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# THE ASSESSMENT OF THE NOISE LEVEL GENERATED BY A WIND TURBINE BASED ON THE RESULTS OF THE ACOUSTIC PRESSURE MEASUREMENT

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**Abstract**

The subject matter of this paper refers to the assessment of noise generated by the work of a wind turbine, which was carried out based on the measurements of the acoustic pressure emitted. The methodology of the measurement taking was based on the European standard IEC 61400-11:1998. For the turbine under study, of a unit power 150 kW, the acoustic pressure measurements were taken which were registered each time in 16 measurement points spaced every 30º on the circle around the unit under study. The measurements were taken in the distance range (5-100) m from the turbine tower construction. Basic values characterizing climatic conditions that were present at the time of the measurement taking were measured during the research tests. The results of the wind measurements obtained were converted into equivalent wind speed values at the reference height and irregularity of the site. Based on the measurements taken, spatial distributions of the acoustic pressure levels for various views of the turbine under study and their changes depending on the distance from the construction of the generator under study were determined. Also the distributions of the lines representing the acoustic pressure levels around a wind turbine under study were drawn. The results obtained were referred to the environmental standards being in force and connected with the permissible noise levels in places with people.

## 1. Characteristics of the measuring set-up applied

The measurements of the corrected acoustic pressure level were taken with a digital meter type 945A by the SVAN company. This appliance is meant for taking measurements of the sound level with accuracy corresponding to class 1 according to IEC 651 and IEC 804 standards and for analyzing acoustic signals in the band from 1 Hz to 20 kHz.

The object under study was a MK ii 150 air turbine of the power of 150 kW, produced by a Danish company BONUS in 1990, which was founded on a flat surface, on wind farm fields. Technical details, descriptions of the processing, adjusting, protective and measurement systems, the generator applied and aerodynamic properties have been presented in information materials by the manufacturer, which are available on web pages [4, 5]. On this farm there are two more identical turbines, which were turned off during the measurements of noise emission so that their work would not influence the results obtained.

The measurements of the acoustic pressure level, corrected with frequency A characteristics, generated by the air turbine, were taken each time in 16 measurement points distributed equally every $30^0$ on the circle around the turbine under study. Registrations were carried out in the distance (5-100) m from the turbine tower construction. Each measurement was taken for 1 minute, each registration in a given measurement point was repeated 30 times. The measurement result was obtained from integration of the run registered in the time interval under study. In order to verify whether the measurement results obtained are representative according to the standard recommendation [3], registration of the surrounding background at an immobilized turbine was carried out and the environment noises were registered during the measurements of sound intensity. The environment noise was determined as the average from 10 measurements, which were taken every two minutes when the air turbine was immobilized. The measurements of the acoustic pressure level were also taken directly at the turbine under study, which after being averaged was of 52.8 dB. Measurement positions were selected in such a way as the influence of the reflected constructions calculated (buildings, walls) would not exceed 0.2 dB; the closest farm buildings were 112 m away from the turbine under study.

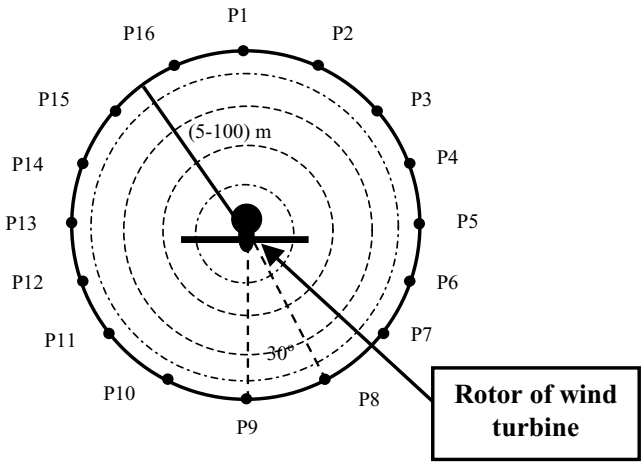


Fig. 1 Distribution of the measurement points around the air turbine

During the investigations, the measurements of the wind speed and direction were taken with a digital meteorological station WS 2300 by Technoline. The rule was observed that the measuring anemometer and the wind direction converter were not in the area of the wake of any part of the turbine wheel or any other interfering

construction during the investigations. The meteorological station WS 2300 complies with the requirements of the EU Directive R&TTE 1999/5/EC [2].
The measurements of the sound intensity were taken at a full load of the air turbine, at a variable wind speed in the range from 11.6 m/s to 18.3 m/s, and practically at an invariable wind direction from the east to the west at the angle of 247 degrees. Acoustic properties in the surrounding of the turbine under study were close to the conditions of the free field. Table 1 lists the measured values of basic parameters characterizing climatic condition during measurement taking.

Table 1 Non-acoustic measurement values

| Non-Acoustic Values Measured | |
|---|---|
| Temperature | 15° C |
| Air Humidity | 49% |
| Atmospheric Pressure | 1013.2 kPa |
| Wind Speed | 11.6 – 18.3 m/s |
| Corrected Wind Speed | 12.84 |

## 2. The analysis of the measurement results of the acoustic pressure level emitted by the air turbine under study

Fig. 2 shows, in the form of a column diagram, the values of the corrected acoustic noise level emitted by the air turbine analyzed in the distance range from 5 to 100 m (measured from the tower construction in the direction opposite to the wheel axis of rotation).

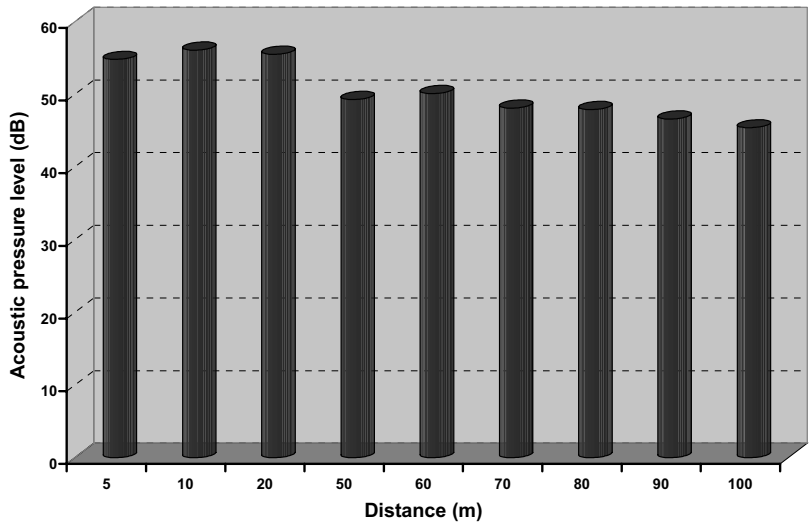


Fig. 2 Diagram of the sound intensity level depending on the distance from the air turbine, measured in the direction opposite to the wheel axis of rotation

The measurement results of the corrected acoustic pressure around the turbine under study are contained in the range (51.3 – 56.6) dB, and their highest

In order to visualize more precisely the area characteristic of the highest value of the acoustic pressure, radar diagrams with marked measurement points were drawn for three circles of the radii: 5, 10 and 20 m, respectively, which are shown in Fig. 3.

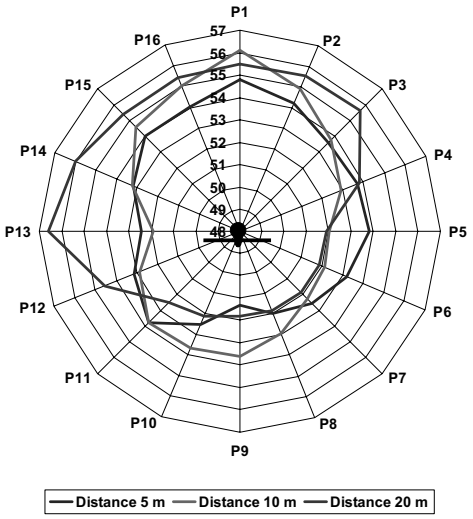


Fig. 3 Circular diagrams showing the acoustic pressure distribution around the air turbine under study for three distance values: 5, 10 and 20 m

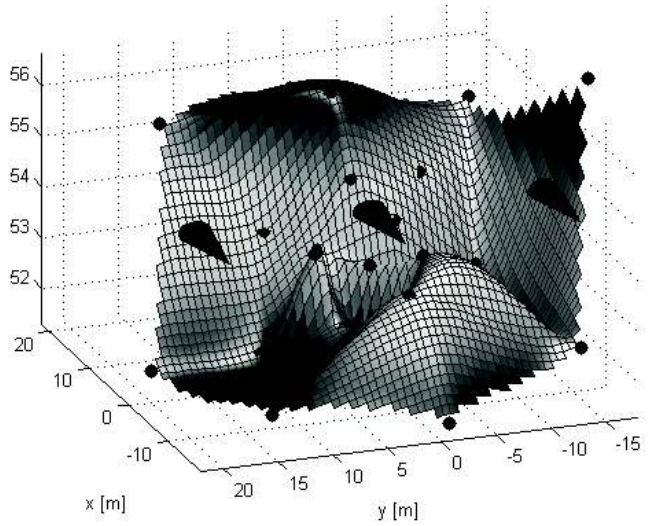


Fig. 4 Spatial distribution of the acoustic pressure level, view from the front of the air turbine

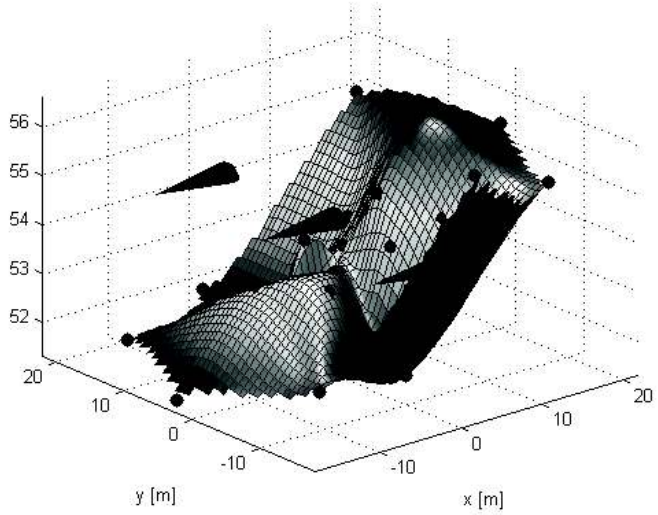


Fig. 5 Spatial distribution of the acoustic pressure level, view from the left side of the air turbine

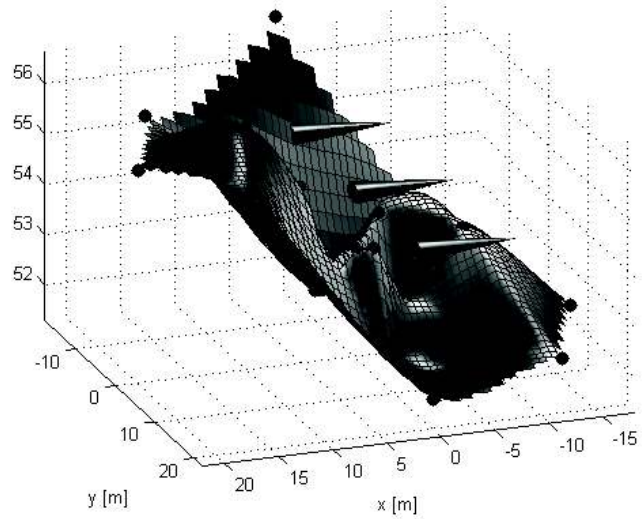


Fig. 6 Spatial distribution of the acoustic pressure level, view from the right side of the air turbine

Figs 4-6 show spatial distributions of the measured corrected acoustic pressure level for three different directions: from the front of the wheel side (Fig. 4), from the left side (Fig. 5) and from the right side (Fig. 6) of the air turbine under study (the front of the turbine with a rotating wheel is marked with cones). The characteristics obtained were determined using the program Matlab 7.3.

The measurement results show that the spatial distribution of sound intensity is highly non-uniform (non-uniform acoustic field). The highest level was measured directly behind the turbine, and much lower values were registered at the front of the turbine and its both sides. With the increase of the distance from the supporting

structure of power plant, this level decreases from 56.6 dB at 5 m to 45.4 dB at the distance of 100 m. This drop is perceptible for hearing, but staying in the direct vicinity of the turbine under study does not ensure due mental comfort, which according to legal regulations being in force in Poland should not exceed the level of 45 dB in the night and 50 dB during the day in the regions located beyond urban areas. It should be stressed that the turbine under study is a construction of an older type, out of production nowadays, and which, additionally, has been in use for over 16 years.

## 4. Summing-up

The observed and planned for the nearest years development of wind power engineering makes investors take regular measurements of the noise level generated, which accompanies operation of wind installation. This refers mainly to wind farms founded in rural areas, but also to single generators (most often of low power), which are more and more often installed in urban areas. In this scope a European standard is in force but there has also been elaborated its equivalent, which is used in Poland [3].

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