Middle-East Journal of Scientific Research 17 (8): 998-1001, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.17.08.8139

Effects of Polystyrene Panels as Sound-Absorbers in the Saw Setting Unit of Saveh Rolling and Profile Mills

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Abstract: Noise is one of the major health issues of industries including metalworking industries. Due to its devastating impacts on the workers' auditory system and other organs, we have decided to design and implement a plan to control and reduce noise in the saw setting unit of Saveh Rolling and Profile Mills. In the present descriptive-analytical research, assessment and measurement of sound was performed according to American Conference of Governmental Industrial Hygienists standard, using a sound lever meter equipped with a CEL-480 analyzer in the A frequency weithing. Sound absorbing panels made of two inch thick EPS were applied to increase the effective absorption level of the saw setting cab placed around Iranian saw setting devices. Results showed that, before applying the changes, the effective level of absorption in the cab was 10.81 Sabin m². After the installation of absorbing panels, the index increased to 18.2. Sound pressure level (91 dB) at a distance of 150 cm from the sound source which was higher than the allowable level was lowered than 83 dB. In conclusions, the results revealed that EPS (expanded polystyrene foam) plays a significant role in increasing the level of sound absorption and noise pollution control in the saw setting units and decreasing the sound pressure level below the allowable limit.

Key words: Noise Pollution · EPS · The Effective Absorption Level · Noise Control

INTRODUCTION

Along with industrial and technological developments and utilization of noise-generating instruments, investigating the effect of noise on job completion, task efficiency, health, loss of hearing, etc has always been the subject of extensive laboratory and field studies. When you need to get the audio signals to perform a task, the sound intensity which prevents hearing or perceiving the alarm, affects the process of task completion. Unfamiliar and intense sounds can cause more disruption and interference with the job such that the occurrence of some incidents could be an indicator of sound effects on the performance. When sound level is high, people make more errors and the probability of accidents increases [1]. Mental activities that require intense memory exercise are noise sensitive and their function is damaged just as attending to number of phenomena simultaneously in complex systems [2]. Although people possess different levels of talents toward sound, when the sound exceeds the allowable level, it brings a certain effect on individuals' performance [3]. Shojaei *et al.* measured the industrial productivity among the workers who are exposed to noise. They indicated that the productivity of workers who used protective earpieces was 12% more than others [4].

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Individuals' occupational performance suffers from sound effects [5]. The National Institute for Occupational Safety and Health and (NIOSH) stated that nearly two hundred million workers in the United States of America have been damaged from noise-induced hearing loss (NHL). NIOSH's surveys demonstrated that 14% of workers are employed in environments where noise levels exceed 90 dB [6]. Labor and social security laws of Islamic Republic of Iran support environmental monitoring and control over pathogens and hazardous factors. Articles 95, 92 and 85 of the Labor Act and 88 and 96 of the Social Security Act directly and indirectly manifest and provide subsidies for such support [7].

Noise control is performed to control its harmful effects, provide workers with safety and include technical, management, education and information control [8]. The presence of reflective surfaces in workshops, surrounding the sound source makes sound pressure level rise due to repeated reflection of sound; sound absorbers can greatly control this phenomenon [9]. Layered or panel absorbers have the most straight forward application for absorbing low frequencies. Leaky structures are suitable at high frequencies and encapsulated absorbents are used for sound absorption at a narrow range of frequency bands [10]. Layered absorbers contain a layer of lightweight material with low density and possibly a porous structure [6]. Multiply board, particleboard, polyurethane (Yonolit) and porous absorber plates are among the absorbers of this group. Today composite materials, which have appropriate absorption levels and are made of mineral and organic fibers, are also extensively applied [11-13]. Absorbent walls can be used in various forms such as coating the main structure of the building from the inside with a layer of absorbent material that effectively prevent sound reflection and approximate the diffusion of sound to the diffusion in a free field [14]. Polystyrene is one of the most widely used materials in the polymer industry which due to economy and health has many consumers. Lightness, resistance against mechanical impacts, cheapness, convenient transportation, permeability to gases and vapors, impermeable to moisture, good pressure strength and its many other features which can justify the use of these materials can be mentioned [5].

Shojaei *et al*. [4] employed a combination of sound barriers and absorbers to control the noise in lounge smooth body lines of Iran Khodro Company which had announced the sound pressure levels of about 105-100 dB. In another case, Alamdari and colleagues [5] initiated to manufacture sound absorbers based on combined recycling of polyethylene trephetalat and polystyrene at low and median frequencies.

Saveh Rolling and Profile Mills were established and exploited in 1975 with the purpose of producing steel tubes and profiles [15]. In this factory, saw blades which have broken teeth or being blunted are referred to the saw setting units in order to be re-sharpened. Blunted blades are installed on the saw sharpener machine to be re-sharpened in a specified time period and be ready to use. Saws make a loud noise due to the impact of the sharpener stone on the saw blades. Focusing on Iranian saw setting machines, the present study attempted to measure the effect of Yonolit as a sound absorbent material when installed on the sound barrier walls of the saw setting cab in order to assess the simultaneous use of sound barriers and absorbers.

MATERIALS AND METHODS

The present study was a descriptive-analytical one. Measurement and assessment of noise in the saw setting units was performed according to American Conference of Governmental Industrial Hygienists (ACGIH) standard [16], using a sound lever meter equipped with a CEL-480 analyzer in the A frequency weithing. For calibration, the CEL-282 calibrator was applied, performing the calibration 1000HZ and 114 dB. There were 5 devices in the saw setting unit. Three of them are soapy or Italian types with full cover which partly prevents the transmission of sound as well and the other two devices known by the Iranian brands are not shielded. A room is built around them, using metal and glass (the lower part of the cab is made of steel and the upper part of glass). Before installing Yonolit panel within the distance of 1.5 m from the barrier (cab), the sound was measured and analyzed. After installing Yonolit panels, the measurement and analysis were performed in the same place.

To increase the effective absorption level of the saw setting cab which is placed around Iranian saw setting, sound absorbing plates, made of two-inch thick EPS with 1.04-1.09 g/mm density, were used.

The cab area was $6\ m^2$ (3×2) height of walls, 250 cm (the height of steel plates was 130 cm and the height of glass sheets were 120 cm), the absorption coefficient of steel plates was 0.02, glass absorption coefficient was 0.775 and absorption coefficient of 2-inch Yonolit was 0.545. To determine the effective absorption, the R = S.α relation was applied where R is the effective absorption (Sabine m^2), S, the total area of the inner surface of the cab (m^2) and α, the mean sound absorption coefficient of the interior surfaces of the cab which is between zero and one.

RESULTS

Sound pressure level in the saw setting unit at a distance of 150 cm, before the installation of Styrofoam panels was 91 dB (Table 1) which is higher than the allowable limit.

Table 1: The results of sound analysis before and after the installation of EPS sound-absorbing panels

Sound pressure levels before and after the installation of sound-absorbing panels (dB)		
After the installation	Before the installation	The central one-third octave frequency
81.7	91.6	125
80.9	90.3	250
82.8	92.7	500
78.0	86.7	1000
77.0	85.0	2000
82.5	87.5	4000

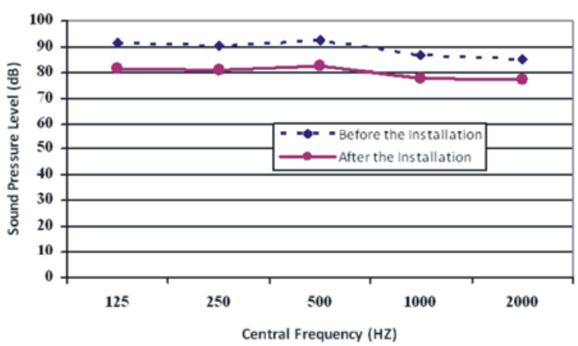

Fig. 1: Sound pressure level at central frequency before and after the installation of EPS absorbers

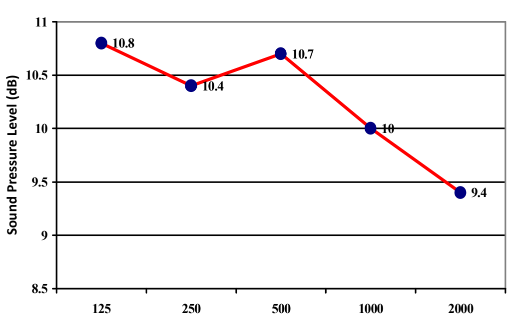

Fig. 2: Reduction percent of sound pressure level based on central frequency after installation of ESP absorbers

After the installation of Styrofoam panels, as absorbent panels, the sound pressure level was re-measured from the distance of 1.5 m which showed 83dB level. Therefore, the sound pressure level was reduced by 8 dB.

The effective absorption level before the installation of EPS (Styrofoam panels) was

$$R = S.\alpha = 2.08 + 3.21 + 2.08 + 0.2334 + 0.12 + 0.09 = 10.81;$$

and after the installation of the absorbers

$$R = S.\alpha = 6.1 + 5.3511 + 6.1 + 3.234 + 3.42 + 0.09 = 18.2$$

This demonstrated an increase of about 1.7 times.

Sound pressure level at central frequency before and after the installation of EPS absorbers has been showed in Fig. 1 and also reduction percent of sound pressure level based on central frequency after installation of ESP absorbers determine the reduction based on central frequency (Fig. 2)

The sound pressure level before installing the absorber, when only the sound barrier exists was 91.6 dB. However, after the installation of absorber on the existed barrier, it reached 83 dB. Consequently, an 8.6 dB noise reduction is obtained. Thus, the overall transmission loss equals: $TL^1 = 8.6$ dB.

DISCUSSION

The results revealed that after the installation of sound absorbent panels, the sound pressure level in the saw setting unit reached lower than the allowable limit of ACGIH and Iranian National Committee for Occupational Health. Based on the proposed plan, according to conducted calculations, the absorption level of walls is increased approximately 1.7 times through changing the materials and using the above mentioned composite. Basically, we can predict that the reflected sound in the space between the partitions was reduced 10.5 dB on average within 125-4000 Hz, which is due to the absorption of sound reflections by absorbent panels. The results are consistent with Shojaei and colleagues' study [4] when they mentioned that the simultaneous apply of the combination of absorbers and barriers increases the effective absorption level and consequently reduces sound reflections induced from the impacts of sound with sidewalls. In addition, Alamdari *et al*. [5] came to the same conclusions when manufacturing sound absorber based on combined recycling of polyethylene trephetalat and polystyrene at 125-1000 frequencies.

Sobrala, *et al*. [17] investigated the manufacturing of sound absorbers on the basis of granules out of milling timeworn tires in Portugal and indicated that at the one-third octave frequencies the absorption rate of manufactures sound absorbents decreases by 20%. Liu *et al*. [18] successfully used dominant sound absorbers in the aircraft cabin to control noise and vibration.

Given the numerous flaws of materials such as stone wool, health problems, allergies and physiological effects and regarding the appropriate absorption coefficient of polymer absorbers at some frequencies, utilizing polymer-based materials prevents many job-induced diseases. Moreover, since such absorbers are cost-effective in terms of economy and manufacturing [5], they can play a crucial role in the noise absorption and control in industrial environments.

It is, therefore, suggested that combined walls (absorber-barrier) are created to reduce sound reflections to avoid the transmission of sound in workshops to elsewhere. This is theoretically one of the methods of noise control in the diffusion path.

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