of the asymmetry coefficient above its allowable level may be conducive to overheating of the three-phase motors even in case they are loaded with the rated moment.

II. ANALYSIS OF THE PROBLEM

The transformer load results from the value of the impedances connected to the windings of its secondary side.

In order to analyze the problem some preliminary assumptions should be made. The most convenient approach consists in assuming impedance values of particular phases.

III. CALCULATION

Taking the parameters of the power transformer of 630 kVA, voltage values 15000V/420/242.5 V and short-circuit voltage of 5.6% the characteristic values important for the topic of the present paper have been calculated. The figures show graphical presentation of some calculation results. The calculation has been carried out on the example of an asymmetric receiver of the following parameters:

$$Z_{zu}(k_1) = \left(k_1 Z_{odb} e^{0.107 \cdot 2 \cdot \frac{\pi}{3}} \right)$$

$$Z_{zv}(k_2) = \left(1.2 e^{jk_2 \cdot 0.307 \cdot 2 \cdot \frac{\pi}{3}} \right)$$

$$Z_{zw}(k_3) = \left(k_3 0.8 \cdot Z_{odn} e^{-j \cdot 0.207 \cdot 2 \cdot \frac{\pi}{3}} \right)$$

In this case of asymmetric load and various values of k_1, k_2, and k_3 coefficients the voltage asymmetry coefficients are equal to

$$K_u(1,1,1)1 = 0.073 \qquad K_u(1,0.85,0.9)1 = 0.067$$

$$K_u(0.9,1,1)1 = 0.076$$

For another exemplary loads one may obtain

$$K_u(1,1,1)1 = 0.022 \qquad K_u(1,0.85,0.9)1 = 0.025$$

$$K_u(0.9,1,1)1 = 0.025$$

It may be easily noticed that in the considered loadcase the asymmetry coefficients exceed the allowable value. The changes in the asymmetry coefficients caused by varying k_1 are depicted in the figure.

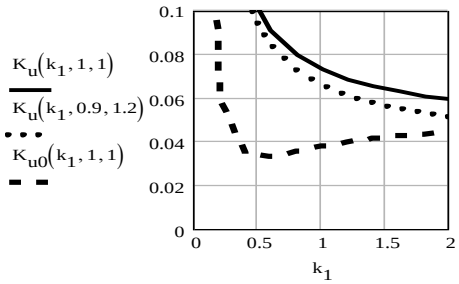

Fig. 1. The changes in the asymmetry coefficients vs. the k_1 coefficient

IV. CONCLUSIONS

The current flowing through the transformer windings cause the voltage drops. The voltage drop values depend not only on the current intensity but also on the load type, i.e. on the value of the power coefficient. In case of capacity loads the output voltage values may grow as compared to the input ones. Under asymmetric loads the output voltages take various values in particular phases. In case of supplying the three-phase motors the value of the asymmetry coefficient should be adjusted as in case of its high value the motor windings may overheat.

V. LITERATURE

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