

# Research Direction of Oil-immersed Transformer

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**Abstract:** With the continuous development of the electric power industry in the world, the application of oil-immersed transformer in all walks of life has become more and more extensive. But the safety problem of oil-immersed transformer, environmental protection problem, heat energy recovery and utilization problem are always the three mountains in front of the power system researchers. Therefore, it is particularly important to develop a new type of transformer that can adapt to the green, innovative and sustainable development of the power system. This paper will discuss the new ideas and new directions of oil-immersed transformer research in the future from three aspects: the study of transformer oil, the recovery and utilization of transformer heat energy, and the noise reduction of transformer.

**Keywords:** Oil-immersed transformer, Energy-saving, Environmental-friendly.

## 1. Instruction and Background

1.1 The working principle of oil - immersed transformer cooling—The heat from The working transformer is conveyed to The transformer oil , and the transformer oil flows into the tank wall and the heat pipe after being heated and expanded.Then,the heat in oil is dissipated by air convection and air heat conduction. After cooling, it flows back into the tank to re-engage in heat absorption and cycle.

1.2 According to statistics from the National Bureau of Statistics, China's annual electricity generation is about 7.42 trillion kilowatt-hours, topping the list of all countries in the world.According to incomplete statistics, the loss of energy in the form of heat from the step-down transformers of 35kV to 220V in the urban power grid accounts for about 1.6% of the power generation.Thus, it can be roughly estimated that about 118.721 billion kilowatt-hours of electric energy will be released into the air in the form of heat energy.It will not only waste energy, but also cause heat pollution in the air and further contribute to global warming.After the 19th National Congress of the Communist Party of China (CPC), China has given top priority to the concept of innovative, coordinated, green, open and shared development. Energy recycling and sustainable development have become increasingly important than ever before.

1.3 The noise decibels of oil-immersed transformer generally ranges from 50 decibels to 60 decibels.According to the Environmental Noise Standard of Urban Area of China.The noise level in residential areas should not be higher than 50 decibels during the day and 40 decibels at night, otherwise it will affect people's normal daily living.Therefore, the work of oil-immersed transformer may cause noise pollution to urban residents.

The above three contents indicate the future research direction of oil-immersed transformer in a direct or indirect way.

## 2. Analysis of the Research directions

### 2.1. Research direction 1: Composition of transformer oil

The working principle of oil-immersed transformer cooling can be summarized as follows: when the transformer works,

heat will be generated and transferred to the transformer oil. When the transformer oil is heated, it will expand and then flow into the tank wall and the heat pipe. After the heat of the transformer oil cools, it will flow back to the tank to participate in a new heat absorption.By analyzing the working principle of oil-immersed transformer cooling (Refer to 1.1), it is not difficult to see that transformer oil (cooling medium) plays a crucial role in the transformer cooling process.The function of transformer oil can be mainly divided into three aspects: insulation, heat dissipation and arcsuppression.Under the guidance of these three functions, the study of transformer oil material will be the first scientific research direction of the new oil-immersed transformer.In the future, we can improve and develop a new type of transformer oil, which contains the following characteristics:

1. Lower density.A less dense transformer oil will make it easier to layer transformer oil with water and other impurities, thus facilitating the re-flow of hot oil into the tank wall and heat pipe for a new heat cycle.

2. High flash point.An important reason for oil-immersed transformers to be used outdoors is safety.Because the main component of transformer oil is the mixture alkanes, cycloalkanes, and naphthenic saturated hydrocarbons.It belongs to the combustible and its flash point is generally between 135 and 140 degrees.There is a new research idea that we can add a new kind of chemical substance to the transformer oil to improve the flash point, which can greatly reduce the probability of explosion and combustion of oil-immersed transformers

3. Higher insulation and oxidation resistance.Oxygen is the main culprit in transformer oil oxidation.At the same time, the insulation of transformer oil will also decrease with the oxidation of transformer oil.Once the insulation of the transformer oil decreases, the huge voltage difference between the phase and phase of the three-phase transformer may have the risk to break down the insulating medium, and then destroy the transformer.In the future, we can invest more money and energy to study the oxidation and insulation of transformer oil.For example,we can develop a new type of antioxidant to add to the transformer oil in order to improve the oxidation and insulation of transformer oil.

4. In response to China's green and sustainable development idea and policy,the composition of transformer oil should become more environmentally friendly,.It is

imperative for us to research with the target to reduce the acid, alkali and sulfur content in transformer oil. On the one hand, it can reduce the corrosion of transformer oil tank of transformer and on the other hand, it can also reduce the damage to the soil and the environment in case the fuel tank leaks.

As long as we put more scientific research funds and time into the research and upgrade of transformer oil properties and make it better able to meet the above properties, the power system can make a huge breakthrough in the solution of the oil-immersed transformer safety and environmental friendliness, which can recover unnecessary economic losses.

## **2.2. Scientific research direction 2: Recovery and utilization of transformer oil heat energy**

According to the statistics of the National Bureau of Statistics, China's annual electricity generation is about 7.42 trillion kilowatt-hours, of which the energy lost in the form of heat accounts for about 1.6% of the total electricity generation. It can be roughly estimated that about 118.72 billion kilowatt-hours of electricity will be released into the air in the form of heat every year in China, which is equivalent to the annual electricity consumption of 100 million households. It will not only cause air thermal pollution, but also cause huge energy waste. Therefore, the next research direction of oil-immersed transformer can be turned to the recovery and utilization of transformer heat energy. Due to the iron consumption and copper consumption, the heat will be transferred from the working machine to the transformer oil in the form of overheating transfer, and then the transformer oil will transfer its heat to the oil wall box and heat pipe in the process of cooling. If we collect the heat energy of oil wall box and heat dispersing pipe and make use of it, our country will take a big step on the road of sustainable development. As for the recovery and utilization of heat energy, it can be divided into two categories: direct utilization and indirect utilization. For example, in northern China, we can put the hot air blown by the oil-immersed air-cooled transformer (ONAF) into the caliducts. In the cooling process to provide heat to residents purposes without any energy, this is a form of direct utilization. Another example is that we can transfer the heat energy of the hot oil of the transformer to other substances (such as tap water) in the form of heat transfer. Thus, hot water can be supplied to residents without the need for natural gas, which is a form of indirect utilization. In the future, we should put more scientific research efforts into the recovery and utilization of transformer heat energy, which can not only reduce air thermal pollution, but also contribute to sustainable

development.

## **2.3. Research direction three: transformer noise reduction**

An important reason for oil-soaked transformers to be placed outdoors is that compared with dry transformers, there is greater noise. Generally speaking, the noise of oil-immersed transformer is between 50 and 60 decibels, and its main source is the iron core vibration caused by magnetostriction at power frequency and voltage, which will affect people's life and work. In order to reduce the noise pollution of transformers, it is necessary for us to put more effort into researching the noise reduction system of transformers in the future. Among them, the research and update of core structure and transformer noise enclosure are the core of transformer noise reduction technology breakthrough. In the future, we should develop a new transformer noise reduction system on the premise of ensuring the ventilation and heat dissipation of transformers, which can not only achieve the effect of noise reduction, but also effectively shield electrostatic radiation.

## **3. Conclusion**

In order to better realize the green, innovative and sustainable development of power system in the world, the future research direction of oil-immersed transformer can be diverted to the following three aspects: 1. the performance of transformer oil. 2. the recovery and utilization of transformer heat energy. 3. the noise reduction of transformer. As long as the above three points have a huge breakthrough, we can develop a more environmentally friendly and energy-saving oil-immersed transformer which can better adapt to the development of human society.

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