

Chapter 6

Gainful Utilization of Excess Heat From Power Transformers

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ABSTRACT

The study analyzes the various methods of gainful utilization of excess heat from power transformers. The ways to reduce heat loss inside the tank power transformer are found. The potential amount of heat emitted by power transformers of different capacities is calculated. New ways of combining the functions of electric transformation and heating in a power transformer are described. A system has been developed to use the excess heat of power transformers in the agricultural power systems. There are the structural and schematic diagrams of the system and a method for calculating its main elements. An improved design of the power transformer cooling system has been developed to combine the functions of electric transformation and heating. Experiments to verify the effectiveness of decisions are described. A feasibility study of the implementation of the developed system was carried out.

INTRODUCTION

Nowadays, much more attention is paid to energy saving issues, various options for reducing energy costs are increasingly being sought. New ways of generating electric and thermal energy are emerging due to the development of renewable energy sources and distributed energy (Kharchenko, Gusarov & Bolshev, 2019) as well as methods of managing such systems (Vinogradov et al., 2019) reducing costs for the operation of power supply systems (Vinogradov et al., 2018).

Power transformers are characterized by high efficiency reaching 99% and high reliability as they do not contain moving parts. At first glance, the loss of electricity by 1-3% may seem insignificant. But when the power of a transformer is measured in tens of megavoltamperes, the energy loss reaches hundreds of kilowatts. Since these losses are allocated in the form of heat, it makes sense to take it for further use.

Combining the functions of voltage transformation and electrical heating in a power transformer is a very promising idea for heating not only electrical installations, but also agricultural facilities. These heat consumers are often located away from central heating systems. Therefore, it is required to install autonomous heating systems, the work of which is accompanied by considerable financial expenses for electricity or other resources. The power transformer can be installed at power plants, at step-down substations, at consumer power centers and directly at electrical consumers where there are facilities that need heating (Baishev & Toropov, 2018).

High-power transformers (from 25 MVA) always acted as heat sources in the works of predecessors since the amount of released heat is so great that it was possible to get enough thermal energy without resorting to significant changes in the design of transformers when high percentage of heat loss. Therefore, there is a need to develop an improved design of the transformer cooling system allowing to maximize the targeted heat extraction for the needs of heat supply. This will make it possible to use power transformers of much lower power (from 1000 kVA) as heat sources. It will expand the area of application of the gainful utilization of the excess heat from power transformers by tens of times. So, the aim of the work is to develop methods and means of gainful utilization of excess heat from power transformers with improved design of their cooling system.

BACKGROUND

When creating and operating any system, the first question is its efficiency. Although a power transformer has almost maximum efficiency, yet a small part of the electric power is lost in its active elements (magnetic core, winding) and is released in the form of excess heat. And if this thermal energy is used to heat any objects? This theme was studied in many works. For example, Lavrentiev (2018) describes the system of the use of transformer heat for the purpose of heating substation premises of 110–400 kV on the basis of an external low-water heat exchanger, a thermal pump and a control cabinet. Kjell (2013) offers a system allowing to profitably use the excess energy of a power transformer. This is achieved by introducing an external heat exchanger, a heat pump and a heat accumulator. At the same time, Novikov and Taybakhtin (2015) described a system that provides for the collection of air transformer emitted by radiators and its transfer to a heated room. A number of options for the taking and using heat from power transformers for heat supply at power substations (PS) are also proposed in works of Gridin & Petrenko (2013), Mostofizadeh and Kulick (1998) and Cortes & Rivera (2010). These methods can be divided into the following groups:

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