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Original Article

An Intervention for Noise Control of Blast Furnace in Steel Industry

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ABSTRACT

Background: Noise pollution is currently a major health risk factor for workers in industries. The aim of this study was to investigate noise pollution and implement a control intervention plan for blast furnace in a steel industry.

Methods: The measurement of sound pressure level (SPL) along with frequency analysis was done with the sound-level-meter Cell-450. Personal noise exposure was performed using dosimeter TES-1345 calibrated with CEL-282. Before planning noise controls, acoustic insulation properties of the furnace control unit and workers' rest room were assessed. Control room and workers' rest room were redesigned in order to improve acoustical condition.

Results: The SPL before intervention around the Blast Furnace was 90.3 dB (L) and its dominant frequency was 4000 Hz. Besides, noise transmission loss of the control and rest rooms were 10.3 dB and 4.2 dB, respectively. After intervention, noise reduction rates in the control and rest rooms were 27.4 dB and 27.7 dB, respectively. The workers' noise dose before and after the intervention was 240% and less than 100%, respectively.

Conclusions: Improvement the workroom acoustic conditions through noise insulation can be considered effective method for preventing workers exposure to harmful noise.

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Introduction

Noise pollution is considered as the most common harmful physical agent in the work environment[1]. About 600 million workers are exposed to noise pollution in the workplaces[2]. According to some reports by the National Institute of Occupational Safety and Health (NIOSH), almost 30 million workers are exposed to industrial sound in the United States[3]. About 2 million Iranian workers are exposed to harmful noise in their work environment [4]. Continuous and long-term exposure to noise can lead to unknown complications as temporary and permanent impairment in hearing, sleeping disorder, hypertension, tachycardia and psychological disturbs[5,6]. In addition, exposure to occupational noise can cause decrease in staffs efficiency, and increased accident risk in work environment[7]. World health organization (WHO) estimated that about 278 million people suffer from mild to severe hearing disorders in the world which 16% of hearing losses is due to occupational noise exposures[8]. In the developing countries, about 2% of the gross domestic product is devoted to compensation of disabilities related to noise pollution [9].

Noise pollutions in workrooms can be produced due to various factors including low technology, amortization, incomplete maintenance of equipment and machineries, high speed of fluids in ducts, deteriorated fans, inappropriate foundation, and structural vibration of the devices, issues related to the building design and reflection of their interior surfaces[10,11].

In steel industry, special equipment including pumps, compressors, furnaces, air blowers, cooling towers, ducts, gas and vapor valves, and other vibrating equipment are used which can be considered as main sources of noise pollution. Nassiri et al. showed noise pollution due to the employed compressors and fans were 70 to 94 dB (A) in a petroleum zone [12].

The blast furnace (BF) is one of the most important huge equipment in steel industry used for smelting iron and producing steel and cast iron ingots. Smelting function is performed in conjunction with other adjunct equipment as blowers, boiler and kaopers or air-warmers. The air provided by the blower unit enters huge equipment, called kaopers through some ducts. The air warmer warms up the air sent from the blower using CO escaping from the furnace as fuel and the warm air enters the BF. Hence, the high-pressure air flow is created in the entrance of ducts with diameter of 0.8 m which can produce high noise level. Kerketta reported the noise levels of equipment furnace, boiler, and cooling tower system in a steel factory are 83 to 98 dB (A) [13]. In the current study, noise controls in blast furnace of a steel industry are considered. The previous study suggested the noise dose received by furnace workers is more than 200% [14]. Hence, this study aimed to investigate noise pollution and implement a noise intervention plan for blast furnace in a steel industry.

Methods

This experimental study was performed in the blast furnace plant of a steel industry located at the west of Iran. The basic information about the BF unit and its workers exposure were collected. Then, noise emission around the BF unit and personal noise exposure of workers were measured. In next step, noise control interventions were planned and its performances were estimated.

Study of noise levels around the blast furnace

The sound pressure levels (SPL) around the BF were measured at each defined station characterized on designed grid map using sound level meter CEL.450 calibrated with CEL-110/2 based on ISO-9612 and ISO-11200 methods [15].

The furnace unit with 31 m in length, 15.8 m in width was divided into grid pattern squares of 4 x 4 m and finally, 32 measurement stations were considered. The noise map was designed by Surfer software. This software can display the buffers and isometric map of noise propagation in the measured domain[1].

Evaluation of the efficacy of interventions employed in the furnace unit was performed based on actual personal noise exposure. Then, the received noise dose was measured during 8 h before and after interventions using noise dosimeter TES-1345 calibrated with CEL-282. In this way, dosimeter was attached to the worker's lumbar region and its microphone was attached to the worker's collar from the back region. The rate of the dose received by three workers during the three work shifts of morning, evening, and night was measured.

Acoustic analysis of rooms based on noise transmission loss

Acoustic characteristics of rooms and the walls separating those rooms around the BF were reviewed based on noise transmission loss[16]. For determining of actual transmission loss, sound pressure levels were also measured in tow points besides the window and wall in the external and internal side of the rooms.

Design and implement of noise control solutions

Based on the results of acoustic analysis, appropriate noise controls were designed for control room and rest room with considering the three criteria including interventions cost, efficiency and effectiveness.

In the control room, a UPVC window with vacuumed double-layered glass 80x80 cm and double wall for entrance by 90° rotate plus a 2.0×1.2 m steel door without glass were applied.

For the rest room, noise control solutions were including change the locations of the door and window towards the external side of the furnace and installation of two cameras to monitor furnace operation at rest times. For reduce exposure to direct noise, a wall facing to the furnace was made from the armed concrete with a thickness of 20 cm, length of 9 m, and height of 3 m and was located in the entrance by 90° rotate. For providing natural lighting, a window with ordinary 1.0×1.2 m glass panel was installed on the external side of the furnace behind the room.

For evaluation the results of noise control methods [11,16], data were analyzed using Excel software. For drawing the noise maps, Auto CAD and Surfer software for GIS calculation were used.

Results

The results of noise measurement at the considered stations around the BF are presented in Figure 1. The noise levels were from 78 to 106 dB (A) and the dominant frequency was 4000 Hz. Near the furnace noise levels were from 95 to 105 dB (A) and near the target rooms were about 90.5 dB (A). The noise level inside control room was 80 dB (L) and inside rest room was 86.1 dB (L).

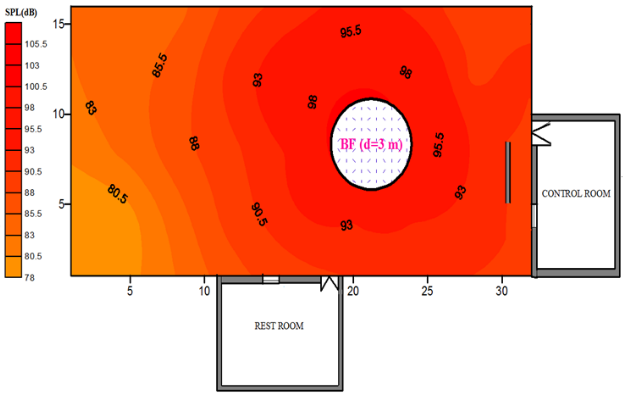

Figure 1: The noise map contours around the furnace and the location of control and rest room

The acoustic analysis of the control and rest rooms based on sound transmission loss showed that the actual noise reduction before intervention in control and rest rooms was 10.30 dB and 4.23 dB, respectively.

The location of rooms around the BF is displayed in Figure 2(left). Due to inappropriate design of the rooms around the BF, some modifications were considered to reduce the noise exposure problem related to those structures. the considered modifications were include replacing the door by steel material and UPVC double layer vacuumed glass window and adding an internal wall for rotating on entrance in control room.

For rest room the window was removed and two cameras were installed for monitoring the furnace operation at rest times. Direct noise was reduced by implement a 20 cm thickness armed concrete wall and install a steel door for entrance by rotate of 90°. The intervention plan was shown in Figure 2(right).

Table 1 shows the results of noise reduction in control and rest rooms. The theoretical transmission losses for control and rest rooms were 55 dB and 34 dB, respectively. Considering the 0.001% leakage area for windows and doors, the noise reduction was estimated about 30 dB. After implementation of control plans, the noise reduction in control and rest rooms were 27.4 dB (L) and 27.7 dB (L), respectively. Moreover, the noise frequency analysis in octave bands indoor the target rooms are presented in Figure 3.

To assess the effectiveness of the noise control interventions, the personal noise dose was measured. Results of personal noise doses in three typical shifts for the exposed workers were presented in Table 2.

Table 1: Results of noise reduction in control and rest rooms, before/after interventions

Target	SPL[a] before intervention dB (L)	Control interventions	Noise reduction, dB (L)			SPL after intervention dB (L)
			Theoretical	Predicted with the 0.001 opening	Actual	
Control room	80.0	Steel door, UPVC window with vacuumed double-layered glasses. Screw entrance by 90°	55	30	27.4	52.6
Rest room	86.1	Armed concrete wall, Screw entrance by 90°	34	30	27.7	58.4

[a] Sound Pressure Level

Table 2: Doses of noise among workers in three work shifts

Work shift	Before intervention		After intervention		Ratio of increased exposure limits
	Noise dos (%)	Daily exposure limits (h)[a]	Noise dose (%)	Daily exposure limits (h)[a]	
Morning	240	3.33	137	5.83	1.75
Evening	235	3.40	130	6.15	1.81
Night	234	3.42	122	6.55	1.92
Average	236	3.38	130	6.18	1.83

[a] Based on limitation of 85 dB(A) and 3 dB exchange rate

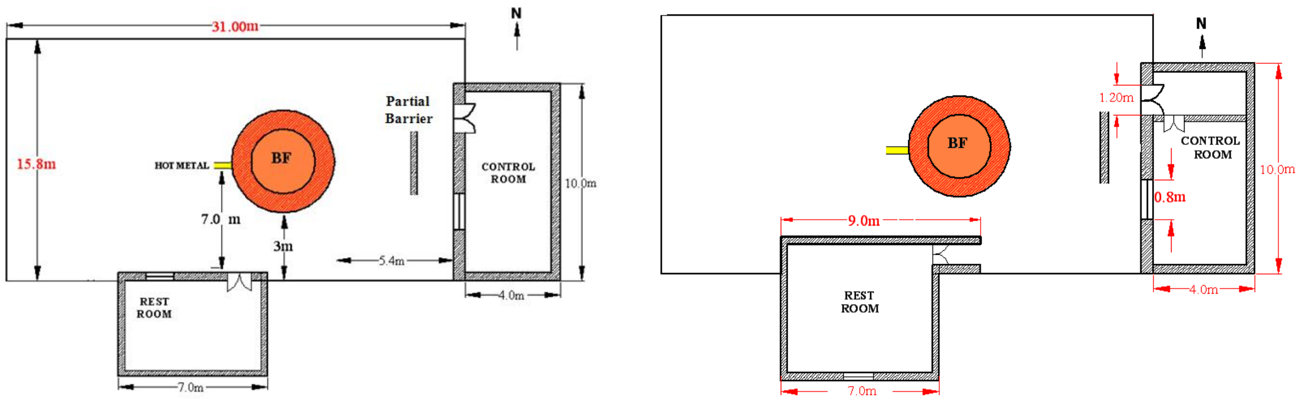

Figure 2: The location of control room and workers' rest room, before (left) and after (right) interventions

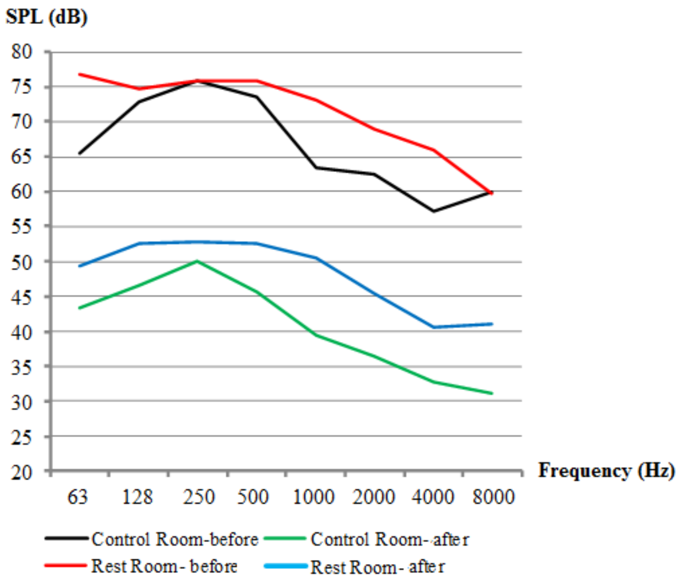

Figure 3: Noise frequency (Hz) analysis in the target rooms before/after interventions

Discussion

Study of noise propagation around the blast furnace showed some locations in the BF had high noise levels exceeded than the recommended limits[2,3]. The BF was main source of the noise pollution related to the furnace equipment. The frequency analysis showed that the noise of the BF was continually in the dominant frequency of 4000 Hz.

Results of noise dose before applying the interventions showed the noise overexposure condition. In this regard, the allowed work time was calculated about 3.38 hours. After applying intervention, the allowed work time was increased to 6.18 hours. This allowed work time to be increased by using of personal hearing protection up to 8 hours in order to cover all time of work shift [2,3]. Golmohammadi et al. showed that noise pollution up to 94 dB (A) and daily mean noise dose about 240% in a petroleum industry. In the mentioned study, the noise enclosure as the best solution was proposed [17].

The passive control method in target rooms were identified as the best intervention methods in the BF unit. The findings of acoustic conditions of target rooms showed that high noise levels are produced due to some imperfections and improper design. Moreover, noise leakage from all the openings area of the doors and windows which were directly exposed to the sound source. In the control room, noise isolation by replacing steel door, using of UPVC double layer vacuumed glass window and adding an internal wall for rotating on entrance could increase noise transmission loss up to 17.1 dB. In rest room, implementation of armed concrete wall and install a steel door for entrance with rotate of 90° could increase noise transmission loss about 23.5 dB. In the current study, the efficiency of noise control interventions was better than the study of Golmohammadi et al. related to designing noise control refinery room with noise transmission loss about 20 dB [18]. Further, Nassiri et al. showed the efficiency of various types of enclosing rooms is about 20 dB in a petroleum industry[19].

Nikola et al. investigated noise controls in an industrial room with local noise sources such as pumps and electric discs in Australia. They proposed the barriers with noise absorbent layers to separate the sources from workers leading to 10 dB decrease in noise levels[20]. However, in the current study, the noise reduction was 27.4 dB and 27.7 dB in rest and control room, respectively. There was only a 2-3 dB difference between the predicted and measured noise levels after applying noise interventions in the studied rooms. After implementing the noise interventions, noise levels in control and rest room was about 52.6 dB and 58.4 dB respectively, this was lower than recommended noise exposure limit.

Conclusions

This study presented effective interventions for noise control in typical noisy industries. Improvement the workroom acoustic conditions through noise insulation can be considered to be effective method for preventing workers exposure to harmful noise. The results confirmed identification of main noise sources is the principle step for effective noise control in workrooms.

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Conflict of interest statement

The authors have no conflict of interests to declare.

References

1. Golmohammadi R, Monazzam MR, Nourollahi M, Momenbellafard S. Assessment and Control Design for Steam Vent Noise in an Oil Refinery. *J Res Health Sci*. 2011;1(11):14-19.
2. American Conference on Governmental Industrial Hygienists. *Thresholds limit values and biological indexes*. New York: *ACGIH*; 2010.
3. Ministry of Health and Medical Education. *Occupational Exposure Limits (OEL).* 3rd ed. Tehran: MHME; 2012.
4. Jafari M, Karimi A, Haghshenas M. Extrapolation of experimental field study to a national occupational noise exposure standard. *Int J Occup Hyg*. 2010;2(2):69-74.
5. Sulkowski WJ, Szymczak W, Kowalska S, Sward MM. Epidemiology of occupational noise-induced hearing loss (ONIHL) in Poland. *Otolaryngologiapol*. 2004;58(1):233-236.
6. Atmaca E, Peker I, Altin A. Industrial Noise and Its Effects on Humans. *Polish J Environ Stud.* 2005;14(6):721-726.
7. Amjad-Sardrudi H, Dormohammadi A, Golmohammadi R, Poorolajal J. Effect of Noise Exposure on Occupational Injuries: A Cross-sectional Study. *J Res Health Sci*. 2012;12(2):101-104.
8. World Health Organization. *Occupational and community noise*. Geneva: WHO; 2001.
9. Marisol CB, Diarmid CL, Kyle St. *Occupational Noise*. Geneva: WHO; 2004.
10. Bell LH, Bell DH. *Industrial Noise Control*. New York: Marcel Dekker Inc; 1994.
11. Golmohammadi R. Noise and Vibration Engineering. 5th ed. Hamadan: Daneshjoo; 2012.
12. Nasiri P, Mehravaran H, Ghosi R. Equivalent sound level measurements and modeling (Leq) A case study in an automotive company. *J Environ Sci Technol*, 2007;9(4):47-56.
13. Kerketta V. Work zone noise levels at Aarti steel plant, Orissa and its attenuation in far field. *J Environ Biol*. 2009;30(5Suppl):903-908.
14. Golmohammadi R, Aliabadi M, Darvishi E. Study of noise pollution in the blast furnace of a steel industry in order to noise control. *J Health Syst Res.* 2014;9(12):262-272.
15. ISO-9612, Guidelines for measurement and assessment of exposure to noise in working environment, International Standard Organization, 1997.
16. Barron RF. *Industrial noise control and acoustics*. New York: Marcel Dekker Inc; 2001.
17. Golmohammadi R, Monazzam MR, Nourollahi M, Nezafat A, Momen Bella Fard S. Evaluation of Noise Propagation Characteristics of Compressors in Tehran Oil Refinery Center and Presenting Control Methods. *J Res Health Sci*. 2010;10(1):22-30.
18. Golmohammadi R, Monazzam MR, Nourollahi M, Nezafat A. Noise Characteristics of Pumps at Tehran's Oil Refinery and Control Module Design. *Pak J Sci Ind Res.* 2009;52(3):167-172.
19. Nassiri P, Zaree M, Golbabaei F. Evaluation of noise pollution in Lavan oil field and determination of source enclosure for noise reduction. *Iran Occupational Health Journal*. 2007;4(3):49-56.
20. Nikola H, Bošnjaković R. The Acoustic Treatment of an Industrial Hall. *Working and Living Environmental Protection*. 2008;5(1):1-10.