www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

ARCHIVES OF ACOUSTICS
36, 1, 49–56 (2011)

DOI: 10.2478/v10168-011-0004-1

Technical Possibilities of Reducing the Sound Pressure Level Emitted into the Environment by a Power Transformer

Sebastian BORUCKI, Tomasz BOCZAR, Andrzej CICHOŃ

Opole University of Technology
Institute of Electric Power Engineering
Prószkowska 76, 45-758 Opole, Poland
e-mail: {s.borucki, t.boczar, a.cichon}@po.opole.pl

(*received November 29, 2010; accepted January 10, 2011*)

The subject presented in this paper refers to measurements and assessment of the corrected sound pressure level values (noise) occurring around a medium-power transformer. The paper presents the values of noise accompanying the operation of the power object before and after its modernization, which consisted in repeated core pressing and replacement of the cooling system. The main aim of the research work was the assessment of the influence of the repair work on the noise level emitted into the environment.

Keywords: power transformer, corrected sound pressure level, noise, modernization.

1. Introduction

The operation of medium- and high-power transformers is connected with noise emission into the environment, the main source of which, among other things, are: cooler fans of the induced air circulation, insulation oil circulating pumps and magnetostrictive vibrations of the core.

A transformer installed on a professional or industrial power object should be selected so as to prevent the noise occurring during its regular operation from exceeding permissible values, defined especially by environmental standards (Journal of Laws of the Republic of Poland, No. 62, Pos. 627, 2001 and Journal of Laws of the Republic of Poland, No. 178, Pos. 1841, 2004). These standards define permissible levels of the revised sound pressure, which may occur in the vicinity of an operating power object (e.g. a substation or a power line) depending on their location. However, these standards do not define permissible noise values occurring around the power object diagnosed in the place of its installation.

Meeting the environmental standards related to the permissible level of sound pressure occurring around power devices in operation cause a lot of problems

connected with the limitation of noise emitted into the environment (Borucki S. *et al.*, 2007; Wszołek T., 2009). Due to constant wear processes of the particular elements of power appliances at the substations, mainly the cooling systems of the transformer units, the sound pressure level (SPL) gradually increases with their operation time (Borucki S. *et al.*, 2006). It is advisable to measure the level of the revised sound pressure occurring around the transformer unit diagnosed during a routine check-up of the technical condition of power transformers. Such check-ups are required not only for environmental reasons but they may also become an additional criterion during a technical check-up, e.g. of a gradual fan bearing wear of cooling systems (ABB Company, 2003).

The paper presents a comparison of the measurement results of the revised sound pressure level (L) occurring around a power transformer both before repair works and after its modernization. The latter consisted in a repeated core pressing and a total replacement of the cooling system. The main aim of the research carried out was the assessment of the influence of the repair works done on the level of noise emitted into the environment.

2. The power object under study and the measurement methodology applied

The assessment of the power transformer noise was carried out for a 68 MVA unit, which was characteristic of the following nominal parameters:

- manufacture year: 1971 (repair works 2008),
- nominal power: 68 MVA,
- primary voltage: $121 \pm 2 \times 2.5\%$ kV,
- secondary voltage: 10.5 kV,
- rated current GN: 600–693–729 A,
- type of work: C,
- type of cooling: ON – AF,
- connection group YNd11.

The measurements of the corrected sound pressure level (L) were taken with a meter type 945A by SVAN. This appliance is meant for taking measurements of the noise level with accuracy corresponding to class 1 and for a frequency analysis of the signals in the band 1 Hz – 20 kHz. A KA-50 calibrator by Sonopan was used for the calibration of the measuring instrument used. Figure 1 shows an overall view of the measuring instrument used.

The level of the revised sound pressure (L) of the transformer under study was measured at 25 measurement points distributed symmetrically around the unit diagnosed. The total length of the measurement line positions l_m was 26 m, the height of the power object under study was $h = 4$ m and the area of the measurement surface was $S = 156$ m^2. Figures 2 and 3 show the detailed distribution of the measurement positions and external dimensions of the transformer unit under study.

Fig. 1. Overall view of the measuring apparatus used.

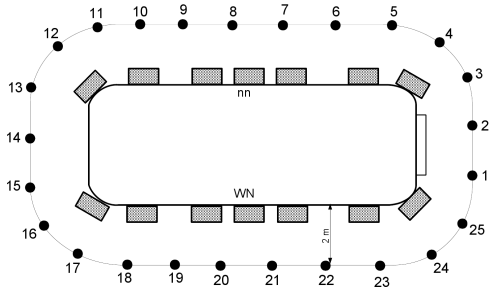


Fig. 2. Distribution of measurement points around the transformer under study.

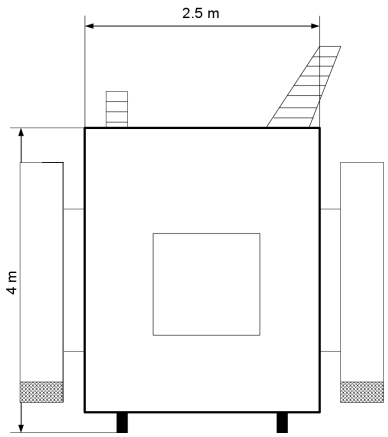


Fig. 3. External dimensions of the transformer under study.

Measurements of the noise emitted into the environment by the transformer operating in industrial conditions were taken twice. The first measurements were

taken in 2007, i.e. a year prior to the planned general repairs of the unit. The assessment of the modernization effectiveness in respect of the reduction of noise emission into the environment was carried out in spring 2009, immediately after re-installing the transformer at its operation site.

During the measurement of the revised sound pressure level (L) all cooling appliances were working – the cooler fans were on. The transformer was loaded in the particular years with the following apparent power:

a) year 2008 $S = 57.7$ MVA,
b) year 2009 $S = 59.3$ MVA,

which was 85 % and 87 % of its rated power, respectively.

The transformer diagnosed was equipped with air circulation coolers induced from the bottom side. The noise level at the transformer ventilation on was measured at points 2 m away from the main radiation surface defined in the standard PN-EN 60076-10 (International Standard, IEC 60076-10, 2001). Due to the height of the transformer tank $h > 2.5$ m, the noise measurements were taken for two measurement lines. The first measurement line was determined at the height of $h_1 = 1.3$ m, and the other one at the height of $h_2 = 2.6$ m. The measurements of the background of the revised sound pressure level (L) were taken at a significant distance from the transformer installation place. It was connected with the fact that it was impossible to measure the background around the unit under study because the technical conditions made it impossible to disconnect the cooling systems and the transformer from the power system. During the measurement procedure the conditions around the transformer under study were close to those of a free field since the sounds reflected from the building walls and screens around the transformer had an insignificant influence on the measurement results obtained. A detailed description of the measurement procedure and dependencies connected with determining (calculating) the particular parameters of the noise emitted by the power transformer into the environment can be found, among other things, in (International Standard, IEC 60076-10, 2001).

3. Analysis of the measurement results obtained

The values of the revised levels of the sound pressure (L) occurring around the power transformer under study were determined basing on the measurements. During the measurement a correcting filtration complying with filter A characteristics was used and a repeated calibration of the measuring instrument – at the beginning of the tests and after their completion – was carried out in compliance with the recommendations of the standard (International Standard, IEC 60076-10, 2001) and the order minister of the environment's (Journal of Laws of the Republic of Poland, No. 178, Pos. 1841, 2004). In both calibration cases the value of the correction difference between the beginning and the end of the measurements did not exceed 0.3 dB. Table 1 lists the values of the background

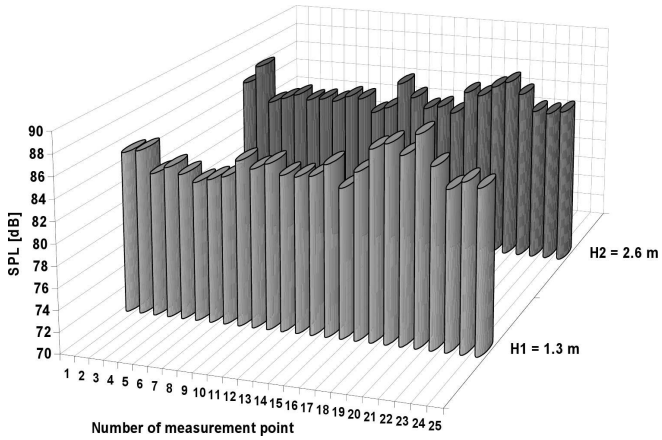
sound pressure level accompanying the measurements of the noise emitted by the operating transformer unit in the particular years.

Table 1. Revised sound pressure levels of the background noise.

No.	Year of measurement	Measurement on start of test [dB]	Measurement on end of test [dB]
1	2007	65.5	65.8
2	2009	58.5	58.7

Values of the corrected levels of the sound pressure (L) measured in the years 2007 and 2009 for two measurement lines around the unit under study at the heights: 1.3 m and 2.6 m are shown in Fig. 4 in the form of column diagrams.

a)



b)

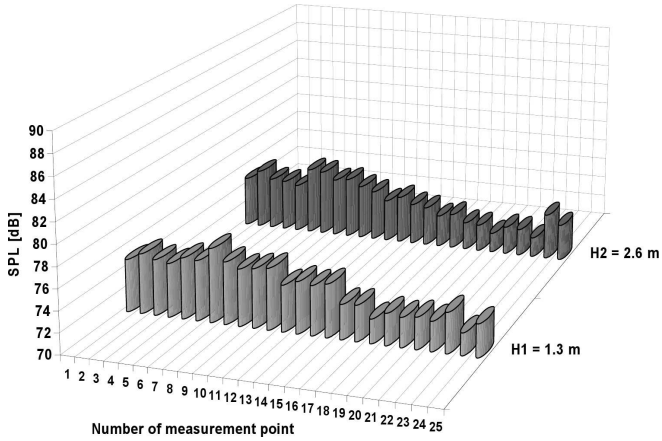
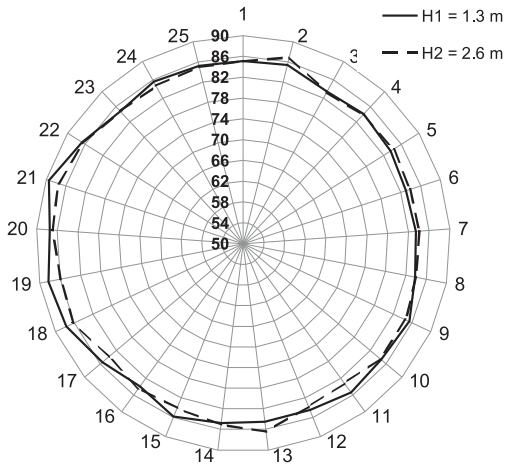


Fig. 4. Levels of the sound pressure (noise) registered around the transformer under study for two different measurement heights: a) before repair works (2007), b) after repair works (2009).

In order to visualize more clearly the level of the noise emitted by an operating transformer and the areas characteristic of the highest sound pressure amplitude, circular diagrams, on which the particular measurement points were marked, were drawn in Fig. 5.

a)



b)

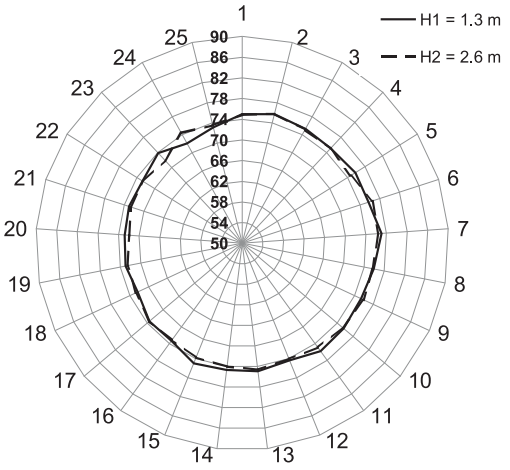


Fig. 5. Circular diagrams showing the sound pressure distribution around the transformer under study: a) before repair works, b) after repair works.

Analyzing the run of the circular diagrams it can be observed, like in Fig. 4, that the transformer before the repair works is characteristic of a significantly higher emission of noise into the environment than in case of the unit after modernization. Elevated values of the revised level of the sound pressure (L) of the

transformer before the repair works are caused mainly by a considerable wear of the bearings of the cooling system fans.

Additionally, a mean value of the sound pressure level and a revised level of the power were determined for the measurements performed for both cases of the transformer operation (before and after modernization). The results obtained are shown in Table 2.

Table 2. A comparative listing of the mean values of the sound pressure level and a revised level of the sound power.

No.	Year of measurement	Average revised sound pressure levels [dB]	Average revised sound power levels [dB]
1	2007	85.3	100.2
2	2009	74.3	89.2

The values of the determined revised level of the sound pressure (L) provided in Table 2 show explicitly that modernization of the transformer, which had been in operation for 30 years, by replacement of the cooling system elements (replacement of radiators and fans) and by pressing the core made it possible to silence significantly the operating unit and reducing the noise emitted into the environment even by 11 dB.

4. Summing-up

The research carried out and periodical measurements of the noise level show that the sound pressure level emitted into the environment is not constant but changes continually during a many-year operation of the electric appliances installed at the power substations. This is caused by a gradual wear of the particular sub-assemblies of these appliances, mainly of the cooling systems, or by changes taking place in the transformer core. An increase of the noise level above the permissible values may result in failure to comply with the environmental standards.

Due to a significant increase of people's awareness and readiness to claim their rights, the consequence of the elevated noise emission into the environment by electric appliances is an increasing number of claims against power enterprises. Therefore it is vital that the sound pressure level should be regularly monitored during routine check-ups, especially around high-power transformers. The detection of an elevated level of the sound pressure makes it possible for a company operating a given unit to get prepared logistically and financially for some repair works.

The results of the works performed presented in this paper show that a significant decrease of the noise emission can be achieved mainly by the replacement of the cooling appliances of power transformers (especially engines and fans),

which does not require a considerable financial outlay from the point of view of economy. It should be also noted that in Poland there are presently no criteria for an explicit interpretation of the measurement results of the sound pressure level around high-power transformers. Hence the assessment of the measurement results is possible basing on observation of changes of the sound pressure level in time and referring the results obtained to the level occurring at the beginning of a given transformer operation.

Acknowledgments

This research work is financed with the means devoted to science development as a research project No. 4575/B/T02/2009/36.

Preliminary results of this study were presented at the Open Seminar on Acoustics, Gliwice, September 20–24, 2010.

References

1. ABB Company (2003), *Testing of Power Transformers*, Zürich.
2. Borucki S., Boczar T., Cichoń A., Lorenc M. (2006), *Measurement results of the acoustic pressure level during unit transformer operation*, Proceedings of 36th International Conference and Exhibition on Defektoskopie, pp. 25–31, Tabor.
3. Borucki S., Boczar T., Cichoń A. (2007), *Investigation of the acoustics pressure distribution occurring around an aerial substation adjacent to apartment buildings*, Archives of Acoustics, **32**, 4, Supplement, 291–297.
4. International Standard, IEC-60076-10 (2001), *Power transformers – Part 10, Determination of sound level*, [in Polish: PN-EN 60076-10 (2003), *Transformatory, Część 10: Wyznaczanie poziomów dźwięku*].
5. Journal of Laws of the Republic of Poland, No. 62, Pos. 627 (2001), *Statute with day 27 April 2001, Right of environment protection*, [in Polish: *Ustawa z dnia 27 kwietnia 2001 r., Prawo ochrony środowiska*].
6. Journal of Laws of the Republic of Poland, No. 178, Pos. 1841 (2004), *Decree of Environment Minister's with day 29 July 2004 in matter of admissible sound pressure levels in the environment*, [in Polish: *Rozporządzenie Ministra Środowiska z dnia 29 lipca 2004 r. w sprawie dopuszczalnych poziomów hałasu w środowisku*].
7. Wszołek T. (2009), *Noise indicators for corona acoustic signal from power lines – estimation in intensified interference conditions*, Archives of Acoustics, **34**, 1, 41–49.