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NOISE TESTING METHODOLOGY IN THE PACKING INDUSTRY

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Polish packaging market accounts for 1.4% of the world packing market and it is constantly developing. According to the Central Statistical Office of Poland, Polish packaging industry consists of 3100 subjects producing packaging made of wood, plastic, paper and cardboard, metal, and glass. This industry employs about 230 000 workers. In many cases, depending on technology, machines and devices used during producing process (e.g., cutting machines, carving machines, presses, or machines for waste granulation) are sources of excessive noise which exceeds limit values (e.g., 5 dB at workstations in the cardboard package factory). Noise is one of the harmful factors, which cause annoyance effects (problems with attention and communication) or dangerous effects (temporary hearing threshold – TTS or permanent hearing threshold – PTS up to occupational hearing loss) to the human body. Previous research showed that noise and high frequency noise have negative impact on psychophysical performance of human body (productivity and work quality). The paper shows the noise testing methodology in the working environment of the packaging industry. The tests performed according to this methodology will be the base for establishing the guidelines for limiting noise in the working environment.
Keywords: noise, testing methodology, packaging industry

1. Introduction

Polish packaging market accounts for 1.4% of the world packing market and it is constantly developing. According to the Central Statistical Office, there are about 8000 factories producing packaging in Poland which, according to the Polish Chamber of Packaging, employ about 230 000 workers [1, 2]. Most of them are small and middle factories producing packaging made of wood, artificial materials, paper and cardboard, metal, glass, and textiles materials. In literature, there are no notifications about the assessment of acoustic conditions and occupational hazards resulting from the exposure to noise at workstations in the packaging factories. According to the information from occupational safety and health services, in many cases, depending on the technology, machines and devices used during producing process (e.g., cutting machines or technological lines) are sources of excessive noise which exceeds limits of the maximum admissible intensities (MAI) of noise.

This paper shows the testing method and preliminary results of measurements and assessment of exposure to noise in the ranges of infrasonic, audible and ultrasonic frequencies performed at chosen workstations in the units producing packaging made of plastics, paper and metal (iron plate).

2. Testing Methodology

The testing method of the noise at workstations in the units producing packaging consists of determining parameters characterizing the noise on the basis of measurements and questionnaire survey which aim is a subjective assessment of acoustic conditions in the given working environment. Measurements of the noise in the determined range frequencies were performed with indirect method in

accordance with the requirements included in standards: PN-N- 01338: 2010, ISO 9612: 2011 and PN-N- 01307: 1994 [3, 4, 5] and with the test procedure developed by CIOP-PIB [6].

According to the standards, determined are:

- infrasound frequencies range - G-weighted the equivalent sound pressure level (SPL),
- audible frequencies range - A-weighted the equivalent SPL, noise exposure level ($L_{Ex,8h}$), the maximum A-weighted SPL and peak C -weighted SPL,
- ultrasonic frequencies range - equivalent SPL in the one-third octave frequency bands with the center frequencies from 10 kHz to 40 kHz, normalized for an 8-h working day using and maximum SPL determined in the one-third octave frequency bands with the center frequencies from 10 kHz to 40 kHz.

Admissible values of noise in terms of health protection (MAI values of noise) for workers which are obligatory in Poland are determined in the Regulation of Minister of Labour and Public Politics from June, 6, 2014 [7]. Admissible values in terms of the chance of realization by workers basic jobs on the selected types of workstations are determined in the Polish standard PN-N-01307: 1994 [5]. To the annoyance range of infrasonic noise Polish standard PN-N-01338: 2010 is applied [3].

A questionnaire form was prepared to perform the subjective tests on the noise. The questionnaire consists of 20 questions divided into three parts. The first part included questions on general information, e.g., age, working experience. The second part included questions on the assessment of working conditions and the third part included questions on health conditions of employees.

3. Test subject

Preliminary measurements of parameters characterizing the noise were performed at workstations in the two units producing packaging made of artificial materials and paper.

In the unit producing packaging made of plastics measurements of the noise level in an audible frequencies, ultrasonic frequencies and infrasonic frequencies were performed at 12 workstations: injection blow molding machines for packaging production (from polypropylene and polythene), 11 packing workstations of finished products and one granulation of plastics (recycling) workstation. A technology of pressing was applied in the forming of products. Devices were automated and consisted of the following systems: dosage of pellets and dyes, plasticization and homogenization of raw materials, grinding down and dosage of industrial waste, forming of products, conveyor belts of finished products, automatic packing devices. Work at workstation of injection blow molding machines involved control of the process during work of machine and control of a control panel. Workstations of packing finished products were partly automated. The above-mentioned workstations were in a production hall with acoustic adaptation (plate sound-absorbing on walls, sound-absorbent-insulating panels type sandwich on ceiling and partial casing of injection blow molding machines). Operation of recycling line located in a separate room consisted of supplying material to mills, controlling the process of granulation and storing away ready pellets.

The second unit in which measurements of noise were performed was the unit producing wavy cardboard and packaging. Twelve workstations located in the production hall were chosen for the test. These workstations included single cardboard machine (to glue together cardboard machine), double cardboard machine, Starcker line (cardboard transport line), line to excision and overprint (3 colours), line to excision and overprint (5 colours), line to rotary excision and line to flat excision. Production lines were mechanized. Work at these workstations (except for workstation of main operator of cardboard machine) involved feeding, controlling the process (control panel) and collecting from the production line.

4. The results of preliminary measurements and assessment of the noise at workstations

The measurements of parameters characterizing the noise in the infrasonic frequencies, audible and ultrasonic range were performed with sound analyzers Svan 979 and Svan 945 firm Svantek, microphones (the diameter ½" and ¼") and acoustic calibrator BK type 4230 of firm B&K. Measuring points were located on standing areas at the workstations in the distances from 0.5 to 1 m from the machines.

The results of measurements of noise at workstations of plastics packaging production show that at tested workstations A-weighted noise exposure level normalized to an 8-h working day is contained in the range from 85 dB to 95.4dB. The measured maximum A-weighted SPL fluctuates from 86.7 dB to 104.9 dB, the uppermost peak C-weighted SPL fluctuates from 106 dB to 118.5 dB. The values of G-weighted SPL fluctuate from 80.2 dB to 86.9 dB.

Determined exposure level exceeds admissible value determined for an 8-h working day. Other values of the permissible maximum A-weighted SPL and peak C-weighted SPL in terms of hearing protection are not exceeded. Admissible value G-weighted SPL determining the criterion of the annoyance of infrasound noise is not exceeded. Measured equivalent SPLs in the one-third octave bands with frequencies from 10 kHz to 40 kHz for an 8-h working day at tasted workstations do not exceed admissible MAI value for the ultrasonic noise.

Figures 1 and 2 show exemplary results of A-weighted noise exposure level normalized for an 8-h working day at the tested workstations of injection blow molding machines, recycling and packing. Great part of the spectra of the noise appearing at injection blow molding workstations have low-frequency components.

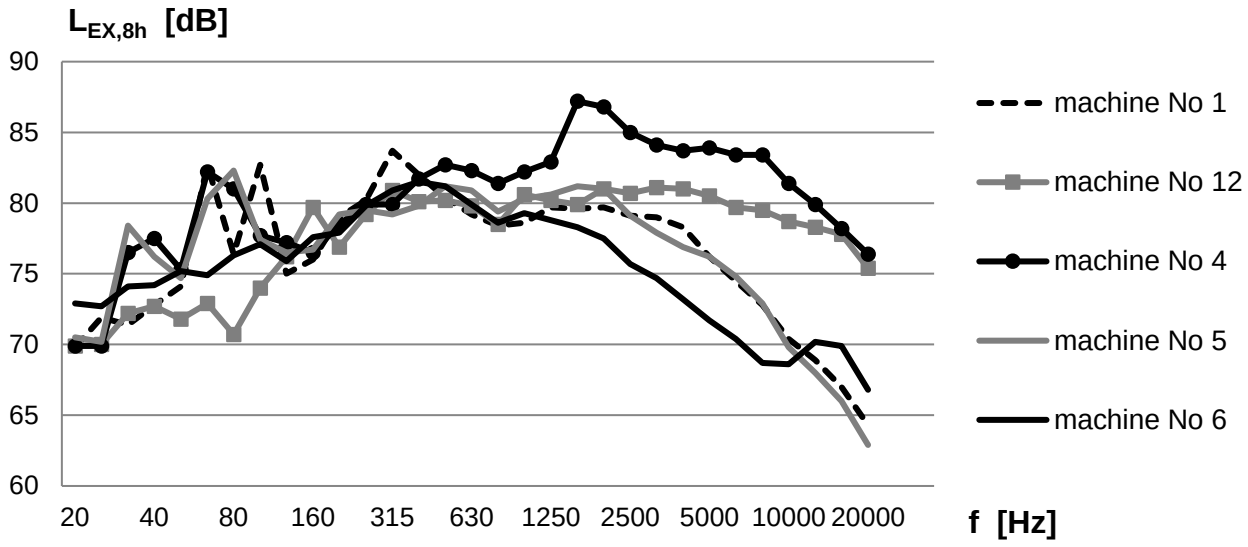

Figure 1: The results noise at chosen workstations injection blow molding machines

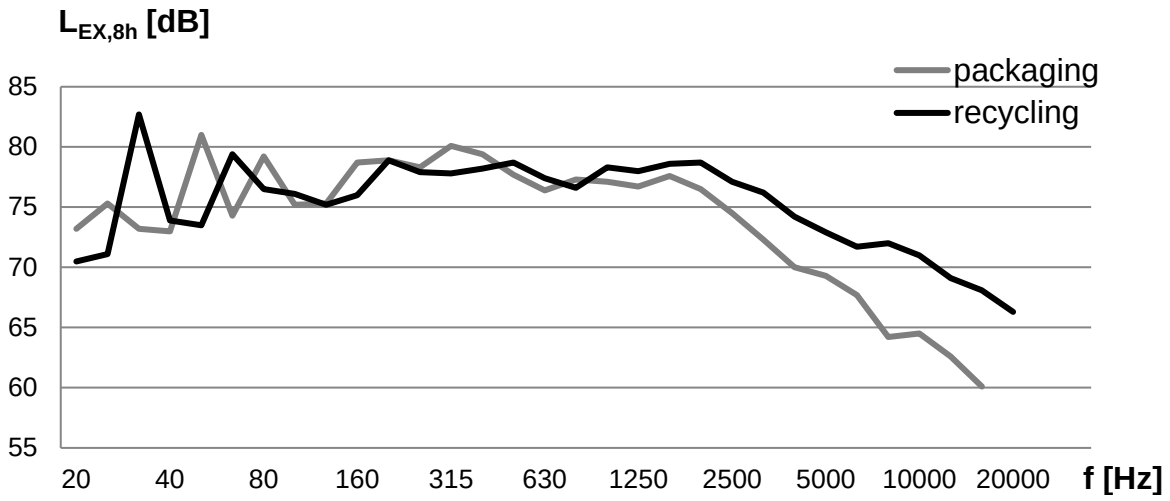

Figure 2: Exemplary results noise at workstations recycling and packing products

The results of measurements of the noise at the workstations of wavy cardboard production show that:

- at tested workstations A-weighted noise exposure level normalized to an 8-h working day is contained in the range from 84.8 dB to 90.7 dB,
- the measured maximum A-weighted SPL fluctuates from 86.2 dB to 91.4 dB,
- the uppermost peak C-weighted SPL fluctuates from 102.8 dB to 114.1 dB,
- values of G-weighted SPL fluctuate from 82.3 dB to 91.2 dB.

The noise exposure level exceeds the admissible value determined for an 8-h working day. Other values of the maximum A-weighted SPL and peak C-weighted SPL in terms of hearing protection are not exceeded. Admissible value of G-weighted SPL determining the criterion of the annoyance of infrasonic noise is not exceeded. Measured equivalent SPLs in the one-third bands with frequencies from 10 kHz to 40 kHz for an 8-h working day at tested workstations do not exceed admissible MAI values for the ultrasonic noise. Figures 3 and 4 show exemplary results of the noise exposure level for an 8-h working day at tested workstations.

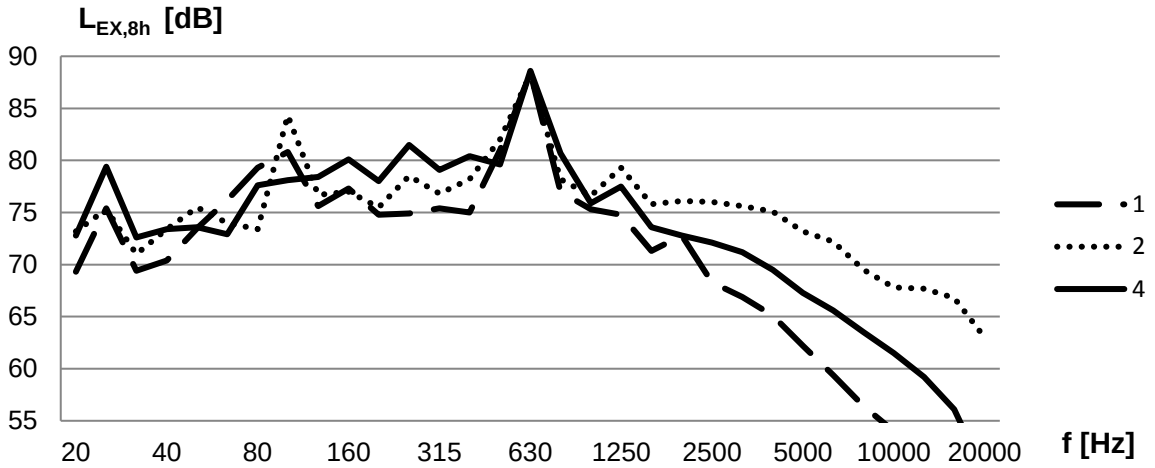

Figure 3: The results noise at workstations: 1- single cardboard machine, 2-double cardboard machine, 4-Starckera (transport of cardboard),

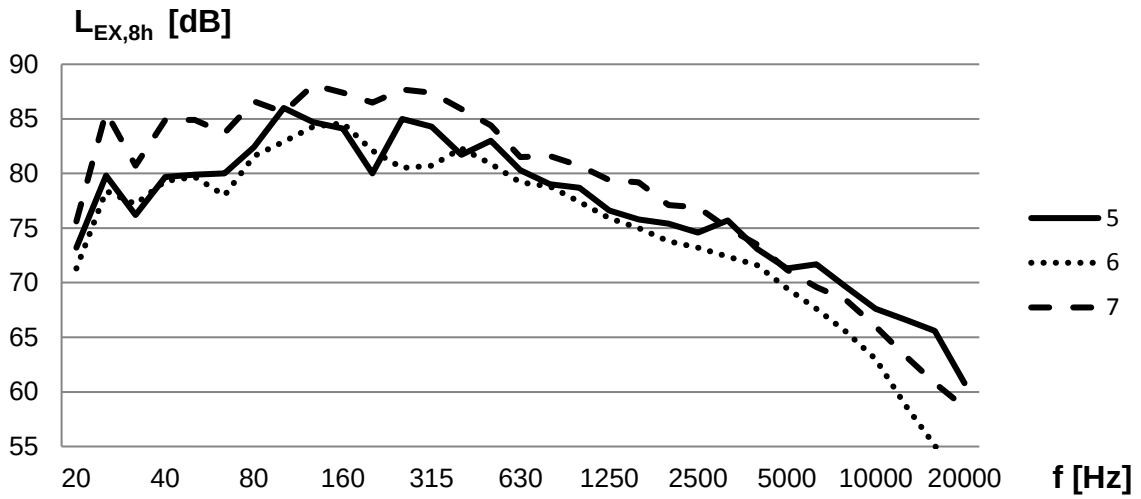

Figure 4: Results of the noise at workstations of the service the line of cutting out and the overprint: 5 - the control and the loading of cardboard (3 colours), 6 – main operator of the processing cardboard machine, 7 - the control and the loading of cardboard (5 colours)

5. Summary

The results of measurements of the noise at the workstations (infrasonic, audible and ultrasonic frequencies) of packaging products made of artificial materials and paper shows that:

- in the audible frequencies range – measured noise exposure level exceeds the admissible value determined for an 8-h working day at all workstations, the remaining parameters characterizing noise, i.e., the maximum SPL and peak SPL are below the admissible values defined for this range of frequencies,
- in the ultrasonic frequencies range - admissible values are not exceeded,
- in the infrasonic noise range – admissible values are not exceeded in terms of determining the annoyance criterion.

Despite of acoustic adaptation in a production hall and application of casing to injection blow molding machines at tested workstations noise pollution occurs, in terms of health protection [8, 9, 10]. Technological holes in production machines reduce acoustic insulation. To protect workers from the effects of noise in the working environment preventive actions should be taken.

The assessment of existing acoustic adaptation and location of machines should be performed to reduce the emission of noise. Adequate isolation (dilatations or vibration isolators and movable protection of existing technological holes) between machines and ground should be selected. The inside of casings should be lined with absorbing material.

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