Express diagnostics of power oil transformers by vibroacoustics and partial discharges

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Abstract. This article presents the results of Express Diagnostics conducted in the working state of the autotransformer ATDTN-125000/220/110-U1. Three measurement pribors were used in the research process to determine the vibroacutic, partial discharge, and current strength values in the working state of the oil power transformer. Experimental studies and their analysis have shown that by evaluating the technical condition of the oil power transformer at a short opportunity, it is possible to give a conclusion to its ecpluation or release into repair.

1. Introduction

The development of all economic sectors, an increase in the standard of living of the population causes an increase in electricity consumption and, as a result, an increase in the load on electric power equipment [1-4]. At the same time, a large number of powerful power transformers, which are important and expensive equipment of the electric power industry, are operated in excess of the designated resource [5, 6]. Despite extensive experience in the power system of technical operation of transformers, there are cases of sudden failure of transformers without the possibility of their further restoration. There are parameters that are diagnostic and factors that significantly affect the life of transformers. These are moisture, vibration and partial discharge. The interaction of these factors has not been thoroughly studied. The most dangerous defect of transformers is partial discharge. The physical processes of the formation of partial discharges have not been sufficiently studied. Technologies and methods of restoring the technical condition of transformers are also not fully developed. To date, the distribution of transformers in the power system according to their service life is as follows: according to statistics, up to 15 years - 15%; 15-25 years old - 20%. The number of transformers working for more than 25 years reaches about 60-70%. A similar problem can be noted for substations of large industrial enterprises. In recent years, both in the energy system and in industrial enterprises, cases of damage to transformers are frequent. Reducing the breakdown rate of transformers and increasing the service life of each transformer by 10-15 years will allow you to save a lot of money [5-6]. Despite the constant increase in funds allocated for the renewal of the fleet of power equipment, to date, it has not been possible to significantly change this situation [7, 8, 9]. On the other hand, many experts note that it is often impractical to change a transformer after its designated life (25-30 years) [10]. The fact is that if the operating conditions of the equipment during the service life corresponded to the calculated ones, and the loads did not exceed the nominal values, it is likely that the state of its solid insulation (the main parameter determining the actual service life of the transformer) after the completion of the assigned resource will remain satisfactory.

Thus, at the present stage of energy development, the urgency of the issues of diagnostics of power transformers of higher voltage classes is increasing.

The main tasks of diagnostics of transformer equipment are to identify defects and damages, assess the functional serviceability of equipment, determine the possibility of extending the service life without carrying out repairs, determine the amount of repairs if necessary, assess the remaining service life, as well as develop recommendations for extending the service life [11]. In addition, the use of diagnostic methods makes it possible to assess the condition

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of entire transformer fleets, thereby allowing the ranking of transformers by condition, which, in turn, reduces the cost of operation and repair [6,9,10, 12,14,17,18].
The purpose of this scientific work is to carry out express diagnostics of power oil transformers in long-term operation by applying vibration acoustics and measuring partial discharges.

2. Methods

Diagnostics of power oil transformers by applying vibroacoustics and measuring partial discharges was carried out on modern measuring instruments of the brand "VESTA" and M4202 (Siemens)
Vibroacoustic diagnostics and measurement of partial discharges are carried out on a working power oil transformer and make it possible to determine insulation defects with a decrease in its electrical strength at an early stage of their development.
The object of the study is a high voltage power transformer of the ATDTSTN-125000/220/110-U1 brand. This power oil transformer was put into operation in 2010.
The measurements were carried out according to the following stages:
-registration of vibroacoustic characteristics in the frequency range from 50 to 3000 Hz of each phase and OLTC;
-registration of partial discharges in the transformer tank at the same points (pCl) by the device;
-registration of partial discharges in inputs remotely by the device;
-measurement of leakage current by current clamps in grounding buses.
Vibroacoustic characteristics were measured at 12 points. A slight excess of the vibration level from the minimum value was noted at the following points: phase A of the tank bottom, phase B of the tank bottom.

3. Results

In the frequency range of 50-1000 HZ, the vibration level is average and well below the limit value of 88 dB. Figures 1-6 show the vibration characteristics of the transformer with the indication of measurement points.
2. There are no partial digits in the inputs.
3. The leakage current in the grounding buses is less than 2 A.

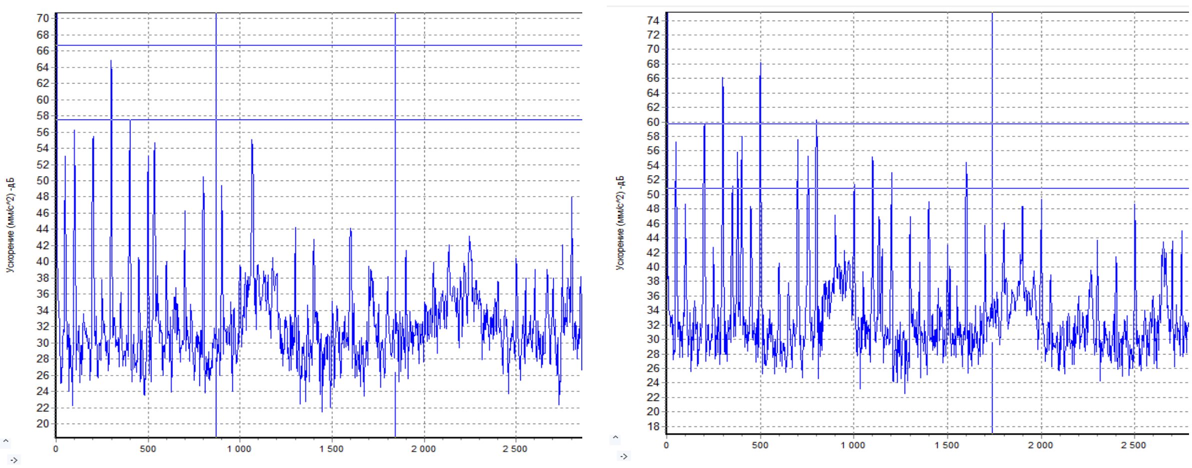

Fig. 1. Vibroacoustic characteristic phase A, tank bottom and phase A, tank bottom

Figure 1 shows the vibroacoustic characteristic phase A, tank bottom - this point is located in the lower part of the oil power transformer tank and is considered the main point of the vibroacoustic characteristic. Vibroacoustic parameters obtained from this point are calculated more accurately than from other points. The oil pressure is high and the transformer is considered to be very close to the main point. The transformer tank and the magnetic core inside reflect the condition of the core very well. According to the given characteristic, it falls within the limits of the minimum and maximum standards, since it has a value of less than 60 Hz, the rest up to 750 Hz and less than 88 dB, and up to 1500 Hz less than 70 dB. Therefore, the condition is considered normal.
The vibroacoustic characteristic phase A is calculated, the lower point of the tank is the second of the points receiving the main parameters. This point well reflects the vibroacoustic characteristics of the internal devices of the transformer. The magnetic core in and inside the transformer tank is a good indication of the condition of the core. According to the specification above, this point falls within the minimum and maximum references as it is less than 88dB up to

750Hz and less than 70dB up to 1500Hz. Therefore, the condition is considered normal and confirms the characteristics obtained above.

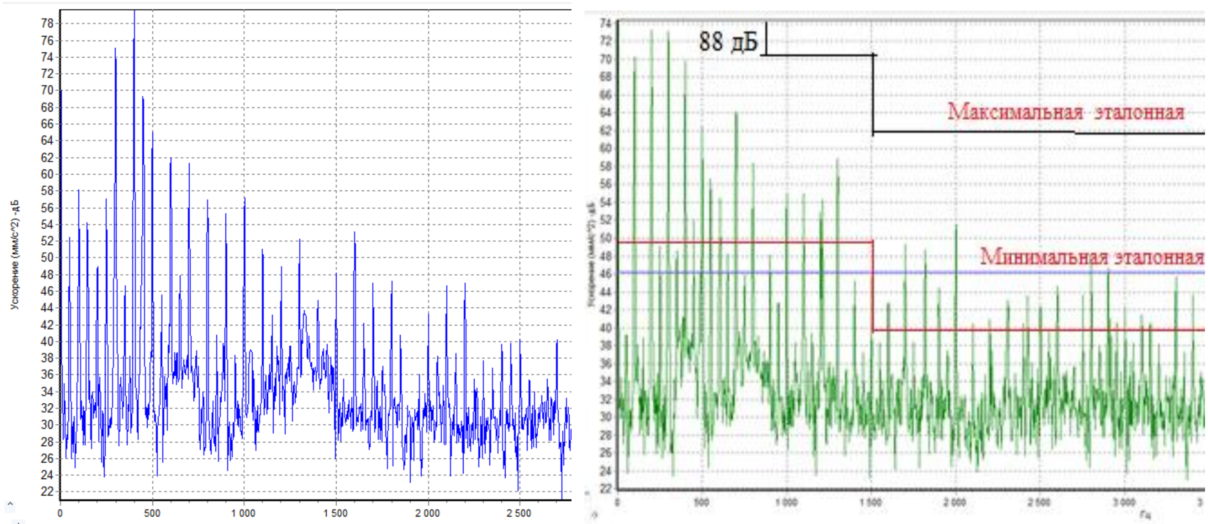

Fig. 2. Vibroacoustic characteristic phase A, the middle point of the tank and phase B, the bottom of the tank

The vibroacoustic characteristic is calculated, phase A, the middle point of the tank is the third of the points for obtaining the main parameters. This point well reflects the vibroacoustic characteristics of the internal devices of the transformer. The magnetic core in and inside the transformer tank reflects the state of the coil. According to the given characteristic, this point has a value close to 88 dB to 750 Hz (one note to 500 Hz. This is not considered a defect) and is below 70 dB to 1500 Hz, and the rest are below 60 Hz. Thus, the condition is generally considered normal and confirms the characteristics obtained in the next paragraph (Figure 2).

Vibroacoustic characteristic phase V, tank bottom - this point is located in the lower part of the oil power transformer tank and is considered the main point of the vibroacoustic characteristic of phase V. The vibroacoustic parameters obtained from this point are calculated more accurately than from other points. The oil pressure is high and the transformer is very close to the main point. The transformer tank and the magnetic core inside reflect the condition of the core very well. According to the given characteristic, it falls within the limits of the minimum and maximum standards, since it has a value of less than 60 Hz, the rest up to 750 Hz and less than 88 dB, and up to 1500 Hz less than 70 dB. Therefore, the condition is considered normal.

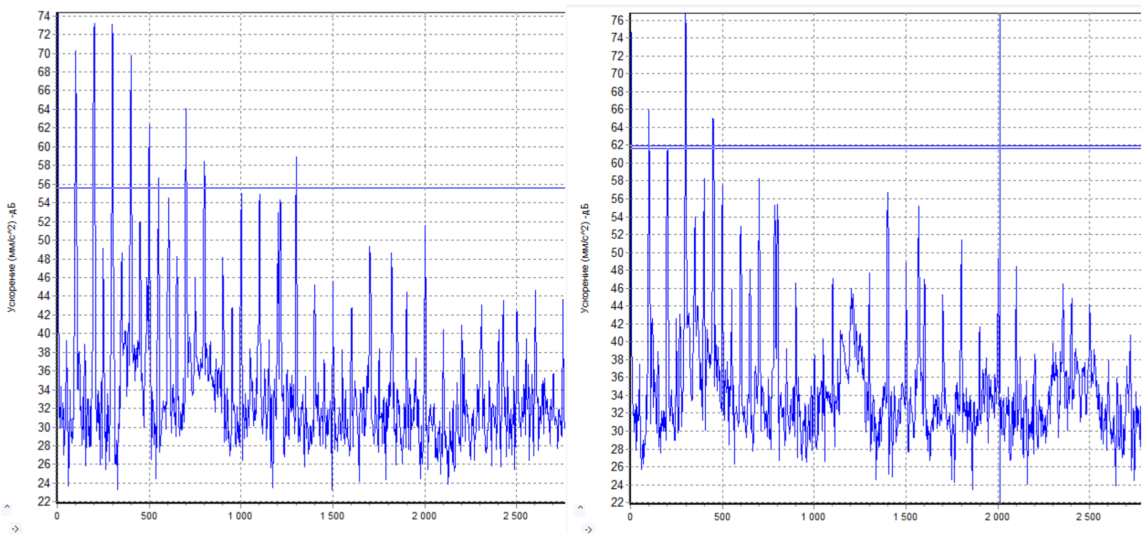

Fig. 3. Vibroacoustic characteristic phase B, the bottom of the tank and phase B, the lower point of the tank

The vibroacoustic characteristic phase b is calculated, the tank bottom point is the second of the points that receive the main parameters of the lower part of the transformer. This point very well reflects the vibroacoustic characteristics of the internal devices of the transformer. The transformer tank and the magnetic core inside reflect the condition of the core very well. According to the given characteristic, this point is on the border of the minimum and maximum standards, since it has a value of less than 88 dB up to 750 Hz and less than 70 dB up to 1500 Hz (Figure 3).
Vibroacoustic characteristic phase V, the lower point of the tank - the upper part of the transducer is considered the second of the points for obtaining the main parameters. This point well reflects the vibroacoustic characteristics of the internal devices of the transformer. The magnetic core in and inside the transformer tank is a good indication of the condition of the core. According to the specification above, this point falls within the minimum and maximum references as it is less than 88dB up to 750Hz and less than 70dB up to 1500Hz. Therefore, the condition is considered normal and confirms the characteristics obtained above.

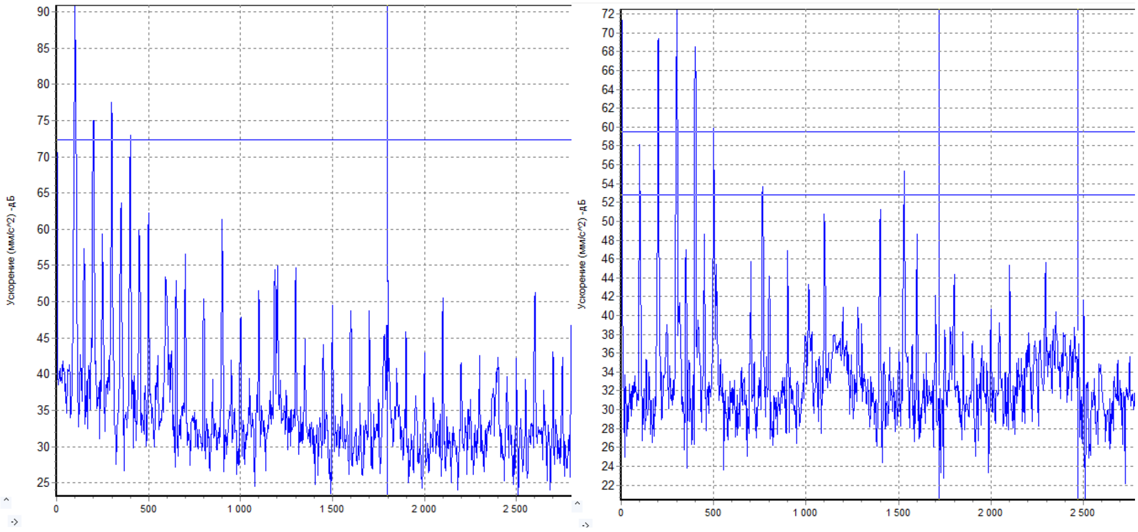

Fig. 4. Vibroacoustic characteristic phase B, the lower point of the tank and phase B, the middle point of the tank

Vibroacoustic characteristic phase b, the lower point of the tank - transformer buckinigg is calculated from the lower part of the main parameters of the second paragraph. This point is also a good representation of the vibroacoustic characteristics of the internal parts of the transformer. The magnetic core in and inside the transformer tank is a good indication of the condition of the core. According to the given characteristic, this point is less than 88 dB up to 750 Hz (an increase is observed at 150 Hz. This is not a characteristic of a defect as harmonics) and less than 70 dB up to 1500 Hz, otherwise it is on the border of the minimum and maximum standards. Confirms the vibroacoustic characteristic of phase b, points of the lower tank (Figure 4).

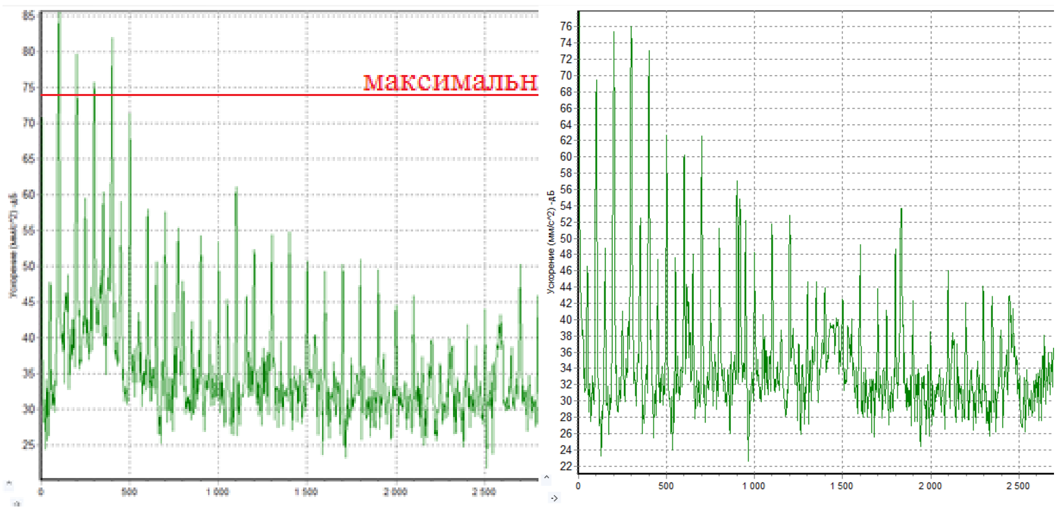

Fig. 5. Vibroacoustic characteristic phase b, the middle point of the tank and phase c, the bottom of the tank

Vibroacoustic characteristic phase V, middle point - the upper part of the transformer is considered the third of the points receiving the main parameters. This point well reflects the vibroacoustic characteristics of the internal devices of the transformer. The magnetic core in and inside the transformer tank is a good indication of the condition of the core. According to the specification above, this point falls within the minimum and maximum references as it is less than 88dB up to 750Hz and less than 70dB up to 1500Hz. Thus, the condition is considered normal and confirms the characteristics obtained in step V above.

Vibroacoustic characteristic phase b, middle point - the third of the points receiving the main parameters of the lower part of the transformer is considered. This point is also a good representation of the vibroacoustic characteristics of the internal parts of the transformer. The magnetic core in the transformer tank and interior is a good representation of the condition of the core. According to the above characteristic, this point is less than 88 dB up to 750 Hz (there is an increase at the frequency of 150 Hz. This does not represent a characteristic of the defect due to harmonics) and less than 70 dB up to 1500 Hz. It confirms the vibroacoustic characteristics of the facet at the points of the lower tank (Figure 5).

Vibroacoustic characteristic phases, tank bottom point - the main points of the transformer lower circuit are considered to be the main parameters. This point represents very well the vibroacoustic characteristics of transformer internals. The transformer tank and the magnetic core in the inner part represent very well the parameters of the state of the coil. According to the above characteristic, this point is at the limit of the minimum and maximum standards, as it has a value of less than 88 dB up to 750 Hz and less than 70 dB up to 1500 Hz.

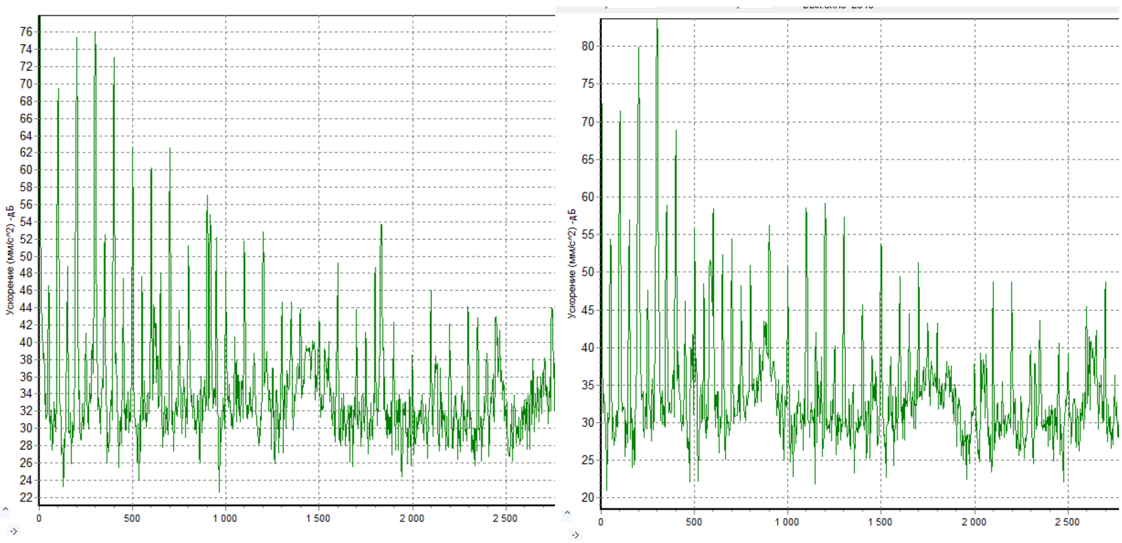

Fig. 6. Vibroacoustic characteristic phase c, lower point and phase c, middle point of the tank

Vibroacoustic characteristic phase s, end point and phase s, middle point tank - parameters obtained through the lower and middle tanks of the lower circuit of the transformer. These points represent the vibroacoustic characteristics of the internal parts of the transformer. According to the figure, the minimum and maximum standards are within the limits. The upper dot confirms the characteristic of the upper dot (Figure 6).

Due to the fact that the vibration of the transformer tanks in the three frequency zones is minimal, it is impractical to measure the overall vibration level with the VESTA device in the frequency range of 50-1000 Hz and register frequency characteristics until the end of the year.

Since the vibration of the tank is minimal, it is impractical to measure no-load losses and short-circuit losses by the end of the year, which characterize a decrease in the dynamic resistance of the windings. Due to the fact that there are no partial discharges in the transformer oil, it is impractical to register partial discharges with the device until the end of the year. The measurement of the vibro-acoustic characteristics of the backup must be performed in a year. The measurement of all other parameters not listed does not prevent damage to the power oil-filled transformer.

4. Conclusion

1. The obtained expressive results and their analysis showed that through Express Diagnostics, oil strength at a short time makes it possible to determine the need for Transformers.
2. According to the analysis of the results obtained, if there is a need to repair the oil power transformer, it is necessary to predict which part of it is a technical malfunction, which will reduce the time of the installation work.

3. Express Diagnostics of the Moi power transformer in the "vibroacoustics+partial discharge +current in the same way" sequence can give the technique state of these electrical equipment a manuscripts conclusion from operation dot.

References

1. R. Nepal, N. Paija, Energy security, electricity, population and economic growth: The case of a developing South Asian resource-rich economy, *Energy Policy* **132**, 771-781 (2019)
2. K.R. Abbasi, J. Abbas, M. Tufail, Revisiting electricity consumption, price, and real GDP: A modified sectoral level analysis from Pakistan, *Energy Policy* **149**, 112087 (2021)
3. I.F.U. Muzayanah, H.H. Lean, D. Hartono, K.D. Indraswari, R. Partama, Population density and energy consumption: A study in Indonesian provinces, *Heliyon* **8**(9), e10634 (2022)
4. I.V. Petrov, Assessing the reliability of various methods for measuring and processing vibroacoustic characteristics during technical diagnostics of electrical machines, GGTU, Gomel (2014)
5. K. Muratov, O. Ishnazarov, A. Isakov, I. Nuritov, Assessment of effect of lining material on energy efficiency of starting up ball mills, *E3S Web of Conferences* **365**, 04005 (2023)
6. R. Sarathi, A.J. Reid, M.D. Judd, Partial discharge study in transformer oil due to particle movement under DC voltage using the UHF technique, *Electric Power Systems Research* **78**, 1819-1825 (2008)
7. D.T. Yusupov, O.M. Kutbidinov, Sh.A. Samadov, E.S. Abdullaev, Investigation of winding faults of traction transformers, *IOP Conference Series: Earth and Environmental Science* **868**, 173024 (2021)
8. D. Yusupov, M. Rakhmatova, Sh. Tashmatova, Study of optimal temperature during adsorption cleaning of transformer oil under conditions of long-term operation, *E3S Web of Conferences* **383**, 04058 (2023)
9. Dolf Gielen, Francisco Boshell, Deger Saygin, Morgan D. Bazilian, Nicholas Wagner, Ricardo Gorini, The role of renewable energy in the global energy transformation, *Energy Strategy Reviews* **24**, 38-50 (2019)
10. O.A. Nazarov, D.T. Yusupov, R.F. Yunusov, S.A. Shoyusupov, Q.S. Tolipov, Assessment of technical state of power transformers based on dissolved gas chromatographic analysis in oil, *Journal of Physics: Conference Series* **2176**(1), 012001 (2022)
11. N.V. Gruntovich, Ye.L. Juk, Investigation of the causes of PD in power oil-filled transformers, *Vestnik GGGT* **7**, 60-67 (2020)
12. I.D. Andrienko, A.A. Saxno, S.I. Konogray, Special monitoring of technical condition of the main isolation of high-voltage outputs and current transformers, *Elektronika i elektroenergetika* **1**, 43-47 (2014)
13. A.M. Denmukhammadiev, D.T. Yusupov, S.A. Shoyusupov, A.U. Djalilov, O.A. Nazarov, Diagnostics of power transformers operating for many years in the power supply system through gases in the composition of transformer oil, *Journal of Physics: Conference Series* **2176**(1), 012064 (2022)
14. G.V. Popov, Diagnosis issues for power transformers, Ivanovo State Energy University named after V.I. Lenin, Ivanovo (2012)