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THE PRINCIPLE OF OPERATION OF TRANSFORMERS

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ABSTRACT

In this article highlights of the principle of operation of transformers and the most common electrical devices in industry. The choice of a power transformer for operation in enterprises is based on the selection of power, as well as in accordance with the requirements for power reliability. To ensure uninterrupted power supply, in some cases, it is necessary to install several transformers. An alternating current is applied to the primary winding, which forms an alternating magnetic flux in the magnetic circuit. This is due to its closure on the magnetic circuit and the formation of coupling between the windings, inducing EMF.

KEYWORDS: *Power Transformers, Magnetic Induction, Efficiency, Operating Principle, Classification, Parameter.*

INTRODUCTION

Power transformers: definition, classification and operating principle

The most common electrical devices in industry and in everyday life are transformers. Their purpose is to transfer power within an uncoordinated electrical circuit between its various circuits. They are used in cases where it is necessary to lower or increase the voltage between the energy source and the consumer. Transformers are also included in the circuits of power supply units that convert alternating current to direct current. At the heart of the operation of transformers is their ability to transfer electricity between the circuits by means of magnetic induction.

Fig 1. Power transformers

Power transformers are electromagnetic devices designed to convert alternating current voltages while maintaining its frequency, as well as to convert the power supply system itself.

Design and arrangement of power transformers

The main part of each power transformer is its core with several windings, made of ferromagnetic material. As a rule, these are thin sheets of special transformer iron with magnetically soft properties. The sheets are laid in such a way that the shape of the rods under the windings in the cross section is close to the circle. To increase the efficiency of the device and reduce losses, whole sheets overlap the joints between individual plates.

The transformer winding is usually made of copper wire with a rectangular or round cross-section. Each turn is isolated from the magnetic circuit itself, as well as from neighboring turns. For the circulation of the cooler, technical voids are provided between the windings and its individual layers.

Each transformer has at least two windings: the primary (electric current is applied to it) and the secondary (current is removed after its voltage is converted).

Operating principle

The principle of operation of any power transformer is the phenomenon of electromagnetic induction. An alternating current is applied to the primary winding, which forms an alternating magnetic flux in the magnetic circuit. This is due to its closure on the magnetic circuit and the formation of coupling between the windings, inducing EMF. The load connected to the secondary winding leads to the formation of voltage and current in it.

Structurally, to obtain any voltage on the secondary winding, the necessary ratio of turns between the windings is used. The power transformer has the property of reversibility. In other

words, it can be used to increase or decrease the voltage. In most cases, a power transformer is used to solve certain tasks. For example, specifically raise or lower the voltage. In the step-up transformer, the voltage on the primary winding is lower than on the secondary.

Classification of power transformers

Depending on the voltage class and the total power consumption, power transformers are divided into the following categories:

By capacity:

Up to 100 kVA, up to 35 kV;

100 – 1000 kVA, up to 35 kV;

1000 – 6300 kVA, up to 35kV;

More than 6300kVA, up to 35kVA;

Up to 32,000 kVA, 35 – 110 kV;

32 000 – 80 000 kVA, up to 330 kV;

80 000 – 200 000 kVA, up to 330 kV;

More than 200,000 kVA, more than 330 kV.

Types of power transformers

Power transformers can be divided into several types, based on the following characteristics and indicators:

- Type of cooling. There are dry and oil transformers. The first version has air cooling, used where the requirements for ecology and fire safety are increased. The second option is a housing filled with oil with dielectric properties, in which the core with windings is immersed;
- Climate-controlled design: exterior and interior options;
- The number of phases. There are three-phase (the most common) and single-phase;
- Number of windings. There are two-winding and multi-winding options;
- Purpose: raising and lowering.

An additional criterion is the presence or absence of an output voltage regulator.

Power transformer elements

The design of the power transformer implies the presence of the following elements:

- Power inputs – devices through which the load is supplied. They can be located inside the product or outside. The inputs are insulated with various special materials, differ in the type of insulation and construction;

- Coolers. For high-power power transformers, an oil cooling system is provided. Cooling of the oil itself is carried out by means of radiators, a corrugated tank, forced ventilation, oil-water coolers or circulation pumps;
- Output voltage regulators are devices designed to change the transformation coefficient. They can be triggered both under the influence of a certain load, and without it (depending on the design). In fact, the regulators add or reduce the number of turns in the winding.
- Power transformers can be equipped with additional attachments:
- Gas relay-a device with a protection function. If the transformer is unstable, the oil decomposes into its components and releases gas. The gas relay either disconnects the transformer or alerts it with warning signals;
- Temperature indicators-sensors that measure the oil temperature;
- Dehumidifiers – devices that absorb the condensate formed under the protective cover, thereby preventing it from entering the oil;
- Oil recovery system;
- Automatic cooler pressure protection system;
- Oil level indicator.

Power transformer parameters

Rated power. For a transformer with two windings, the parameter is equal to the power of each of them. For the three-winding version with different winding power, the parameter is equal to the larger of the indicators;

- The rated voltage of the windings is a characteristic parameter for idle operation;
- Rated current-the indicator at which long-term operation of the device is allowed;
- Short-circuit voltage-characteristic of the total resistance of the windings.
- Short circuit losses;
- No-load current – losses of magnetic core material (reactive and active);
- No-load current loss;
- Transformation coefficient.

How to choose a power transformer

The choice of a power transformer for operation in enterprises is based on the selection of power, as well as in accordance with the requirements for power reliability. To ensure uninterrupted power supply, in some cases, it is necessary to install several transformers. The power of each device is selected in such a way that when it fails, other devices are able to take over the functions of this missing link, taking into account possible overloads.

Another important criterion is the availability of protection:

- From internal injuries. It is provided by devices that control the presence of gases, temperature, pressure and level of the oil cooler;
- Overload protection. The so-called differential protection is used when current transformers are installed on each phase.

Repair and maintenance

The reliability of power transformers directly depends on the quality and timeliness of their maintenance. Devices installed in the premises where the company's personnel work are subject to daily inspection with monitoring of the oil level, the condition of the absorber and the regeneration devices. In addition, the integrity of the housing and the main elements is checked. Transformers in the premises without personnel are inspected once a month, and transformer points-twice a year.

An unscheduled inspection of the power transformer and its protection systems is carried out in case of a sharp change in the ambient temperature, as well as in emergency conditions. The voltage control devices are also subject to periodic maintenance. The reason is the oxidation of the contact groups, which leads to an increase in their transition resistance. Before seasonal load changes (usually twice a year), the device is disconnected from the consumers and the power supply, after which the voltage regulator is moved sequentially to all possible positions. The procedure promotes the destruction of the oxide film.

Laboratory analysis of the oil is carried out every year during major repairs. If the oil does not meet the requirements for visual inspection (color) or according to the survey data, it is replaced or refilled.

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