ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS INTERNATIONAL

Google Scholar

Crossref doi

SLIB.UZ Scientific library of Uzbekistan

Volume 9
Issue 1
2024

UDC 621.3.048.82

INFLUENCE OF VARIOUS MECHANICAL IMPURITIES IN TRANSFORMER OILS ON ELECTRIC AND MAGNETIC FIELDS

YUSUPOV DILMUROD TURDALIYEVICH

Scientific secretary of the Institute of Energy Problems of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan

AVAZOV BOBOMUROD KURBONOVICH

Tashkent state transport university, Tashkent, Uzbekistan
Phone: (0893) 593-3827, E-mail: avazovbk@gmail.com
ORCID: 0000-0003-3732-5186
**Corresponding author.*

Abstract: The article presents an analysis of the influence of various mechanical impurities of transformer oils on electric and magnetic fields based on scientific literature. The analysis showed that mechanical impurities contained in transformer oil affect the electric field. However, the influence of sludge, fibers and metal particles on the magnetic field is stronger. At the same time, the electromagnetic field is influenced by such types of mechanical impurities contained in transformer oil as asphalt deposits, fibers, soap compounds and metal particles.

Keywords: transformer oil, electric field, magnetic field, electromagnetic field, mechanical mixtures, asphalt deposits, fibers, sludge, resin, coal, metal particles.

Introduction. Various types of mechanical impurities are considered the main factors affecting the performance properties of transformer oil. These mechanical connections are deposits and do not dissolve in or react with oil. These mechanical compounds are varnishes, various paints, etc., fibers, dust used in parts of oil-immersed power transformers. The concentration of mechanical deposits in transformer oil increases due to internal damage to the transformer (as a result of an electric arc, a pulsed increase in the internal temperature of the transformer over a long or short period of time, damage during transportation, vibration of the transformer exceeding the permissible value, partial discharge and other factors) [1, 2].

Materials and methods.

Mechanical deposits are divided into 3 types based on their origin:

a) Mechanical deposits in the oil when pouring oil into the transformer;

b) Mechanical deposits that got onto the oil in transformer parts during production and assembly;

c) Mechanical deposits formed in the working transformer;

These mechanical wastes negatively affect the dielectric characteristics of transformer oil, i.e., they increase dielectric losses and cause a decrease in the breakdown voltage of transformer oil. Mechanical deposits negatively affect the circulation process in the small channels of the transformer cooling system, as a result the heat transfer process slows down and the transformer does not have time to cool down, as a result, the service life of the transformer is reduced. Decreases [3].

Mechanical sediments (slags) in transformer oil are divided into 3 groups:

1) Mechanical asphalt concrete mixtures are dark brown in color, resulting from a mixture of metal and acids. The main negative effect of these mixtures is that the cooling system of the transformer deteriorates.

2) Mechanical chalk mixtures from light brown to dark brown, formed from mixtures of metals and acids. When these substances interact with water, they cause breakdown of the dielectric in the inside of the transformer.

3) Black mechanical connections (carbon material) formed as a result of the action of an electric arc in transformer oil. This deposit has good electrical conductivity and rapid flammability, which reduces the breakdown voltage of transformer oil and increases its flammability [4].

Results and discussion. As a result of partial discharges occurring in transformer oil, fine carbon particles are formed on the high-voltage side of the circuit. The mass of these coal particles is very light, so the oil does not sink to the bottom. On the low-voltage side of a power transformer, the carbon particles generated by partial discharge during overload conditions are larger than those on the high-voltage side. Under operating conditions, these particles mix with the oil and increase the degree of oil colloidation. In addition to the above, the colloidation process is also influenced by the following factors and substances:

a) Varnish applied to the tank, varnish applied before repairing the transformer;

b) Stale transformer oil, which reacts acidically with metal parts;

c) acidic sludge-like waste that does not contain metals (slag, for example: asphalt waste and products of condensation and oxidation of oil);

d) In addition, during assembly of the transformer, metal particles separated from other metal parts of the structure.

e) Copper products used in the transformer accelerate the oxidation process of transformer oil (aluminum, steel, tin and other metallic substances used in structural elements are quite passive in the oxidation process) [5].

Among the mechanical deposits mentioned above, the most dangerous for the insulation of transformer oil are those smaller than 5 microns, which accounts for 95% of the total amount of mechanical deposits [4]. The danger of these substances is that the small size of these substances allows them to easily fit between the molecules of solid insulation, which causes a change in the electrical properties of this solid insulation. Considering the above, mechanical sediments can be divided into the following main substances (Fig.1):

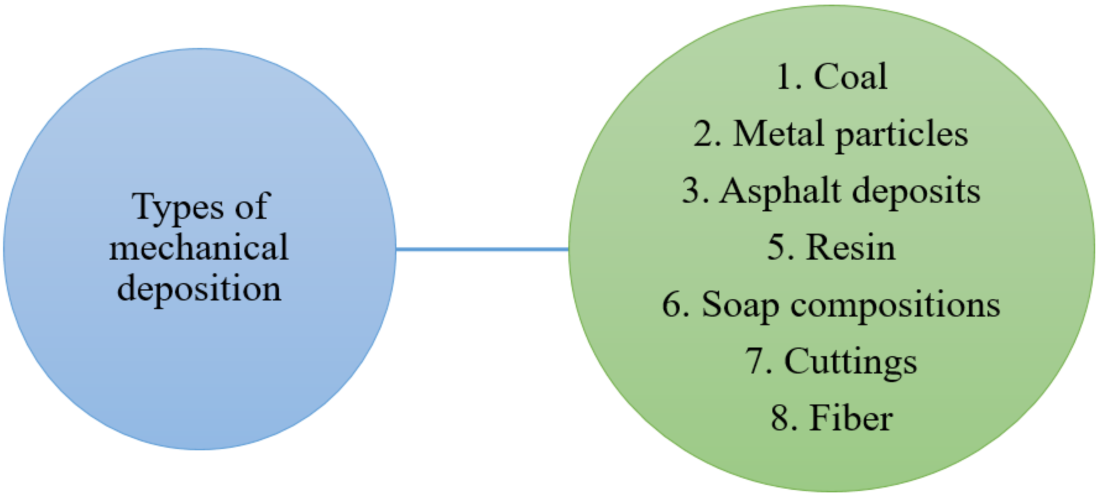

Figure 1. Types of mechanical deposits in transformer oil.

1) Coal:

A) Electric fields affect small particles of coal in transformer oil. In the presence of an electric field, electrical discharges can occur, causing the breakdown of transformer oil and the formation of carbon particles.

B) Magnetic fields usually do not have a significant effect on fine coal particles in transformer oil. Coal particles are formed as a result of oxidation and thermal decomposition of transformer oil. Magnetic fields usually do not affect these processes.

B) Electromagnetic fields usually do not directly affect fine carbon particles in transformer oil. In some cases, high frequency electromagnetic fields can cause ionization or destruction of transformer oil, which promotes the formation of carbon particles. In general, in order to maintain the quality of transformer oil and prevent the formation of carbon deposits, it is important to carry out regular maintenance and diagnostics of the transformer within the established period of the operating instructions [7].

2) Resin:

A) Electric fields can affect small amounts of resin in transformer oil, creating electrical charges that cause the transformer oil to break down and form resin. To avoid such problems, it is necessary to maintain the quality of the transformer oil and regularly analyze it to monitor its condition. Also, the use of dielectric materials and insulation helps reduce the effect of electric fields on the resin in the transformer oil.

B) Magnetic fields usually do not have a significant effect on the resin in transformer oil. Tar is formed as a result of oxidation and thermal decomposition of transformer oil. However, if the transformer oil contains metal particles or other magnetic materials, the magnetic fields will affect the behavior of the resin.

B) Electromagnetic fields usually do not have a direct effect on the resin in transformer oil. High-frequency electromagnetic fields cause ionization or decomposition of transformer oil to form resins [7].

3) Sludge:

A. Electric fields can affect various fine deposits in transformer oil. Sludge in transformer oil can be electrically discharged when exposed to an electric field. These electrical discharges cause the transformer oil to decompose and form various insoluble slurries.

B. Magnetic fields can affect suspensions in transformer oil. Sludges typically consist of insoluble impurities such as metal particles and organic compounds. If these connections contain magnetic elements, they will be affected by magnetic fields. This causes sludge to move and accumulate in certain areas of the transformer.

C. Electromagnetic fields generally do not have a significant effect on transformer oil sludge. Metal particles and organic compounds contained in suspensions are not exposed to electromagnetic fields [8].

4) Asphalt:

A. An electric field can affect transformer oil containing asphalt compounds. Under the influence of an electric field, the phenomenon of electric polarization and perforation may occur in transformer oil, which may change its physical and chemical properties. This can change the thermal conductivity, viscosity and dielectric of transformer oil with asphalt compounds. In addition, the electric field can cause dangerous electrical and corona discharges in transformer oil with asphalt deposits. Therefore, when designing systems in which transformer oil is present, it is necessary to take into account the influence of the electric field and take appropriate measures to reduce or control it.

B. The magnetic field does not directly affect the asphalt joints in transformer oil. Asphalt compounds in transformer oil are an insulating material and do not have magnetic properties.

C. Asphalt compounds in transformer oil are exposed to electromagnetic fields, especially if the asphalt contains transformer oil or other insulating fluids. This is due to the fact that electromagnetic fields can cause various phenomena and reactions in the substances that surround them [7].

5) Volokno:

A. The electric field can affect the fibers in the transformer oil. The fibers contained in transformer oil are polarized or charged under the influence of an electric field. For example, an electric field can lead to the accumulation of fibers in the structure of transformer oil, the formation of electrical circuits or a change in the viscosity of transformer oil.

B. The magnetic field affects the fibers contained in the transformer oil. In some cases, the magnetic field generates a magnetic force in the fibers contained in the transformer oil, which negatively affects the insulation of this transformer oil. The effect of the magnetic field on the fibers contained in the transformer oil affects its intensity and other parameters such as the viscosity and temperature of the transformer oil.

C. Electromagnetic fields affect the fibers contained in the transformer oil. Such fields cause electric current and power currents in the transformer oil, which causes contamination of the transformer oil. In addition, electromagnetic fields cause damage to the oil by forming thermal processes in the transformer oil, and therefore the reliability of the transformer's operation is reduced [7].

6) Soap connections:

A. The electric field affects the soap connections in the transformer oil. In transformer oil, the strength of electrical insulation usually depends on the amount of soap compounds contained in it. These soap compounds can change their structure or take the form of slag or solid matter under the action of an electric field. When an electric field is applied to the transformer oil, it causes the redistribution of soap molecules, causing the formation of soap particles in the oil.

B. The magnetic field does not affect the soap connections in the transformer. Soap compositions are not exposed to a magnetic field, and their properties do not change. Electromagnetic fields can affect the properties and condition of transformer oil, including its electrical conductivity, dielectric strength and thermal conductivity. In addition, magnetic fields cause an induction electric current in the transformer oil, which leads to an increase in heat losses in the oil and a decrease in the efficiency of the transformer.

C. Soap compounds in transformer oil are considered sensitive to the electromagnetic field [5].

7) Metal particles:

A. The electric field affects the metal particles in the transformer oil. The electric field can cause the movement of metal particles and the accumulation of force on the surface of the conductive parts of transformers. This leads to an electrical discharge in the conductors or walls of the tank, as well as to a spark.

B. The magnetic field acts on metal particles in the transformer oil. The magnetic field acts on the alkali metal particles in the transformer oil, causing the particles to move.

C. Electromagnetic fields affect metal particles in transformer oil. The electromagnetic field generated inside the transformer creates electromagnetic forces on metal particles, causing them to move and accumulate in certain areas of the oil [9].

Discussion. The analysis of the influence of various mechanical compounds in transformer oils on electric and magnetic fields based on scientific literature showed that mechanical compounds contained in transformer oil have an effect on the electric field, and the effect of sludge, fiber and metal particles on the magnetic field is greater. At the same time, it was found that the types of mechanical impurities in the transformer oil, such as asphalt deposits, fibers, soap compounds, and metal particles, have an effect on the electromagnetic field, and this is presented in Table 1.

Table 1. The following table shows the sensitivity of mechanical deposits to various fields.

	Coal	Resin	Sludge	Asphalt sediments	Volokno	Soap compounds	Metal particles
Electric field	+	+	+	+	+	+	+
Magnetic field	_	_	+	_	+	_	+
Electromagnetic field	_	_	_	+	+	+	+

Conclusion:

1. It turns out that there is an influence of mechanical impurities in transformer oil on the electric field. But the influence of slag particles, fibers and metals on the magnetic field is greater.

2. Types of mechanical impurities in transformer oil, such as asphalt deposits, fibers, soap compounds and metal particles, affect the electromagnetic field.

References

1. Михеев Г.М. Электроконвективный очиска жидкого диэлектрика / Михеев, Г.М., Тарасов, В.А., Михеева, Т.G., и Михеев // Письмо в журнал технической физики. - г.М. 2008 г. 34 (9), с. 65-72.

2. Черненко Ж.С., Усатенко С.Т., Калинина В.Т. «Влияние магнитной обработки на физические свойства углеводородных жидкостей» Сборник «Вопросы теории и практики магнитной обработки воды и водных систем» Новочеркасск, 1975. С.93-95

3. Попов Г. В. и др. О разработке вариофикационных моделей для представления развития дефектов в силовых маслонаполненных трансформаторах // Вестник ИГЭУ, 2013. Вып. 1. С. 25-31

4. Yokenbah E., Borsi H. Condition and diagnosis of power transformers // Jnternational conference on condition monitoring and diagnostic, 2008. P. 21-24

5. РД 34.43.206-94. Методика количественного химического анализа. Определение содержания производных фурана в электроизоляционных маслах методом жидкостной хроматографии. - Москва: ОРГРЭС, 1995.

6. Карташова А. А., Новиков В. Ф. Определение фурановых соединений в трансформаторном масле газохроматографическим методом с использованием новых сорбентов // Известия вузов. Проблемы энергетики. - 2016. № 1-2. С. 99-103.

7. Морозова Т.Ф. Формирование структуры в магнитной жидкости при воздействии поляризующего напряжения: автореф. дис. канд. физ.-мат. наук. Ставрополь, 2002. 24 с.

8. Yusupov, D. T., Avazov, B. K., Kutbidinov, O. M., & Bazarov, M. (2023, August). Cleaning of transformer oils using the electric field. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1231, No. 1, p. 012024). IOP Publishing.

9. Kurbonovich, Avazov Bobomurod, and Yusupov Dilmurod Turdaliyevich. "Cleaning of Used Transformer Oil." *JournalNX*: 719-724.

10. ГОСТ 982-80 Масла трансформаторные МКС 75.1 Москва Стандартинформ-2011г.

11. Курочкин А.С. и др. Метод сверхглубокой очистки трансформаторного масла и маслонаполненного оборудования как способ повышения надежности работы трансформаторов // Международная научно-практическая конференция «Трансформаторы: эксплуатация, диагностирование, ремонт и продление срока службы». 13–17 сентября 2010 г., Россия, г. Екатеринбург. С.233–243 с.

12. Kurbonovich, Avazov Bobomurod, and Yusupov Dilmurod Turdaliyevich. "Cleaning of Used Transformer Oil." *JournalNX*: 719-724.

13. Липштейн Р. А. Трансформаторное масло / Р. А. Липштейн, М. И. Шахнович. - 3-е изд., перераб. и доп. - М.: Энергоиздат, 1983г. – 296 с.

14. Berdiyev U.T., Vetcher A.K., Hasanov F.F., Avazov B.B. Soft Magnetic Materials for Electric Machine Construction. (2023) AIP Conference Proceedings, 2612, art. no. 050014, Cited 0 times. DOI: 10.1063/5.0117785.

C O N T E N T S