ULTRASONIC NOISE FROM ULTRASONIC DRILLS

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Abstract

In Poland ultrasonic noise is defined as the broadband noise containing high audible and low ultrasonic frequencies include the 1/3 octave band with the central frequency from 10 kHz to 40 kHz. There are a few acoustic parameters characteristic for noise emission from ultrasonic sources. Commonly used are the sound power level and the sound emission pressure level, both in the 1/3 octave bands. One of the main types of the technological ultrasonic sources are the ultrasonic drills. These types of machines use ultrasonic vibrations to internal grinding in diamonds.

There are many types of ultrasonic drills. Ultrasonic noises emitted by these sources depend on the electric power and the different kind of the acoustic enclosures of drills. This paper presents the result of measurement of ultrasonic noise emitted from a several ultrasonic drills. The measured parameter is the sound emission pressure level in the 1/3 octave band, which is determined at the workstations and at the specified point in front of drills.

Keywords: ultrasounds, emission, ultrasonic noise, drill.

1. Introduction

Ultrasounds are acoustic vibrations propagating in elastic medium in the form of waves of the frequency from 16 kHz to 10 GHz. Due to different methods of how ultrasounds are generated, used and how they impact on living organisms, ultrasounds can be divided into low-frequency (below 100 kHz) and high-frequency (over 100 kHz) ultrasounds. In Poland the definition of so-called ultrasonic noise covers audible high-frequency (10 kHz-20 kHz) and low frequency ultrasounds (20 kHz - 40 kHz). Ultrasonic noise is assessed in 1/3 octave bands with mid-band frequencies of 10 kHz to 40 kHz.

As the tests conducted at Central Institute for Labor Protection – National Research Institute and other institutions show, the main sources of ultrasonic noise in the working process are low-frequency technological ultrasonic devices. Ultrasonic vibrations that are the sources of ultrasonic noise are generated by equipment to carry out or improve the technological processes. The ultrasonic noise at the workplaces where such equipment is located exceeds the permissible health protection levels accepted in Poland, which is tantamount to high, unacceptable risk due to exposure to ultrasonic noise at such workplaces [1, 2]. In order to: assess the risk of exposure of ultrasonic equipment operators to noise, design anti-noise safety measures and assess their efficiency, and also to compare these devices to each other (from the viewpoint of produced ultrasonic noise risks) it is necessary to determine the noise emission of these sources.

In the "audible" noise range (20-20 000 Hz) the values used to determine the noise emission of the sources are: sound power level (defining total source noise emission) [4, 5] and/or emission sound pressure level (defining the emission of noise source to a specific location – in most cases to the workplace) [6, 7]. Because of the strong damping of ultrasounds during propagation, in most cases the ultrasound sources present a noise hazard only in their direct vicinity. This is why the emission sound pressure level at the operating station (determined in 1/3 octave bands in the 10 kHz to 40 kHz frequency range) was assumed as the basic value for determining the noise

emission.
Amongst many types of technological ultrasound equipment the ultrasonic drills constitute a large group. At the same time, from the viewpoint of ultrasonic noise emission level, the drills are the second most important group after welders. This is why the paper discusses the results of tests and measurements of ultrasonic noise emission level of two types of ultrasonic drills, used for producing and renovation of diamond drawing dies.

2. Tested ultrasonic drills

Ultrasonic drilling technology is used for machining high-hardness materials. This method is used for making hollows or profiled holes of any shape when high precision is required. Gouging of the material is the result of combined impact of ultrasonic vibration and abrasive powders, placed between the vibrating tool and machined item. This technology is used for such applications as: glass, quartz, natural and synthetic stone machining/processing [3].
Figure 1 shows the ultrasonic drill design diagram. The ultrasonic head, powered by the ultrasound generator, transfers the vibrations through a concentrator to the tools that gouges a hole in the machined item.
Water and abrasive powder is fed between the tool and machined item.

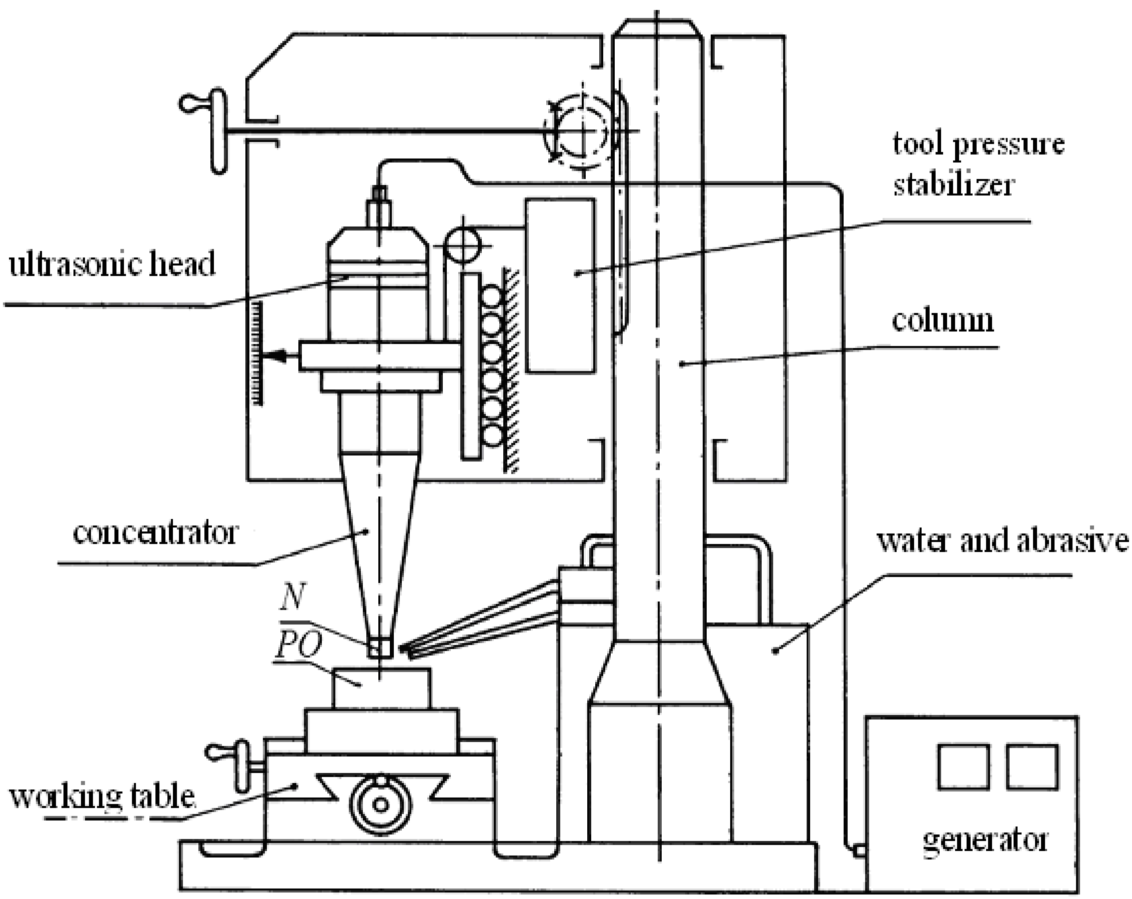


Figure. 1. Ultrasonic drill [4]

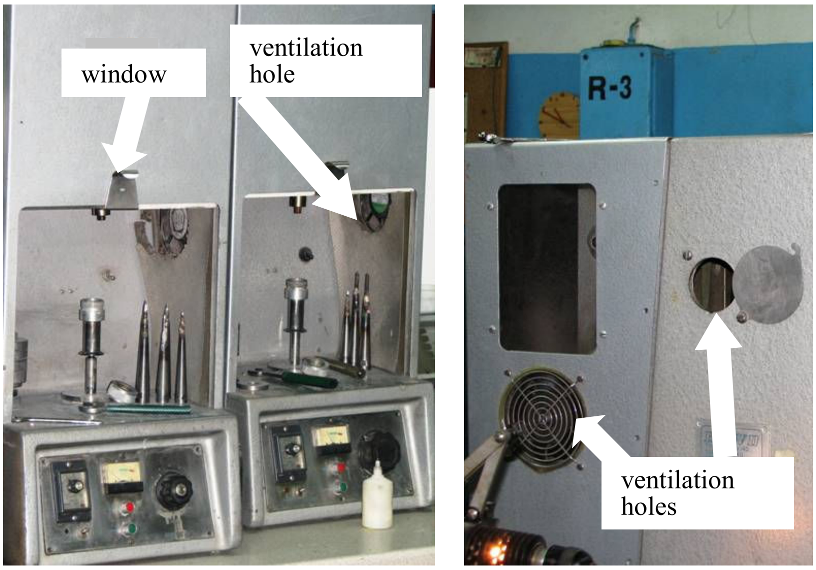
Two types of ultrasonic drill were subject to the ultrasonic noise tests: first type (drills without housing) – A_1 and A_2 (picture 1) and second type (drills with housing) – B_1, B_2, C (picture 2). These drills were located in a production hall of the dimensions of: 15 m x 9 m x 4,5 m (except drill A_1, which was located in a separate room). (picture 3)

Picture 1. First type of ultrasonic drills (A_1, A_2)

Picture 2. Second type of ultrasonic drills (B_1, B_2)

Machines of the second type were installed in housings equipped with a window in the front part of the housing (picture 4). The machines were installed in two types of housings: without ventilation hole (machines designated as B_1, B_2, C) and with ventilation hole ($B_{1,a}$, $B_{2,a}$, C_a). (picture 4).
The exciter operating frequency of all machines was 20 kHz. The machines were set on tables standing directly on concrete floor, during the tests the machines were making holes in diamond drawing dies. The electric power of the machines is given in Table 1.

Picture 3. Separate room
in the production hall



Picture 4. Type machines with holes in the housing (B_{1o}, B_{2o})

3. Ultrasonic noise emission measurement method

Currently in Poland there are no accepted standard noise emission source measurement methods for ultrasonic noise frequencies. According to the provision of EU Directives 98/37/EC (from 2010 this Directive will be replaced by Directive 2006/42/EC) and 2000/14/EC and the ordinances introducing them into the Polish legislation, the values determining emission of machine and equipment noise in the "audible" noise range are :

- the sound power level (corrected by frequency response A and/or in 1/3 octave or 1 octave bands)
- the emission sound pressure level determined at the workplace or other specified location (corrected by frequency response A and/or in 1/3 octave or 1 octave bands).

These values are determined using measurement methods or measurement and calculation methods on the basis of sound pressure measurement (sound power level – EN ISO 3740 series [4, 5] emission sound pressure level - EN ISO 11200 series [6, 7]) or sound intensity measurement (sound power level - EN ISO 9614 series [8]).

The tests were carried out using measurement method as per EN ISO 11202. Ultrasonic noise emission of the drills was determined according to the emission sound pressure level in the 1/3 octave bands, in the 10 kHz ÷ 40 kHz frequency range**.** The room where the measurements were carried out (measurement environment), showed such a high level of sound absorption, in the examined frequency range, that the local environmental correction K3 could have been omitted. Other ultrasonic equipment and devices were switched off during the measurements, which enabled omitting the background noise correction K1 (for the ultrasonic noise).

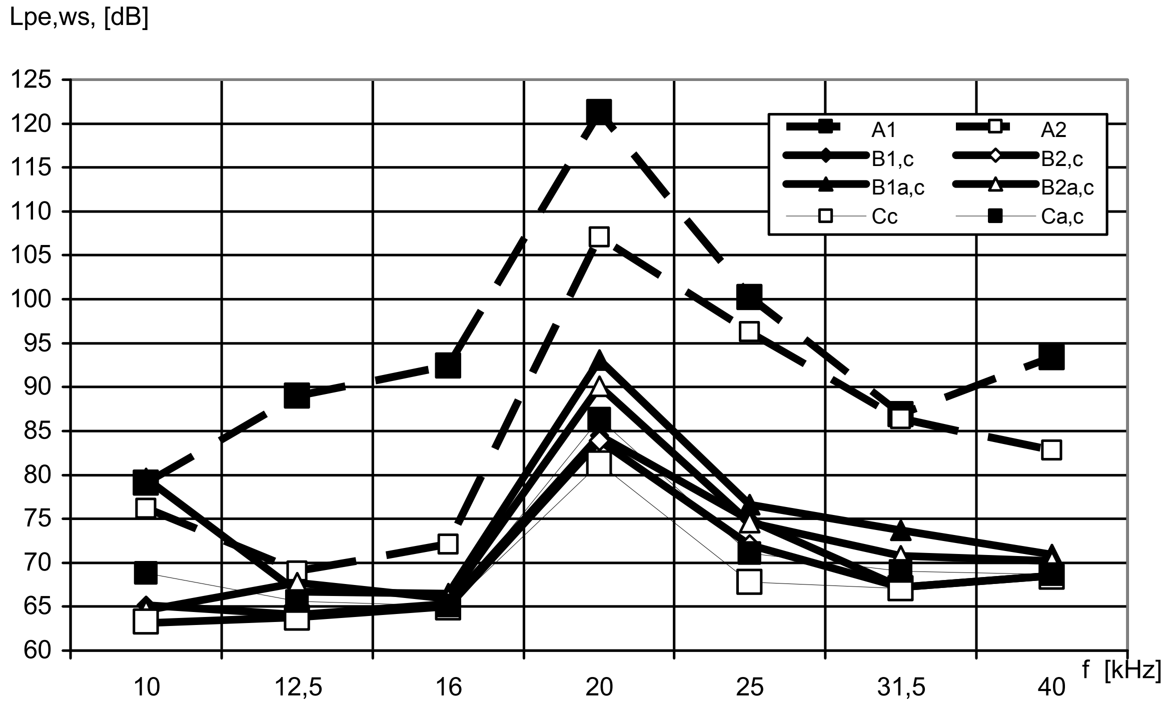
Because the noise emission of the machines had tonal character (Figures 1 – 3), the measurements results provided below are limited to the 1/3 octave band, in which the dominating emission occurred, in the frequency band with mid-frequency of 20 kHz.

4. Measurement results

The results of ultrasonic drills emission sound pressure level measurement are shown in figure 1 – 3 and in table 1.

The results include :

- emission sound pressure level – $L_{pe,ws}$, at the point located near the operator's head (for B_1, B_2, C, B_{1a}, B_{2a}, C_a machines with closed inspection windows) (picture 4),
- emission sound pressure level at a point located in front of the machine at the tool level, at the distance of 30 cm from the machine outline (footprint) – $L_{pe,30}$:
  - Machines B_1a, B_{2a}, C, B_{1a}, B_{2a}, C_a in two options :
    1- inspection window opened– $L_{pe,30,o}$,
    2- inspection window closed– $L_{pe,30,c}$,
  - machines: A_1 i A_2 – $L_{pe,30,o}$.



Rys.1. Emission sound pressure level in the $L_{pe,ws}$ 1/3 octave band in case of machines : without housing -$A_1 \div A_2$, housing without a hole (inspection window closed) - $B_{1,c}$, $B_{2,c}$, C_c ; housing with a hole (inspection window closed) : $B_{1,a,c}$, $B_{2,a,c}$, $C_{a,c}$.

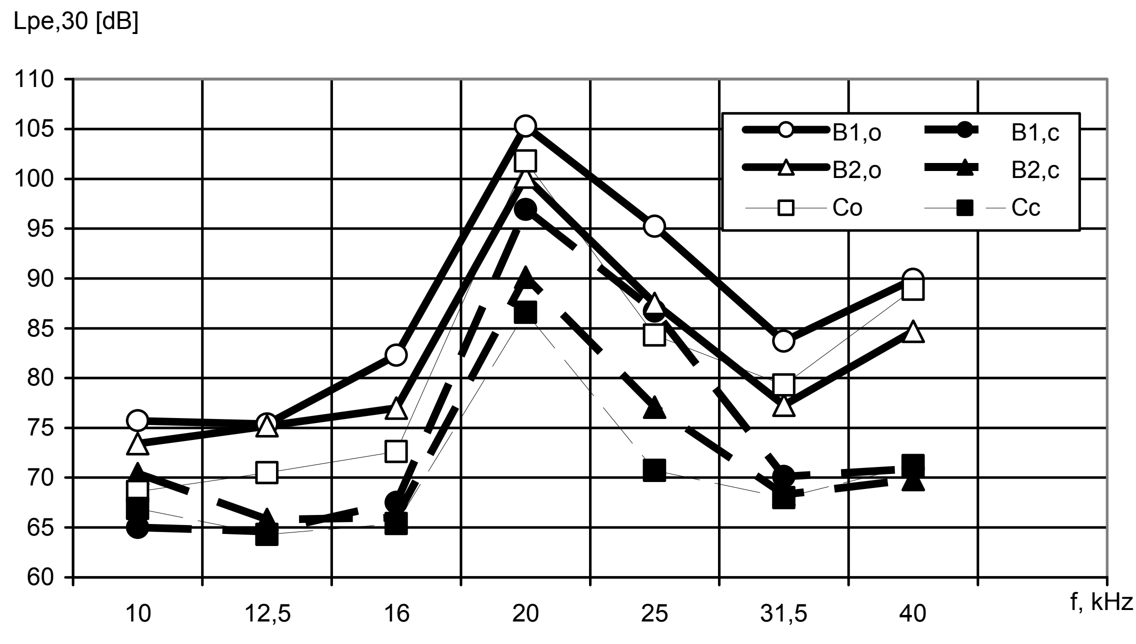


Figure 2. Emission sound pressure level in the $L_{pe,30}$ 1/3 octave band in case of machines without a ventilation hole in the housing:

inspection window opened $B_{1,o}$, $B_{2,o}$, C_o

inspection window closed $B_{1,c}$, $B_{2,c}$, C_c.

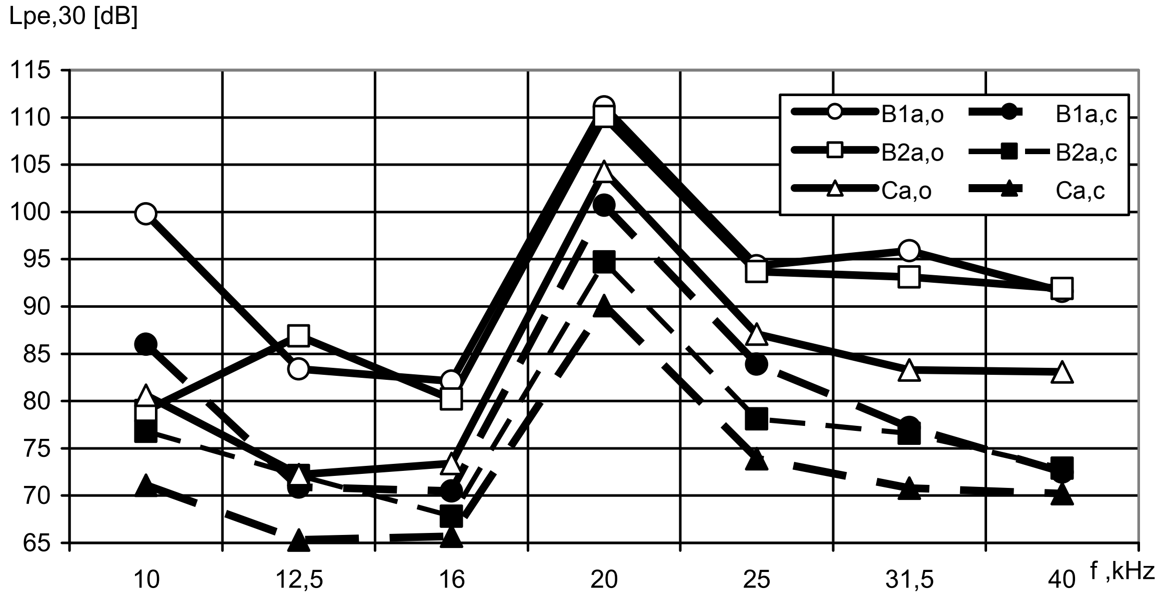


Figure 3. Emission sound pressure level in the 1/3 octave band in case of machines with a hole in the housing: inspection window opened - $B_{1,a,o}$, $B_{2,a,o}$, $C_{a,o}$
inspection window closed - $B_{1,a,c}$, $B_{2,a,c}$, $C_{a,c}$.

Table 1. Ultrasonic drills emission sound pressure level in the 1/3 octave band with mid-frequency of 20 kHz

no.	machine designation	operating frequency, kHz	electric power, W	$L_{pe,30,o}$ dB	$L_{pe,30,c}$ dB	$L_{pe,ws,c}$ dB
1.	A_1	20	400	120,8	–	121,3
2.	A_2	20	140		–	107,1
3.	B_1	20	140	105,3	96,9	84,5
4.	B_2	20	140	100,2	90,1	83,9
5.	C	20	180	101,8	86,6	81,3
6.	B_{1a}	20	140	111,1	100,7	93,1
7.	B_{2a}	20	140	110,1	94,7	91,1
8.	C_a	20	180	104,3	90,1	86,4

Designation:

$L_{pe,30,o}$ – emission sound pressure level in the 1/3 octave band with mid-frequency of 20 kHz, determined at 30 cm from the machine outline (for B_1, B_2, C, B_{1a}, B_{2a}, C_a inspection window opened).

$L_{pe,30,c}$ – emission sound pressure level in the 1/3 octave band with mid-frequency of 20 kHz, determined at 30 cm from the machine outline, (for B_1, B_2, C, B_{1a}, B_{2a}, C_a inspection window closed).

$L_{pe,ws,c}$ – emission sound pressure level in the 1/3 octave band with mid-frequency of 20 kHz, determined at the machines operating position (for B_1, B_2, C, B_{1a}, B_{2a}, C_a inspection window closed).

5. Measurement results analysis

According to the obtained measurement results it was stated that in the 1/3 octave band of 20 kHz frequency (exciter resonance frequency):

a) The highest levels of emission sound pressure at the workplace occurred at the A_1 and A_2 type machines (for electric power of 400 W – 121 dB, for electric power of 140 W – 107 dB),
b) emission sound pressure at the workplace occurred at the B and C type machines were similar:
   - Drills B_1, B_2, B_{1a}, B_{2a} :
     - without a ventilation hole in the housing 84 dB,
     - with a ventilation hole in the housing 91-93 dB,
   - Drills C, C_a:
     - without a ventilation hole in the housing 81 dB,
     - with a ventilation hole in the housing 86 dB,

   this shows that a hole in the housing results in increased noise level at the workplace in the 1/3 octave frequency band by approximately 8 dB (B_{1a}, B_{2a}) or 5 dB (C_a),

c) opening the inspection window (picture 4) in drills B_1, B_2, C, B_{1a}, B_{2a}, C_a results in increased sound pressure:
   - Drills B_1, B_2, B_{1a}, B_{2a}:
     - without a ventilation hole in the housing 9 dB,
     - with a ventilation hole in the housing 5-10 dB,
   - Drills C, C_a:
     - without a ventilation hole in the housing 15 dB,
     - with a ventilation hole in the housing 14 dB,

6. Conclusions

The measurement results confirm the generally known thesis that ultrasonic drills constitute a part of ultrasonic technological equipment that can produce ultrasonic noise hazard at the workplace. In the tested cases many machines were placed in closed housings. These housings performed their function, providing they were not fitted with ventilation holes. If the housing is fitted with ventilation holes, sound dampers must be installed in them.

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