STUDY ON THE DETERMINATION OF THE PARAMETERS OF A SINGLE PHASED ELECTRICAL TRANSFORMER REGIME FOR IDLING OPERATING

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Abstract: The elaborate paper aimed studying the idling operating regime of an electrical transformer, single-phase, with apparent rating power of 250 VA, assembled on a working stand entering in the configuration of the Laboratory machines and electric drives within the Faculty of Engineering and Sustainable Development.

Key words: single-phase electric transformer, idling operating regime, primary winding, secondary winding, power factor, voltage step

1. Introduction

The electrical transformer is legally principle a limiting case of a static asynchronous electric machine, designed to convert electromagnetic energy from a primary winding with w1 number of turns to a secondary winding with w2 number of turns. Power transfer is made on the assumption that both windings are static, placed on a ferromagnetic core and inductively coupled together [1].

From the constructive point of view in the configuration of a power transformer enters a ferromagnetic core on which columns there are placed the usually two isolated windings, both to each other and to the ferromagnetic core connected to the belt ground. The winding of the transformer connected to the power supply with electric energy is referred to as primary winding and the winding voltage level different from the primary winding, which supplies a particular circuit is referred to as the secondary winding. Electrical transformers that have more than one winding, as a rule, one of the windings is the primary winding and the other windings represents secondary windings [1].

It is known that by applying a supply voltage at the primary winding of a single-phase electric transformer, there is a circulation of an electric current, which has as an effect the propagation in the core of a ferromagnetic of an magnetic flux[1]:

$$\Psi = w_1\varphi = \Psi_{1u} + \Psi_{\sigma 1} \qquad (1)$$

Most of this flow(Ψ_{1u}), it is chained with the windings of the primary winding, respectively secondary winding, putting in these electric voltages E_1, respectively E_2.

The other component of the total magnetic flux Ψ , primary dispersion flow $\Psi_{\sigma 1}$, much smaller, especially that closes off the core and the primary winding fetter, induces an electromotive dispersion voltage $\underline{E}_{\sigma 1}$ only in the primary winding [1]. The electrical current(i_{10}) circulated through the primary winding of the single phase electric transformer, causes a voltage drop $R_1\underline{I}_{10}$[1].

To have a balance in relation to emf, the sum $-\underline{E}_1+jX_{\sigma 1}\underline{I}_{10}+R_1\underline{I}_{10}$, will be equal in size to the corresponding primary winding voltage $\underline{U}_{10}$, meaning[1]:

$$\underline{U}_{10}=R_1\underline{I}_{10}+jX_{\sigma 1}\underline{I}_{10}-\underline{E}_1 \qquad (2)$$

Starting from the premise that for an idling operating mode of an electric transformer, the values of active and reactive power failures associated to primary winding, usually are not exceeding 0.5% U_{10},, these components can be ignored.Also, in view of the fact that the afferent voltage to the primary winding (U_{10}) can be equivalent only to the corresponding electrical voltage afferent to this winding (E1), it can be written as [1]:

$$u_{10}=-e_1;\ e_1=-w_1\frac{d\varphi}{dt};\ \underline{U}_{10}=-\underline{E}_1 \qquad (3)$$

Through expression (3) it is highlighted the fact that, for a sinusoidal variation of the primary voltage U_{10} against time, emf associated with the primary winding(E_1) will still have a sinusoidal variation, but out of phase with the voltage U_{10} with an angle of 180 °. Consequently, we can say that the voltage applied to the power transformer primary winding (U_{10}) is equilibrated with emf (E_1) induced in the primary winding of the power transformer single phase by the base flow Ψ_{1u}[1]. Given the fact that the voltage applied to the single phase electric transformer primary winding represents a harmonic function, it can be appreciated that the resulting magnetic flux in the transformer core Ψ_{1u} will also form a harmonic function[1]:

$$\varphi = -\Phi_m \cos\omega t \qquad (4)$$

In figure 1 are represented the characteristics of variation of an electrical transformer for the idling operating regime[1-2].

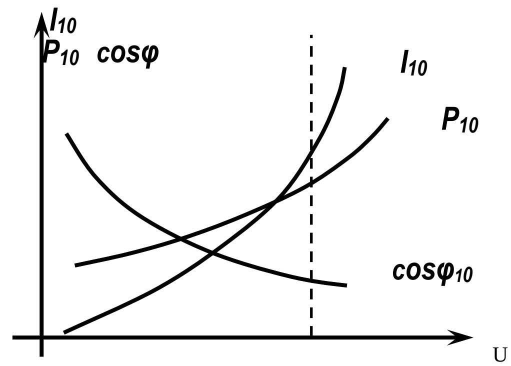


Figure 1.The characteristics of the transformer supplied with variable voltage for an idling operating mode.

2. Case study regarding the idling operating mode of the transformer

To study the regime of the idling operating mode single phase electrical transformer, it was considered the primary winding supply with a variable voltage from a variable autotransformer (ATR) within $(0\div 1,2)U_{1n}$. The case study had as a working hypothesis that the load impedance connected across the secondary winding tends to infinity ($Z_S=\infty$), and the current in the secondary winding tends to zero (I_{20}=0).

Figure 1 shows the experimental design used to determine the parameters that characterize the idling operating mode of the electric transformer which was the subject of the case study.

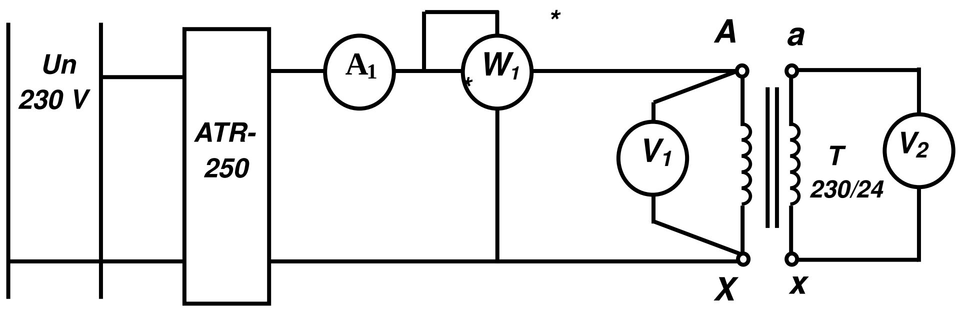


Figure 1. Experimental design used to determine the related parameters to the idling operating mode of the single phase transformer.

In the experimental configuration diagram, we used the following appliances and equipment:
1. Variable auto transformer(Un = 250 V, Sn = 250 VA, In = 8 A)
2. Single phase transformer $k_u = U_{1n}/U_{2n} = 230/24 = 9{,}583$, $S_n = 250$ VA ,
3. Digital Measuring Instruments.

Following the supply power of the primary winding single-phase transformer with variable voltage (U_{10}), were obtained the values (table 1) characteristic of this operating mode(I_{10} ,P_{10}). Using the obtained values, we determined with calculation the power factor value for each voltage step (stabilized through variable autotransformer), with the relationship [1-2]:

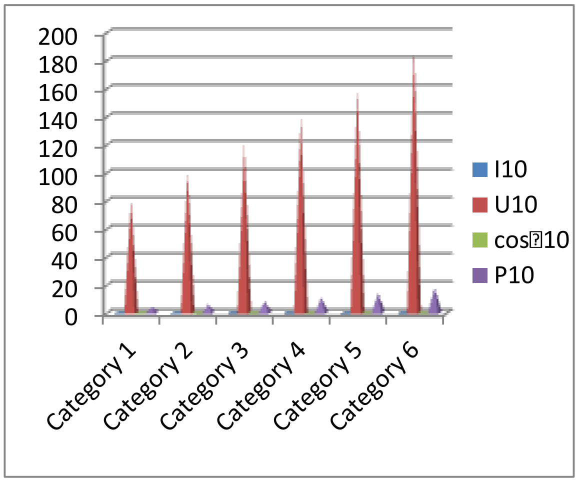
$$\cos\varphi_{10} = \frac{P_{10}}{U_{10} I_{10}} \qquad (5)$$

The values for each successive stages of voltage applied call shown in Table 1:

Table 1

No.	Values of parameters measured at the idling operating mode of the single phase electrical transformer				Values of parameters calculated at the idling operating mode of the single phase electrical transformer	Observations
	I_{10} [A]	U_{10} [V]	U_{20} [V]	P_{10} [W]	$\cos\varphi_{10}$	
1.	0,104	80	8,4	4	0,4807	
2.	0,125	100	10,4	6	0,48	
3.	0,149	120	12,5	8	0,4474	
4.	0,179	140	14,6	11	0,4389	
5.	0,22	160	16,7	14	0,3977	
6.	0,31	190	19,8	18	0,3056	
7.	0,45	210	21,9	23	0,2434	
8.	0,57	230	24	26	0,1983	

With the values obtained by measurement or by calculation, variation features have been built for each series of measurements(Figure 2):



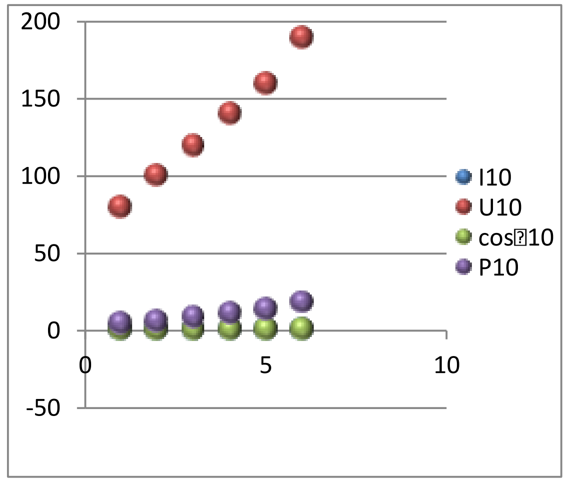


Figure 2 .Characteristics of variation of parameters characterizing the idling operating mode for single phase electric transformer

3.Conclusions

Analyzing the values obtained for each voltage stage applied to single phase electric transformer for the studied idling operating mode, it can be formulated the following conclusions:

1.Increasing the value of electric current (I_{10}) circulated through the primary winding of the single phase electric transformer, is directly proportional to the increasing of voltage (U_{10}) applied to its primary winding.

2. The power factor ($\cos\varphi_{10}$) for the single-phase electric transformer primary winding decreases proportionally with the increasing voltage (U_{10}) applied to the transformer primary winding.

3. Increasing the voltage value in the secondary phase of electrical transformer secondary winding is directly proportional to the voltage applied to the primary winding value growth, and thereby it is preserved the value of constant transformation ratio (k_U).

4. Bibliography

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