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RESEARCHES REGARDING THE DETERMINATION OF THE NOISE LEVEL PRODUCED BY A CORDLESS MULTIFUNCTIONAL TOOL IN VARIOUS OPERATING CONDITIONS

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ABSTRACT

The acoustic power level is a dimension that must be specified on open-air equipment and its determination depends on several factors: the microphone positioning for determining it (lower or higher distance from the noise source), the shape of the surface measurement and operation of the equipment at different speeds.

The paperwork consists in analyzing the results regarding the determination of the acoustic power levels by measuring the acoustic pressure in free field conditions according to SR EN ISO 3744: 2010, under different operating conditions for the tested equipment.

INTRODUCTION

Air quality is a priority issue for the environment, and the management of emissions of any kind is recorded through regulations. A low level of acoustic pollution leads to the satisfaction of the level of environment and consumers health protection and implicitly to the quality of the marketed products.

SR EN ISO 3744: 2010 establishes the method of measuring acoustic pressure levels on a measuring surface that includes a noise source, under conditions close to those of a free field, near one or more reflecting planes, to calculate the level the acoustic power produced by the noise source. The standard contains conditions for the test environment and equipment, as well as procedures for obtaining the level of sound pressure on the surface, from which the sound power level of the source is calculated.

The indication of the guaranteed sound power level will allow consumers and users to choose the product knowingly.

In this regard, the work consists in determining the acoustic power level by measuring the acoustic pressure in free field conditions according to the standard SR EN ISO 3744: 2010. Although the standard recommends a minimum distance of 1 m, within this study we plan to find out what are the results if the distance is smaller.Measurements are made at a distance of 0.5 m and 1 m respectively, for 5 different speeds.

MATERIAL AND METHOD

The sound power level of a noise source is determined using *acoustic pressure (p)*. This represents a fluctuating pressure due to the presence of sound presence overlapped on the static pressure and is expressed in Pascals.

Sound pressure level (Lp) is ten times the logarithm to the base 10 of the ratio between the square of the measured sound pressure and the square of the reference sound pressure (20 µPa). Sound pressure level is expressed in dB.

Sound pressure level averaged over the measurement surface is given by: [1]

$$\overline{L'_p} = 10\lg\left(\frac{1}{N}\sum_{i=1}^{N}10^{0,1L'_{pi}}\right), \text{ [dB]} \quad (1)$$

where N is the number of measuring points;

pi L' - sound pressure level measured in the *i* position of the microphone

Sound pressure level averaged over the measurement surface and corrected is:

$$\overline{L_{pf}} = \overline{L'_p} - k_1 - k_2 \quad (2)$$

where k_1 - is the correction for background noise;

k_2 - the correction for the reflected sound (it applies to enclosed spaces).

The sound power level is given by:

$$L_w = \overline{L_{pf}} + 10\lg\left(\frac{S}{S_0}\right), \text{[dB]} \quad (3)$$

where S is the measurement surface area;

S_0 = 1 m^2.

In view of determining the acoustic power level is used modern equipment that in fact measures the immediately acoustic pressure on measuring surface, makes the necessary corrections and then calculates the acoustic power level by the above formula.

The measurements have been achieved on cordless multi rotary tool type GRO 12V-35, at INMA place.

Cordless multi rotary tool GRO 12V-35 type (fig. 1) is intended for cutting metal and stone materials, and for grinding, sanding and polishing metal and painted surfaces without the use of water. In addition to this, the power tool is suitable for drilling in wood, soft metal, plastic and light building materials when used with the appropriate accessories.

Fig. 1 – Cordless multi rotary tool GRO 12V-35 type [4]

Main technical characteristics of the product are presented in table 1:

Table 1 [4]

Nr. crt.	Characteristic	UM	Values
1.	Rated voltage	V	12
2.	Rated speed	min^{-1}	5000-35000
3.	Collet chuck	mm	3.2
4.	Spanner flat of collet chuck	mm	9.55
5.	Max. outer diameter - cutting disc - gringing accessory - wire brush - grinding disc - drill bit	 mm mm mm mm mm	 38 22.5 20 20 3.2
6.	Max. inner shank dimension L_0	mm	10
7.	Max. shank length	mm	35
8.	Weight according to EPTA - Procedure 01:2014	kg	0.63-0.87

Measuring devices used are: roulette, 4000 Testovent anemometer type, DH 50 Thermohygrometer, 2237 sound level meter, tahometru electronic, accelerometru triaxial and integrator system type PULSE with 12 microphones:

The equipment used to determine the sound power level is a measurement and analysis system based on PC - "System Type 3569 C PULSE multi-analysis" produced by Bruel & Kjaer, wich consists in 12 microphones with preamp, amplifier and signal conditioning module with 12 measuring channels, assisted by a notebook computer and software required for the acquisition, processing, interpretation and presentation of data in tabular form. Also, includes a calibration module type 4231 wich generates on the frequency of 1 kHz, a noise level of 94 dB or 114 dB. The calibration value of 114 dB is used when measurements are made in a noisy environment (noise level> 50 dB). [2], [3], [5]

Calibration of measuring channels is performed at the beginning of each set of measurements required to measure a noise source.

In order to determine the sound power level, the following operations were performed, necessary for preparing the product for tests:

- noise source dimensions were measured;
- measuring surface area was calculated [2].

For positioning the microphones on the hemispherical measurement surface, there were chosen the 10 key positions of the microphones (fig. 2), according to the standard EN ISO 3744:2011.

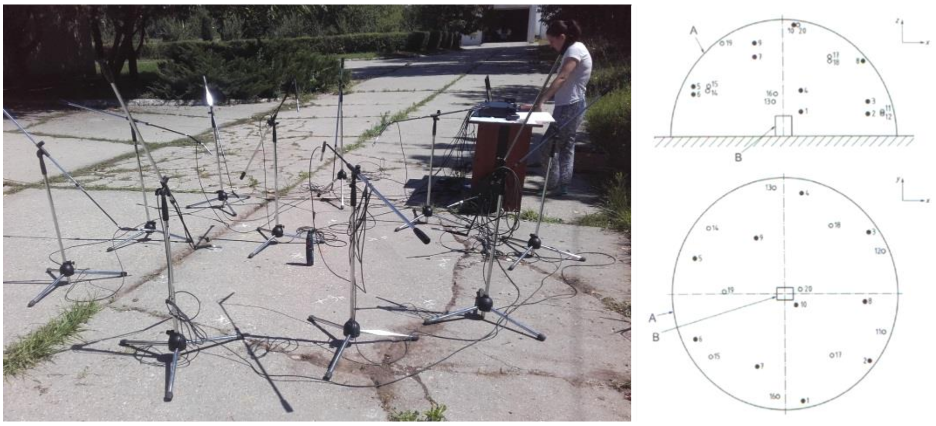

Fig. 2 - The microphones positions on the hemispherical measurement surface

Coordinates of the 10 microphones positions are shown in the table below:

Table 2

r = 0.5 [m]	x	y	z	r = 1 [m]	x	y	z
1	0.08	-0.48	0.11	1	0.16	-0.96	0.22
2	0.39	-0.3	0.10	2	0.78	-0.60	0.20
3	0.39	0.275	0.155	3	0.78	0.55	0.31
4	0.08	0.45	0.205	4	0.16	0.90	0.41
5	-0.415	0.16	0.225	5	-0.83	0.32	0.45
6	-0.415	-0.2	0.19	6	-0.83	-0.40	0.38
7	-0.13	-0.325	0.355	7	-0.26	-0.65	0.71
8	0.37	-0.035	0.335	8	0.74	-0.07	0.67
9	-0.13	0.25	0.415	9	-0.26	0.50	0.83
10	0.05	-0.05	0.495	10	0.10	-0.10	0.99

RESULTS AND DISCUSSIONS

The dimensions of the reference box associated to the noise source were the following:

- length: 0.25 m;
- width: 0.053 m;
- height: 0.053 m.

The characteristic source dimension d_O, determined for acoustic free field over a reflecting plane conditions, was $d_O = 0.13$ m [4].

At the time of testing, near the noise source there were recorded the following air parameters:

- Temperature: 28 °C;
- Relative humidity: 42.8%;
- Wind speed: 0.8 m/s

In table 3 and figure 3 are presented the average acoustic pressure level values for r = 0.5 m:

Table 3

Gear	Average acoustic pressure level per microphone										Average acoustic power level L_w [dB]
	L_{p1} [dB]	L_{p2} [dB]	L_{p3} [dB]	L_{p4} [dB]	L_{p5} [dB]	L_{p6} [dB]	L_{p7} [dB]	L_{p8} [dB]	L_{p9} [dB]	L_{p10} [dB]	
1st	56.9	57.4	56.2	57.6	58.0	57.5	60.5	60.1	61.6	62.4	61.35
2nd	64.0	63.2	63.4	64.4	66.5	64.6	65.8	65.7	67.5	65.3	67.35
3rd	66.2	65.5	67.6	66.6	72.8	68.5	68.0	69.2	71.6	69.9	71.30
4th	69.9	69.2	69.7	69.6	71.2	69.2	69.6	70.4	71.0	70.2	72.20
5th	82.1	83.5	79.8	78.8	83.9	82.3	81.1	81.2	81.9	80.3	84.70

Lp1, Lp2, Lp3, Lp4, Lp5 , Lp6, Lp7, Lp8, Lp9, and Lp10 - represent the determined average acoustic pressure level in each of the 10 measurement points marked in black in Fig. 2.

L_w – represents the average acoustic power level that is calculated by the PULSE system using the formula (Eq. 3)

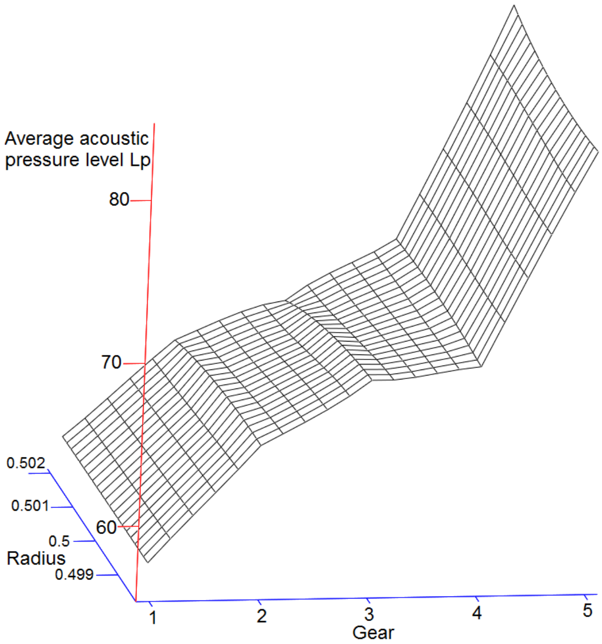

Fig. 3 - Average acoustic pressure level depending on gear, for r = 0.5 m

In table 4 and figure 4 are presented the average acoustic pressure level values for r = 1 m:

Table 3

Gear	Average acoustic pressure level per microphone										Average acoustic power level L_w [dB]
	L_{p1} [dB]	L_{p2} [dB]	L_{p3} [dB]	L_{p4} [dB]	L_{p5} [dB]	L_{p6} [dB]	L_{p7} [dB]	L_{p8} [dB]	L_{p9} [dB]	L_{p10} [dB]	
1st	50.6	51.0	50.7	51.5	53.5	52.7	54.8	54.0	54.5	55.3	60.60
2nd	57.0	56.1	56.6	56.8	58.0	57.0	59.2	58.7	59.5	57.0	65.55
3rd	61.9	61.6	62.7	64.0	63.9	63.5	62.6	62.3	64.6	62.1	71.15
4th	65.6	64.2	64.0	65.3	66.7	67.7	65.6	64.2	66.3	65.0	73.70
5th	76.8	77.8	75.4	74.5	79.0	76.8	76.0	75.5	75.4	75.2	84.85

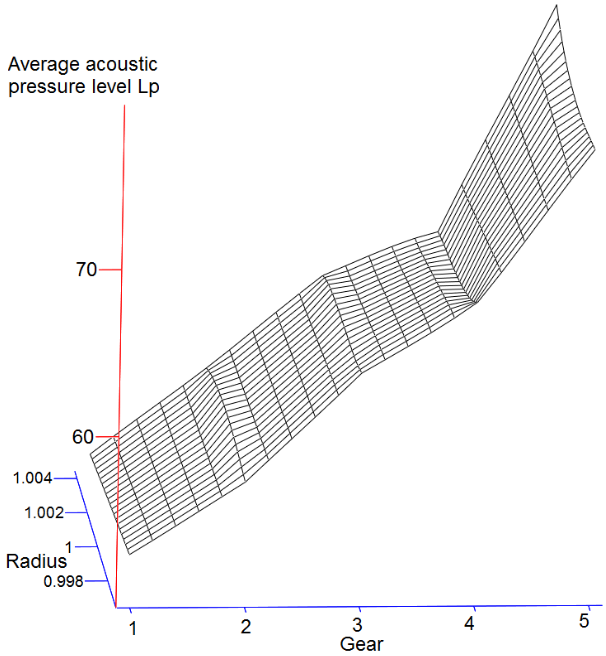

Fig. 4 - Average acoustic pressure level depending on gear, for r = 1 m

The average acoustic power level values for r = 0.5 m and r = 1 m depending on the gear are presented in figure 5.

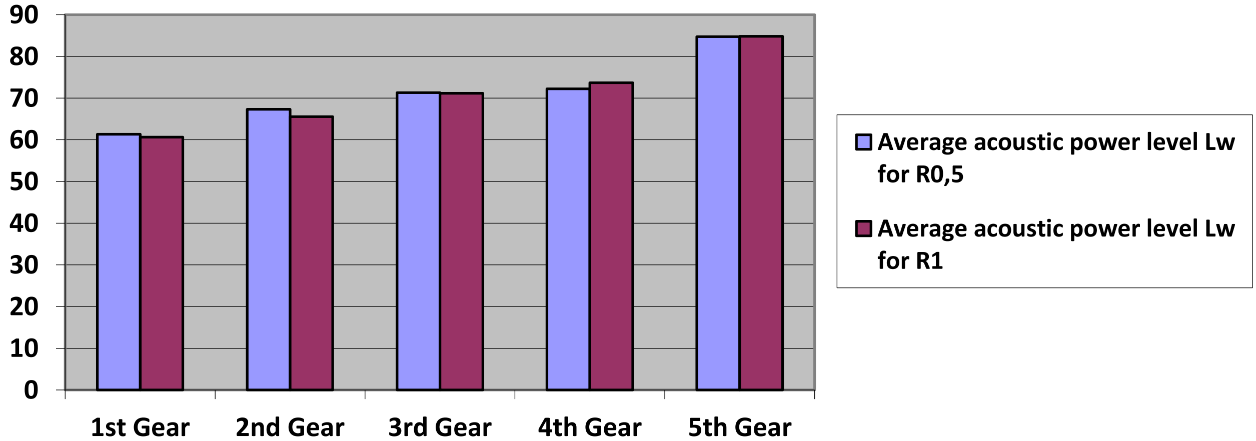

Fig. 5 - Average acoustic power level depending on gear

CONCLUSIONS

The average acoustic pressure level increases with the selection of a higher speed gear, having a rapid increase from 4th gear to the 5th gear, for both radiuses of the hemispherical measuring surface.

The average acoustic pressure level is higher for the measuring surface with a radius of 0.5 m than for the measuring surface with 1 m radius.

The average acoustic power level is higher in the case of a 0.5 m radius than in the 1 m radius for the first 3 speed gears, although the area of the measuring surface is smaller. This is due to higher values of acoustic pressure measured at a radius of 0.5 m compared to those obtained by measuring on the surface of 1 m for the first 3 speed gears. For 4th and 5th gear, the acoustic power determined on a measuring surface with a radius of 1 m becomes greater than that determined on a measuring surface with a radius of 0.5 m.

Analyzing the obtained data we can conclude that using a 0.5 m radius for the hemispherical measurement surface can conduct to inconsistent results. For hemispherical measurement surface the standard recommends at least 1 m radius in order to obtain consistent resuts.

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