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THE COST OF A TRANSFORMER AND THE IMPORTANCE OF ITS HEATING

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Annotation:
The problem of transformer losses and their causes are studied and recommendations for their optimal values are given. Transformer heating and cooling methods are studied.

Keywords: active power, inductive power, waste, load

We know that the losses in a transformer inevitably affect its efficiency. The result of the ratio of the active (useful) power P_2 supplied from the secondary winding to the consumer (load) to the active power P_1 received from the power supply of the transformer primary winding is called the efficiency (FIK) η. The formula for determining it is as follows:

$$\eta=\frac{P_2}{P_1}=\frac{P_2}{(P_2+\sum P')} \qquad (1)$$

Power losses in the transformer ($\sum P'$) are the magnetic losses generated by the alternating magnetic flux in the core and the electrical losses (including additional losses) that occur when current flows through the winding conductors according to the Joule-Lens law.) is included.

$$\sum P' = P'_{O.N} + K_{Yu}^2 P'_{qt.N} \qquad (2)$$

Electricity in the transmission of electrical energy from substation bus sources wastage of 5-10% of electricity on supply lines will be It is impossible to reduce electricity waste to zero, but it is necessary to strive to minimize them.

Since the voltage applied to the transformer is $\sum U_1$ = const and its load is almost constant at the values from salt to nominal, the magnetic losses of the transformer are also constant. These losses are approximately equal to the operating losses of the transformer[1].

The main and auxiliary power losses vary in proportion to the square of the current. Of course, this is also reflected in the heating of the magnetic and electrical conductors in the device, according to Joule-Lens law. A transformer connected to a load loses some of its electrical energy during operation, which is converted into heat energy and distributed to the environment. About 80% of the waste is generated by coils, and the rest by magnetic cores and metal structural elements [2].

When heat is released, the transformer heats up. In this case, its temperature is much higher than the ambient temperature. The main reason for this is the limited power when the load is connected.

Due to the heating, the natural convention of the oil inside the tank is formed, ie due to the heating of the magnetic system and the coils, the oil particles close to them lightly rise to the top of the tank, and those close to the tank wall cool down due to the natural circulation of air from outside. Heat from the tank walls is transmitted to the environment through radiation (invisible waves) and convection.

The paper-based Class A insulation used in the transformer loses its elasticity and becomes brittle when exposed to high temperatures for long periods of time. As a result, even small mechanical forces that occur during operation can damage the insulation and lead to a loss of electrical strength. This shortens the life of the transformer.

The higher the temperature, the faster the insulation will wear out. As the power of the transformers increases, the losses increase in proportion to its mass, which is approximately equal to its linear dimension (third degree), and the cooling surface to its square. This means that the heat dissipated in the transformer increases the losses faster than its cooling surface. When transformer oil is used as the cooling medium, it is 6-8 times more efficient than air-cooled.

If the transformer is in normal operation, ie in the nominal operating mode, and the temperature is at a certain value, it will definitely exceed the operating time. This means that its temperature and cooling system will definitely be affected for a lifetime. Insulation will last at least 20-25 years when oil transformers are used under normal conditions, ie when the insulation temperature at its hottest point does not exceed 105°C. If it operates under temperatures above 8-100C, the insulation service life will be reduced by about 2 times [4].

The requirement for the insulation material is that the insulation does not chemically react with transformer oil up to 110°C.

Figure 1, a shows the change in temperature along the height of the transformer, and Figure 1, b shows the approximate distribution of temperature in the horizontal section of the oil transformer.

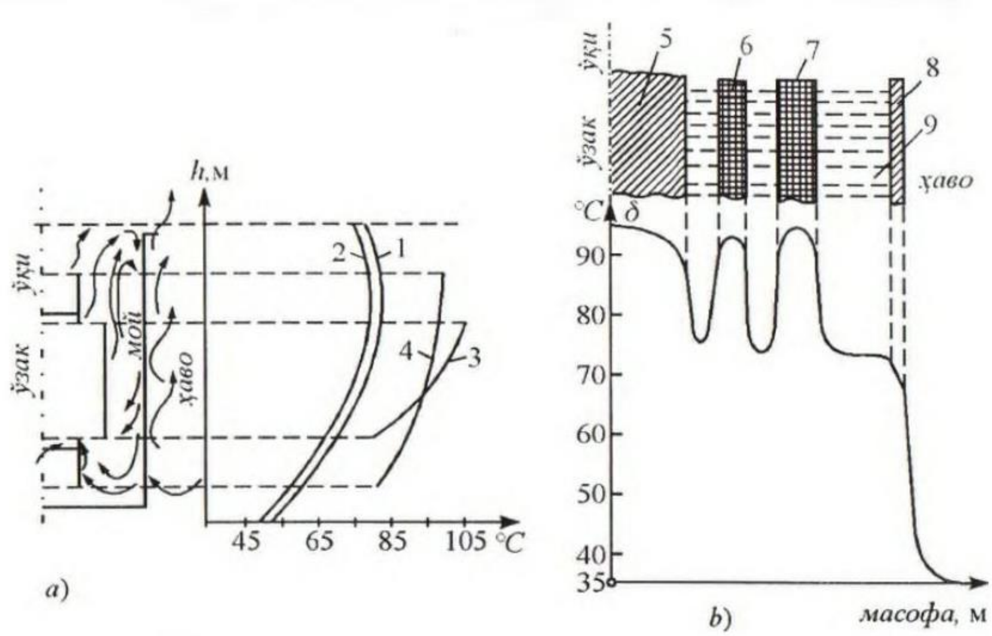

Figure 1. Oil-cooled power transformer: a) approximate temperature change in height (1st oil, 2nd tank walls; 3rd coil and 4th magnetic system); b) the approximate distribution of temperature in the horizontal section. (Core 5; Cells 6,7 PK and YUK; Base wall 8; May 9).

The temperature of the transformer generally varies depending on the load. At the same time, we should consider that it is advisable to make sure that the load does not exceed the nominal value. Therefore, one of these hesitations is that of this electrical loading center (ELM). The load connected to the secondary winding of the transformer causes the transformer to shift to the center of gravity of the load. As a result, firstly, non-ferrous metals are saved, and secondly, the voltage drops across the consumers at the end of the network are eliminated, and at the same time the load on the transformer is reduced [3-5].

The calculation of EYUM and the installation of the main substation in the center of gravity are widely used in these industrial enterprises. This ensures energy efficiency and rated operation of electricity consumers. In the construction of power supply systems for all types of industrial enterprises, master plans of these facilities are created, which show all the industrial production shops. The location of the shops is determined on the basis of production technology. The master plan shows the calculated or determined capacity of the industrial enterprise. The project also includes the above-mentioned shop and the entire company's electrical load schedules. Another important task of the design is to install BPP, BTP, TP in the most convenient place on the territory of the enterprise.

When designing power supply systems, load maps are shown in the master plans of the enterprise to determine the location of BPP, BTP, TP.

Loading cartograms are general-purpose circles, the area bounded by the surface of these circles, which is used to describe the calculated loads of the workshops on the selected scale. Each shop is shown its own circle, the center of which corresponds to the loading center of the shop.

The electrical load cartogram allows the designer to clearly visualize the distribution of electricity in the plant area.

$$\boldsymbol{P_i = \pi \cdot r_i^2 \cdot m}$$

From the expression you can determine the radius of the circle.

$$r_i = \sqrt{\frac{P_i}{\pi \cdot m}}$$

Here m is the scale of finding the circle.

The cartogram of the master plan of the enterprise, of course, must show the separate active and reactive loads. This is because the consumption of active and reactive charges comes from separate sources.

There are currently a number of mathematical methods that can be used to determine the electrical loading centers of shops and businesses. If we say that the load is evenly distributed over the area, then the center of the load can be assumed to be the same as the center of gravity of the figure in the plan view of the shop.

If the actual distribution of the load in the shop is taken into account, then the center of the load does not coincide with the planned center of gravity of the shop, so finding the center of the load leads to determining the center of gravity.

Given that this system will be available in all industrial enterprises, I propose to promote it in TPs used by consumers. In this way, of course, we can achieve a reduction in the value of energy waste.

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