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NOISE CONTROL FOR A BETTER ENVIRONMENT

Case study of a loud machine in industrial hall

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ABSTRACT

This paper presents the analysis of the interaction of noise and vibration of a new machine installed in an industrial hall and its impact on the sound environment. The new machine, a glass hardening furnace, generates vibroacoustic problems at workstations and for other machines located in this hall and the adjacent hall. These problems are mainly due to the errors in the preparation of the space for the furnace, as well as assembly errors of the machine and accessories. Comprehensive tests of noise and vibration of the furnace and its components allow the determination of action proposals required for vibroacoustic protection. It is recommended that when installing new devices that there be analysis of vibration and noise propagation paths to formulate acoustic requirements necessary for the successful installation and operation of that device (which would include the protection of workers, the environment and the work space).

Keywords: Noise, Vibration, Work Environment, Workplaces
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1. INTRODUCTION

The vibroacoustic threats in the work environment are often the effects of mounting faults committed during the installation of new machinery or equipment. Installation errors cause all sorts of excessive vibroacoustic activity within the work space. This leads to significant deterioration of working conditions at neighboring stands when servicing other machines in the hall, and also hinders the installation of other machines and devices that require special technical conditions (for example, low vibration levels). The discussed case shows how an inappropriate approach to the vibroacoustic issues of machines can generate various other problems [1,2]. A number of measurments of the furnace noise and its equipment indicated noise hazards in

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the immediate workspace of the furnace, as well as at the workplaces of neighboring machines and devices. In turn, the vibrations caused by the furnace and its accessories affected the operation of precision devices located both in the hall where the furnace was located and in the adjacent hall.

2. SOURCE OF NOISE AND VIBRATONS

The specifications of the glass hardening furnace include dimensions of 22 m x 3.8 m x 3.8 m and a weight of 32 tons. The heat output of the furnace is 624 kW, with a cooling capacity of 1130 kW. During operation, the furnace will harden glass plates of thickness from 3.2 mm to 19 mm.

The furnace is operated by two double teams of operators whose workplaces are located at the beginning and end of the line. (Fig.1).

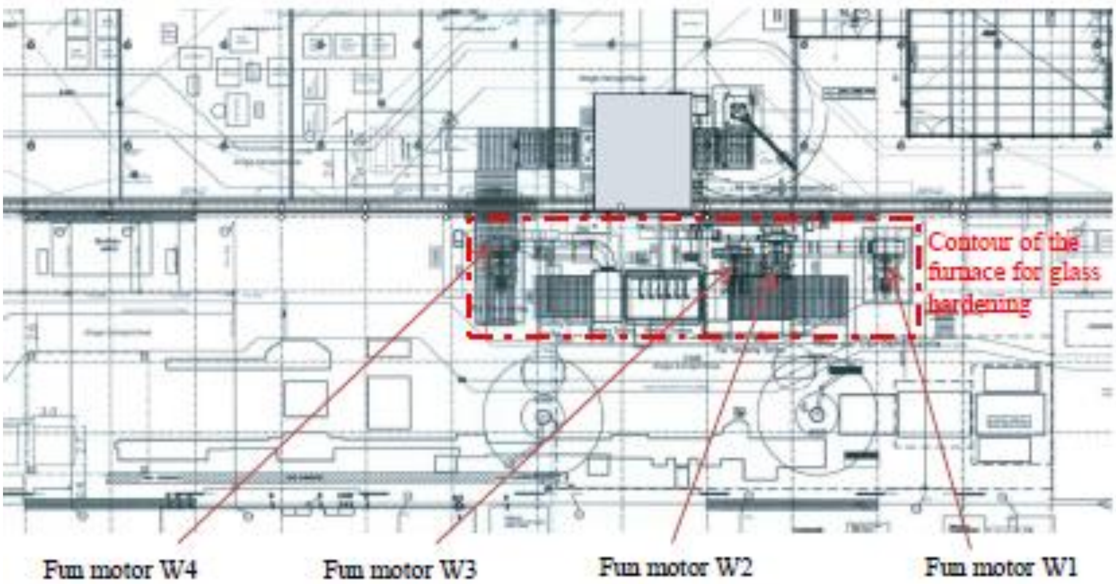

Fig.1. The Furnace for hardening glass

The technical process involves loading two panes of glass on feed rollers, that guide the glass panes through the furnace, where the process of hardening occurs, and then picks up the glass pane with conveyors and their placement in special racks. The cycle of two glass panes passing through the furnace is on average about 4 minutes. The glass hardening process is accompanied by high level noise related to the blowing of air into the furnace, and there are four blowers equipped with 220 kW electric motors operating at a speed of 1450 rpm.

The fan motors of blowers W1 - W4 (Fig.2) are placed on the steel ramp ca. 3 m above the floor of the hall and about 2 m from the halls wall.

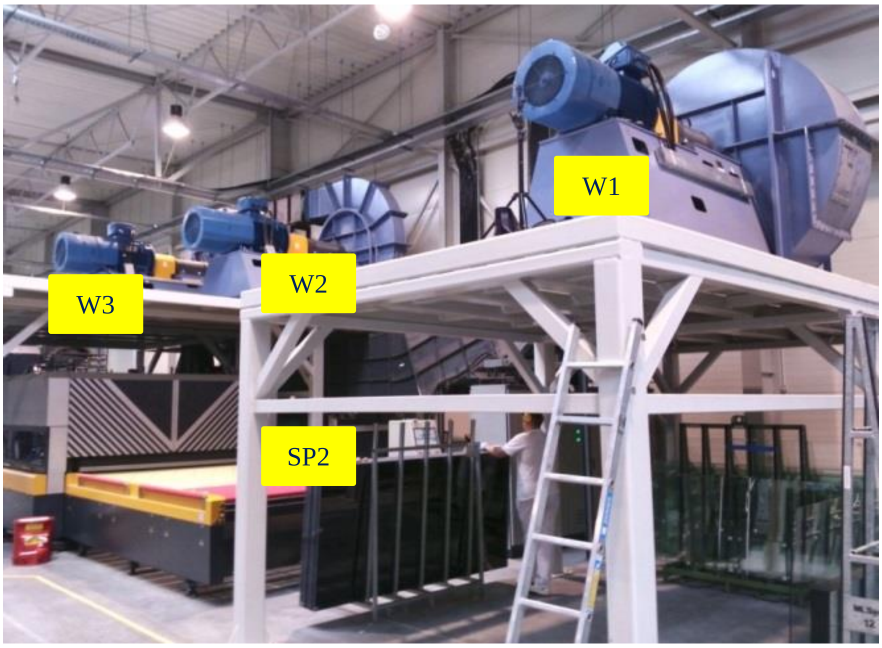

Fig.2. Fan motors W1, W2 and W3

Main sources of noise related to the implementation of the technological process:

1. Fan motors and air ducts to the furnace
2. Noise transmitted through the body of the furnace
3. Technological apertures of the entry of the glass sheet to the furnace and the exit from the furnace
4. Noise coming from under the furnace from the holes in furnace foundations
5. Noise coming from rear wall of the furnace body (no enclosure) and the sound reflected from the walls of the hall.

All of these sources are most active during operation the fan motors.

3. MEASUREMENT OF NOISE AND VIBRATION

To assess the noise impact of the glass hardening furnace, sound measurements were made at the operators workplaces and at selected locations in the furnace hall and in the adjacent hall, using the measurement methods described in the standards [1]:

- noise measurements beside 3 engines that blow air into the furnace at a distance of 1 m from the contour of machine [3],
- measurements of noise around the furnace at a distance of 1 m from the furnace contour [4,5],
- measurement at the operator's stations in the furnace work space [6,7]
- measurements at neighboring workplaces to the glass hardening furnace[7],
- noise measurements at selected locations in the adjacent hall.

All measurements were made using a SVAN 971 sound level meter.

Vibration generation also occurs during the glass hardening process in the furnace. The dominant sources of vibration are:

1. Blower fan motors supplying air to the furnace
2. The body of the furnace for tempering glass
3. Vibration of the hall wall structure behind the furnace.

All of these sources are most active during operation of the fan motor.

For the assessment of the impact of vibrations that are generated and transmitted by the structure of the platforms for the fan motors and from the glass hardening furnace, vibration measurements were performed at the following locations:

- fan W1: measurement on the body of the fan motor, its base and a raised platform on which the fan motor has been placed;
- base of the fan motor platform W1, W2 and W3;
- on the body of the furnace;
- the floor around the furnace
- wall truss construction behind the furnace

For measuring and registration of vibration a SVAN 106A Analyzer, a Dytran 3233A accelerometer and an NI 9234 card were used. Vibration measurements were made for full cycles in each location.

4. NOISE AT THE WORKPLACES

Table 1 contains the noise risk assessment at operator workplaces of the glass hardening furnace at locations SP1 and SP2:

- 105 cycles (one cycle 4 minutes) = 420 minute jobs
- 30-minute-break breakfast (background sound L_{Abckg} = 64.5 dB)
- 30 minutes-preparing for the start and end of the changes (background sound L_{Abcgr} = 64.5 dB).

Table 1. Noise hazard assessment for 8 hours of working time changes in the operator workplace by the glass hardening furnace.

LP	The designation of the position	Equivalent sound level for 8 h of work L_{Aeq} [dB]	The maximum value sound level A L_{Amax}[dB]	Peak sound level C L_{Cpeak} [dB]	Sound level L_{Abckg}[dB]
		Limit value L_{Aeq} = 85 dB	Limit value L_{Amax}= 115 dB	Limit value L_{Cpeak} = 135 dB	
1	SP1	90.6	100.3	116.3	64.5
2	SP2	93.9	103.2	120.4	64.5

In workplace locations SP1 and SP2 at the furnace operator's work stations there is a risk of excessive noise. The greatest value exceeding the equivalent sound level and L_{Aeq} occurs at SP2 (6.6 dB), which is due to the specific location of this position. There is a simultaneous impact of noise coming from fan motors W1, W2 and W3. Fans W1 and W2 are almost equally distant from the operator workplace SP2 (Fig.2). In addition, there is a noise coming from the space behind the furnace and also reflected sound from the wall. From the point of view of noise reduction, the location of the furnace is especially difficult.

The noise levels at operator station SP1 are lower (about 1.5 dB) as a result of the distance of the station from fan W1 and partial shielding of sound propagation through the furnace casing and fans W2 and W3.

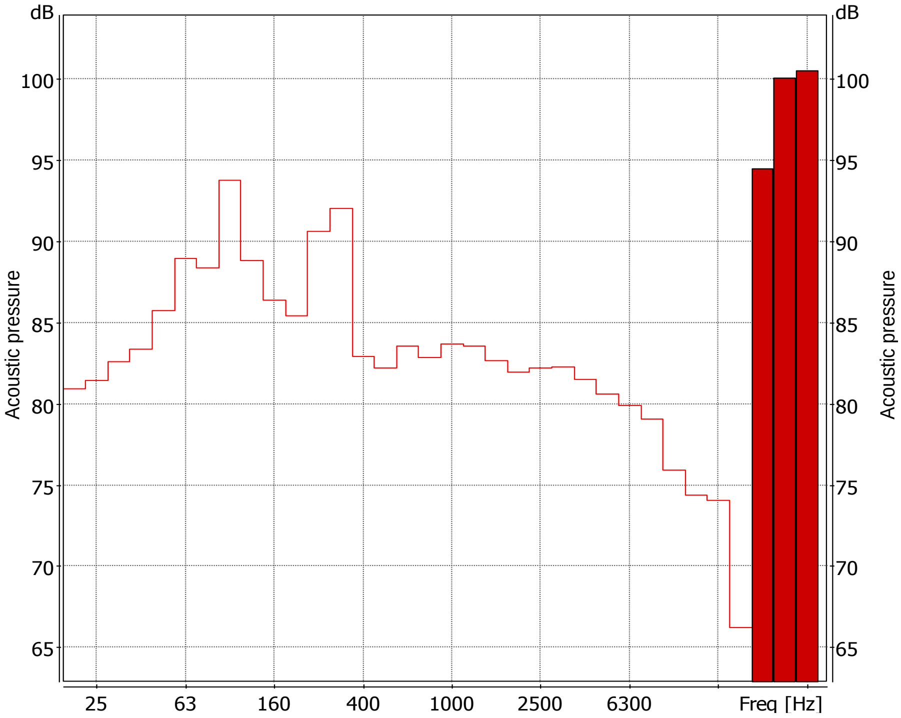

Fig.3. Noise spectrum in the workplace SP2.

Spectral characteristics in 1/3 octave sounds at workplace SP2 are presented on the chart (Fig. 3). At both workplaces broadband noise occurs with clearly elevated values of sound pressure levels at low frequencies. In particular, highlight the dominant values of sound pressure levels in 1/3 octave frequency bands: f = 100 Hz, f = 250 Hz, f = 315 Hz.

5. ANALYSIS OF THE MEASUREMENTS AND DISCUSION OF RESULTS

The vibroacoustic impact of the the glass hardening furnace is significant. Noise at the furnace operator's workplaces on the entry of glass panes into and receiving them from the furnace shows results exceeding the limit values $L_{Aeq,8h}$ = 85 dB. The noise levels vary in impact over the 4 minute cycle time. The fans start to blow when glass plates moves to the rolls in the furnace, and are turned off when the panes leave the furnace. The cycles were checked and measurements repeated. Cycle time is approximately 4 minutes. The variation of noise during one process cycle is shown in Figure 4.

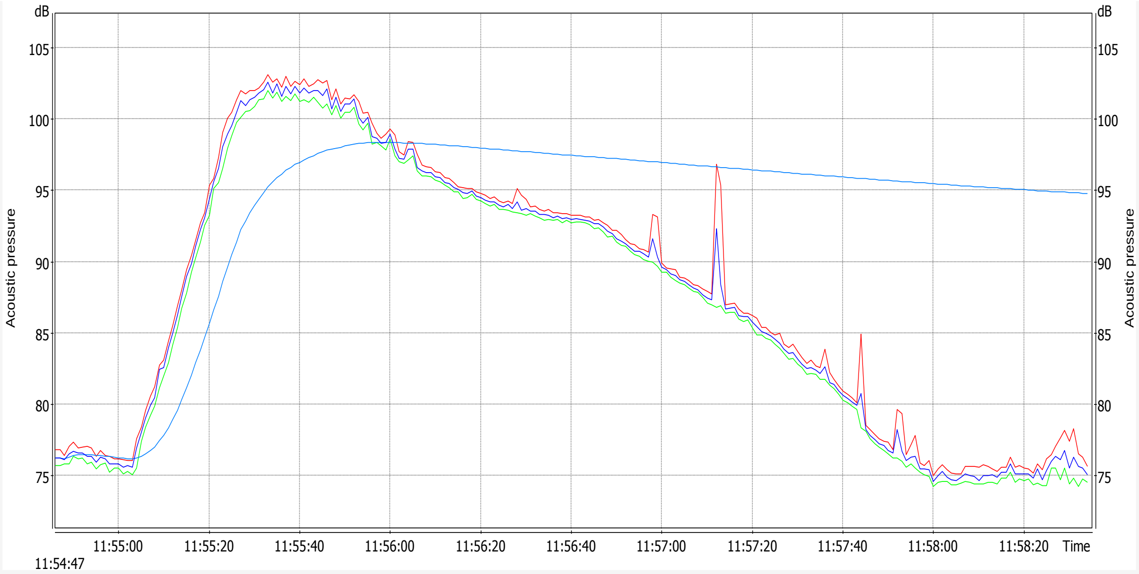

Fig.4. One cycle of process of hardening glass plates.

Measurements of noise and vibrations should provide information on the vibroacoustic influence of the glass hardening furnace on the working environment in the hall, as well as give an answer as to whether new devices can be installed in the adjacent hall based on laser technology. The corrected sound power levels of fan motors are $L_{WA, W1}$ = 94 dB, $L_{WA, W2}$ = 98 dB, $L_{WA, W3}$ = 98 dB. Distribution of sound levels A at a height of 1.5 m above the floor around the furnace made according to [5] vary from 88 dB (A) to 96 dB (A), which means that the noise limits are exceeded from 3.3 dB (A) to 11.2 dB (A). The issue is not just the noise occurring specifically at the monitoring location, as the supervision of the furnace operation requires that the operator move within the area of excessive noise in the vicinity of the furnace. High noise levels also indicate a significant noise impact from the furnace on the surrounding hall space, which results in a significant increase in the A-sound levels at all workplaces next to the machines and devices adjacent to the furnace.

Measurements of vibrations have shown that the vibrations transferred to the floor of the hall and beyond to the machines working in it are substantial [8,9]. Machines that are in the hall belong to a group of very sensitive (VS) and moderately sensitive (MS) machines or devices with dynamic impacts allowing admissible vibration speeds of 0.0001 m/s and 0.001 m/s [10]. For medium-sensitive machines ($v_{max, limit}$ = 0.001 m/s), the measured amplitude of the resultant vibration speed is 0.006 - 0.008 m/s. For very sensitive machines ($v_{max, limit}$ = 0.0001 m/s) the measured vibration values are:

- Laser table cutting device (v_{max} = 0.004m / s),

- INKJET table printer v_{max} = 0.004 m / s).

The assessment of the furnace vibration influence was carried out on the basis of PN-B-0217 [10].
At work stations SP1 and SP2, vibration is shown in table 2.

Table 2. Vibrations levels at furnace operator work stations SP1 and SP2.

No	No Workplace	RMS a_x [m/s^2]	RMS a_y [m/s^2]	RMS a_z [m/s^2]	RMS a_w [m/s^2]
1	SP1	0,1684	0,3533	0,3352	0,5153
2	SP2	0,3964	0,8168	0,8309	1,2307

According Polish legislation, in the case of vibrations with general effects on the human body:

- The daily exposure value A (8h) should not exceed 0.8 m/s^2.
- The value of short-term exposure (lasting 30 minutes and shorter) a_w, 30 minutes should not exceed 3.2 m/s^2.

At the SP1 work station, the vibrations are below the permissible values, however, at the SP2 stand, they significantly exceed the admissible values. The main source of vibrations transmitted to the ground are motors and fan ducts and a furnace set on a separate foundation. The vibrations caused by these machines affect the floor under the remaining machines and devices located in the furnace hall and in the adjacent hall, where the INKJET Table Printer is located, and the Laser Table (for cutting and drilling holes) and other machines planned for installation. Vibration parameters, with the adopted sensitivity class for neighboring devices, do not meet their normative requirements. Therefore, it is necessary to create vibration isolation of individual elements of the furnace, so as to reduce its vibroacoustic impact.

6. CONCLUSIONS

The effect of the location of the furnace in the existing industrial hall is due to the number of errors that were made during its installation. An incorrectly prepared foundation is an important reason for generating excessive vibrations transmitted to floors in both halls and the impact of these vibrations on the operation of machines for precision operations. Blower motors placed on high steel platforms cause a strong impact of noise on workplaces located directly at the furnace as well as with neighboring machines. This position makes it difficult to apply noise protections. The furnace requires many activities related to the reduction of vibroacoustic energy emission to the hall environment, as well as the protection of workplaces being within its noise range. On the basis of the analysis of the measurement results, a preliminary concept of anti-noise protections located in the furnace space was presented.

A significant vibration effect propagating through the foundations and the floor surface requires many actions to apply vibration insulation to the furnace body and platforms on which the blower fan motors are located. Unfortunately, many of these errors will be difficult to correct.

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