ГОДИШНИК на Минно-геоложкия университет "Св. Иван Рилски", Том 53, Св.III, Механизация, електрификация и автоматизация на мините, 2010
ANNUAL of the University of Mining and Geology "St. Ivan Rilski", Vol. 53, Part III, Mechanization, electrification and automation in mines, 2010

ASPECTS OF THE OPERATION IN CHARGE OF ELECTRICAL TRANSFORMERS

Cristinel Popescu[1], Luminiţa Georgeta Popescu[2], Vasile Cozma [3]

[1]University "Constantin Brâncuşi" din Tg-Jiu E=-mail: cristi67pop@yahoo.com,
[2]University "Constantin Brâncuşi" din Tg-Jiu E=-mail: luminita@utgjiu.ro,
[3]University "Constantin Brâncuşi" din Tg-Jiu

ABSTRACT:Electrical transformer represent the crucial electrical device in the process of converting electricity to different voltage level in electrical transformer and power distribution stations that are part of the National Energy System.

НЯКОИ АСПЕКТИ ПРИ РАБОТА НА ЕЛЕКТРОТРАНФОРМАТОРИТЕ

Кристинел Попеску[1] Луминита Попеску[2] , Василе Козма[3]
[1] Университет „ Константин Бранкуши", Търгу Жиу, Румъния E=-mail: cristi67pop@yahoo.com
[2] Университет „ Константин Бранкуши", Търгу Жиу, Румъния E=-mail: luminita@utgjiu.ro
[3] Университет „ Константин Бранкуши", Търгу Жиу, Румъния

РЕЗЮМЕ: Статията предоставя информация за някои особености на електротрансформаторите и тяхната функция като основни електрически устройства за промяна нивата на напрежение в рамките на електростанции и разпределителни системи. Проблемите са описани от гледна точка на Националната енергийна система на Румъния.

1.Introduction

Electrical transformers can have two or more windings, electrically insulated between them, for changing levels of tension in the transport, distribution and use of electricity. Of the electrical transformers used in power stations and posts, one of the largest use represents the two-winding transformers. This category with two windings has the characteristic that high voltage winding has a greater number of turns and winding low tenisune has a smaller number of turns. At the free ends of the windings of transformers are different voltage lines connecting .Between them ,the power tranformer transfer is done by induction,due to the magnetic coupling between windings.The power transfered by induction between windings is called internal power transformer. This paper aims to explain the electrical system which has connected to secondary winding a consumer with the impedance Z_S.

2. Operation analysis of a transformed electric load

When at the terminals of the secondary winding transformer is connected ZS-facilitates consumer, it passes through the current i2, which is phase-uncle to the secondary voltage u2 angle (fig.1) It is now our attention the transition process from electrical transformer load operation to load operating system.

When the transformer is operating under load i2 = 0, and about known it can be assumed that the voltage U1 is fully balanced by fear e_1, $\underline{U}_1 \approx -\underline{E}_1$.

ZS consumer connect through the transformer secondary winding current I2 passes, which creates t.m.m. $w_2 i_2$, which carries the Lenz principle of reverse magnetic action. T.m.m $w_2 i_2$ tends to create magnetic flux in magnetic core mutual induction, directed opposite to the basic magnetic flux, Φ_0 the current i_{10} excited. Reverse the effect of magnetic action, in the first stage of operation of the processor load,the basic magnetic flux Φ_0 is reduced. Due to this reduction in flow Φ_0, is reduced the t.e.m. induced e_1 too.. Since the supply voltage U1 = const.,then $U_1 > E_1$ Then for this reason, the primary winding current increases from i_{10} to $i_1 > i_{10}$.

i_1 creates t.m.m. $w_1 i_1$, which offsets the action of reverse magnetic of t.m.m. $w_2 i_2$ fromthe secondary winding. Therefore, the operating system load of the transformer, each secondary current i2 causes properly the variation change of the primary current i_1.

If it is agreed that under load, $\underline{U}_1 \approx -\underline{E}_1$ by neglecting the active and reactive voltage drops on the primary winding resistance and reactance, the movement from the no-load operating system to the operating system load, the primary winding current increases such a way as to offset entirely the secondary winding opposite magnetic action.

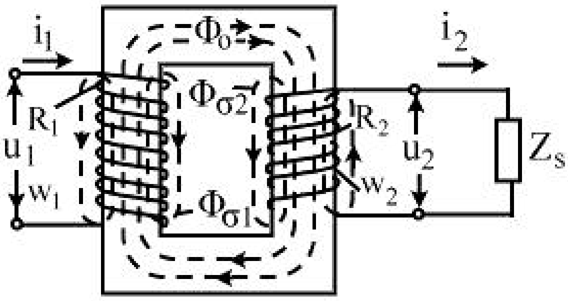

Fig.1 Schematic diagram of the transformer operating power under load

However,the magnetic flux Φ_0 is restored to the size that was operating under no-load operating mode, Φ_{0m} =const. In this case,it is resulting the equality between the resultant t.m.m. w_1i_{10} that creates the flow Φ_0 of no-load operating system and the t.m.m resultant of primary and secondary windings w_1i_1+w_2i_2 ,which creates the same magnetic flux Φ_0 in operating system task:

w_1i_{10}= w_1i_1+ w_2i_2 (1.1)

When using the symbolic method, equation (1.1.) assumes the form $w_1\underline{I}_{10} = w_1\underline{I}_1 + w_2\underline{I}_2$ (1.2.)

Equation (3.17) is equation t.m.m. in the operating system task processor. After solving it in relation to the current I1 is obtained:

$$\underline{I}_1 = \underline{I}_{10} + \left(-\frac{w_2}{w_1}\right)\underline{I}_2 \qquad (1.3)$$

From expression (1.3) it results that the conventional load current I_1 can be decomposed in two components:

- An independent load component I_{10} ,is equal to no load current and excites the main magnetic flux Φ_0 ;
- The second component $\left(-\frac{w_2}{w_1}I_2\right)$ depends on the load and overcome the current I_2 magnetic response. This component is the secondary current reported and is noted I'_2. In this case, equation (1.3) assumes the form: $\underline{I}_1 = \underline{I}_{10} + (-\underline{I}_2)'$ (1.4)

Operating under load, the current through primary winding is I_1>I_{10}, due to which the flow $\Phi_{\sigma1}$ increases, so the rated load it is around 5% of basic magnetic flux. This leads to the growth of t.e.m. He induced dispersion $E_{\sigma1}$. Is amplified the voltage drop R_1I_1. In this case,for the primary winding of the transformer under load, the force is equal:

$$\underline{U}_1 = \underline{E}_1 + R_1\underline{I}_1 + jX_{\sigma1}\underline{I}_1 \qquad (1.5.)$$

As $\underline{U}_1$ = constant., the increase of the voltage drop $R_1\underline{I}_1$ and $jX_{\sigma1}\underline{I}_1$ under load demonstrates the reducing of t.e.m. $\underline{E}_1$ respectively of the Φ_0 flow. More detailed analysis shows that contrary to increase their load voltage drop, they remain substantially lower than.

More detailed analysis shows that contrary to increase their load voltage drop, they remain substantially lower than. $\underline{E}_1$. Consequently, with the known approximations it is acceptable to the load variation,that the Φ_0 flow remains constant. In this case, equation (1.4.) is about character:

$$\underline{I}_1 \cong \underline{I}_{10} + (-\underline{I}_2)'$$

In the equations (1.2) and (1.4) phasor diagrams of t.m.m and current transformer are constructed (fig.2 a, b). I_1 current phasor is obtained if at the the current phasor at load operation I_{10} is added with the sign reversed the reported secondary current phasor I'_2 .

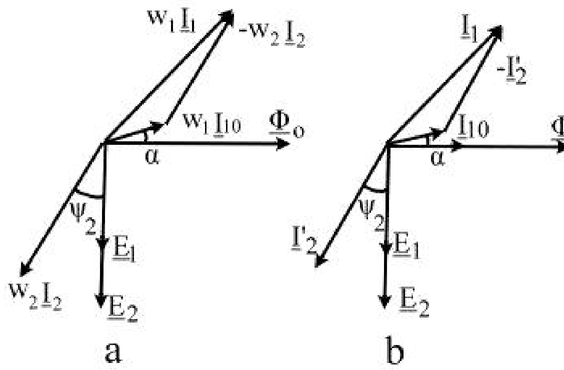

Fig.2 *a, b* Phasor diagrams of t.m.m in current transformer and load

Far examined the response to magnetic secondary winding under load, the influence of that part of the magnetic flux, which closes by magnetic circuit and secondary winding is created by I_2 current crossing.The other side of the stream created by the secondary winding, closes through air and is called leakage flux $\Phi_{\sigma2}$.

He only cuts the secondary winding and induces in her t.e.m dispersion $E_{\sigma2}$. And here as in examining primary winding we can admit that the $\Phi_{\sigma2}$ flow does not exist, and in its place in the secondary winding circuit is connected in series the inductance with the coil $L_{\sigma2}$ in which appears the inductive collapse voltage $-j \cdot X_{\sigma2} \cdot \underline{I}_2$ equal in magnitude and opposite t.e.m. $E_{\sigma2} \cdot \underline{E}_{\sigma2} = -j \cdot X_{\sigma2} \cdot \underline{I}_2$ .By $X_{\sigma2} = \omega \cdot L_{\sigma2}$ is denoted the Inductive reactance of dispersion-release secondary winding.

In addition to inductive reactance, the secondary winding has also active resistance R2. In this case, the total complex impedance of the secondary winding is

$\underline{Z}_2 = R_2 + j \cdot X_{\sigma 2}$. If it is known the active resistance and inductive reactance it can be established equivalent circuit of the transformer secondary winding fig.3 task. .

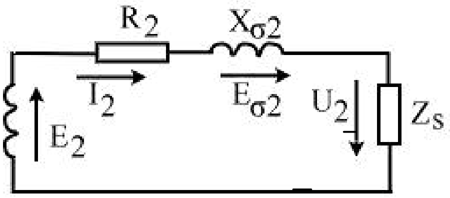

Fig.3 The equivalent scheme of the secondary winding of the transformer load

By the second law of Kirchhoff's for the momentary values of the t.e.m. and the voltage drops of the equivalent circuit (fig.3.) it can be established the equation:

$$e_2 + e_{\sigma 2} = u_2 + R_2 i_2 \qquad (1.6)$$

Equation (1.6) acquires the complex form as:

$$\underline{E}_2 + \underline{E}_{\sigma 2} = \underline{U}_2 + R_2 \underline{I}_2 \qquad (1.7)$$

After the substitution in equation (1.7) of $\underline{E}_{\sigma 2} = -jX_{\sigma 2}\underline{I}_2$ and the solve in report with $\underline{E}_2$ it is obtained:

$$\begin{aligned} \underline{E}_2 &= \underline{U}_2 + R_2 \underline{I}_2 + jX_{\sigma 2}\underline{I}_2 = \\ &= \underline{U}_2 + \underline{I}_2\left(R_2 + jX_{\sigma 2}\right) = \underline{U}_2 + \underline{Z}_2 \underline{I}_2 \end{aligned} \qquad (1.8)$$

The equation (1.8) characterize the electrical state of the secondary winding of the transformer under load If considering equations (1.3) (1.4) and (1.8) which is operating under load equations of single phase power transformer, written in complex form (all sizes are considered sinusoidal electric and magnetic) it can be build the transformer phasor diagram under load.

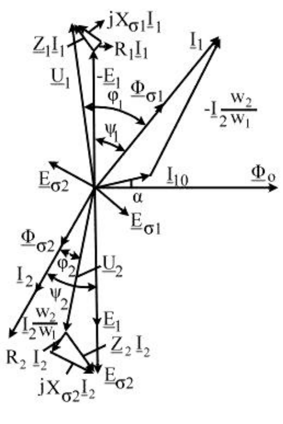

Fig.4 Transformer phasor diagram under inductive load character

Diagram construction starts at secondary voltage phasors. $\underline{U}_2$. Phasors $\underline{U}_2$ of phase angle φ_2 there are built the current phasors I_2 and $I_2' = \frac{w_2}{w_1} \cdot I_2$. In phase with the I_2 current is the secondary winding leakage flux $\Phi_{\sigma 2}$. At 90 ° from the flow phasors $\Phi_{\sigma 2}$ it is built the t.e.m. phasor $E_{\sigma 2}$.

In agreement with equation (1.8) to obtain the t.e.m.phasors E_2, at the secondary voltage U_2 it is added the voltage drops phasors phasors $R_2 I_2$ and $X_{\sigma 2} I_2$ (phasors voltage drop $Z_2 I_2$). The angle between the current phasors and t.e.m. is denoted with ψ_2 .

The direction of phasors E_1 t.e.m. coincides with that of phasors t.e.m. E_2. The difference between the sizes of the two phasors depends on numbers of turns of primary and secondary windings of the transformer. 90 ° before t.e.m. phasors E_1 and E_2 it is built the magnetic flux phasors Φ_0. Because of losses in magnetic core the current phasors I_{10} the flow Φ_0 phasors is phased with angle α .

In agreement with equation (1.4) the I_1 current phasors is obtained if is made the sum between current phasors I_{10} with the current phasors built in reverse which is $I_2' = \frac{w_2}{w_1} \cdot I_2$ .In phase with current I_1 is $\Phi_{\sigma 1}$ flow. 90 ° behind him is phased t.e.m. $E_{\sigma 1}$. To obtain voltage phasors U_1 is needed the continuation of the construction which represents the graphical solution of the equation (1.4). To this end, phasors t.e.m. E1 is traced in reverse and it is added to it the voltage drops phasors $R_1 I_1$ and $X_{\sigma 1} I_1$ ($Z_1 I_1$ voltage drop).

3.Conclusions

The angle between I_1 and t.e.m. --E_1 current phasors is denoted by ψ_1 and the angle between current phasors I_1 and voltage U_1 with φ_1. Transformer is -inductive load. Active power consumed by the processor is $P_1 = U_1 I_1 \cos\varphi_1$ and active power is transferred to $P_2 = U_2 I_2 \cos\varphi_2$ consumer. Phase difference for the case examined the nature inductive load is greater than the current φ_2 due to the influence of the no-load current operation, which is almost purely inductive nature.

Phasor diagram reports give a clear picture for characterizing amplitude and phase variables transform processes. Phasor dia-gram construction work and capacitive load is done similar to the inductive operating. .

Operating regime is normal work procedure for transformer and within it is given the power with the parameters converted to consumers.

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