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Evaluation of noise reduction in a cigarette factory, China

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Millions of workers are exposed to occupational noise that increases their risk of hearing impairment and evidence on the effectiveness of precaution is lacking. This study was undertaken to assess the effect of noise control strategy in a cigarette factory in China. We chose the representative points in the unit, monitored the noise level and analyzed frequency spectrum at the same workplace before and after sound absorbing panels installation on the ceiling and walls. Results showed that the sound pressure levels were dropped from 81.3 dB(A) to 74.8 dB(A) and reduced by 6.5 dB(A) on average. Installation of the panels had a dramatic effect. From the frequency spectrum analysis, the noise was broadband and evenly disturbed. The frequency (1000, 2000Hz) noise was sharply attenuated, which was in consistent with materials' characteristics. We eagerly recommend it as a successful example in other cigarette factories.

Key words: Sound absorbing panel, noise control, evaluation, cigarette factory.

INTRODUCTION

Cigarette smoking is one of the most common habits in the world, especially in China. It has 320 million smokers which constitute one third of the world's total smokers (Liyuan et al., 2013). As one of the largest tobacco-producing countries, tobacco industry plays an irreplaceable role in its national economy. However, with the prosperity of modern industry, noise becomes the most serious hazardous factor at workplace. Worldwide, the industrial noise levels are higher in the developing regions than those in the developed regions (Nelson et al., 2005). It is the third major contemporary world pollution, which ranks after the atmospheric pollution and water pollution (Li, 2012).

Generally speaking, noise is defined as annoying and unwanted sound. It is stemmed by machinery and equipment used in factory, the filter tip shaping machines account for large amounts of noise and it is a necessary by-product of the desired action. Prolonged exposure to noise may present significant damage for workers and those in the surroundings. In the work environment, the disturbing sounds not only affect the hearing of employees but also have physiological and psychological implications (Passchier-Vermeer and Passchier, 2000; Sliwinska-Kowalska and Davis, 2012). Noise-induced hearing loss is one of the most common of all industrial diseases (Tak and Calvert, 2008). Chronic exposure to excessive noise can cause decreased hearing and auditory fatigue. What's worse, it leads to a change from temporary threshold shift to permanent threshold shift with the result of hearing impairment. Severe cases can cause noise-induced deafness. Although hearing loss is permanent and irreversible, it is preventable. Occupational hearing loss depends not only on intensity, exposure time, frequency, but also on type of noise and individual susceptibility (Doko-Jelinić et al., 2009). Shield the noise source, cut off the route of transmission, protect the susceptible population, can all reduce noise level.

In addition to auditory system specificity damage,

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exposure to noise also contributes to cardiovascular disease, psychiatric disorder, endocrine disorder, social behavior and performance non-auditory effects (Stansfeld and Matheson, 2003). Therefore, noise has systemic effects. Studies indicate noise-induced hearing loss may be associated with the chance for development of hypertension (Chang et al., 2011; Nawaz and Hasnain, 2010). Van Kempen et al. (2002) present a very nice meta-analysis of literature on noise exposure and blood pressure and ischemic heart disease, which is consistent with a slight increase of cardiovascular disease risk in populations exposed to environmental noise. Continuous exposure to occupational noise is strongly related with the prevalence of coronary heart disease (Gan et al., 2011). Some epidemiological studies have also suggested that chronic noise exposure may result in neurasthenic syndrome, such as headache, dizziness, insomnia, and memory loss.

Most of the researches focus on administrative controls, that is, on changing the behavior of workers rather than changing the noise in a permanent way. Yet little is known about the effective of this intervention (Verbeek et al., 2012). Few cigarette factory noise control studies are reported in the literature. However whether installation of absorbing materials is an effective way of reducing occupational noise remains unclear. In this study, we try to install sound absorbing materials on the ceiling and walls in a cigarette filter tip shaping room for the first time. Meanwhile we monitor the noise level and frequency spectrum in the workplace before and after noise control strategy.

MATERIALS AND METHODS

Noise control strategy

The filter tip shaping workshop mainly produces cigarette filters. It is from north to south, with a volume of 114×30×4.2 m^3. The north is sealed glass windows, and the remaining three sides are covered with concrete walls. Walls, floors and ceilings in the unit are general for factory. They are hard surface designed for durability and there is no obvious sound absorbing effect. The unit is located 14 sets of filter tip shaping machine aligned in parallel with 6 m space. Each machine with a length of 17 m is operated by 1 or 2 staff in turn who work 8 h shifts.

Taking into account, mechanical noise could not be controlled very well; we believed that the best approach to control the noise was to install sound absorbing materials. As a pilot study, we chose the Ecophon acoustic panels both on ceiling and walls. The Ecophon acoustic panels had two important features. On one hand it had good high frequency sound absorbing effect, on the other hand the surface covered with Akutex FT coating had stain-resistant and dustproof function. In this study, noise reduction project was in two parts, that is, the ceiling and walls. Figure 1 shows the effect of sound absorbing panels installed on the ceiling and walls. Master Solo S was hanged horizontally on the ceiling (1714 m^2). However, given the ventilation and lighting system, it was impossible to install horizontal panels. We chose the Master Baffle, that is, the vertical ceiling (318 m^2). In order to withstand the strong impact, the walls were embedded with Super G (903 m^2) except when met with doors or signaling devices.

Measurements

We chose the evenly distributed seven production lines and each production line testing three points (21 points in total). The three points (east, west and central) were along with the production line. In order to prevent any kind of reflection of sound, the east and west points were in pedestrian corridor centerline 2.0 m away from walls. And the central point was in the operating position 1.0 m away from the machine.

AWA6270+A noise meter (calibrated by Hunan institute of metrology and test) was used for objective measurement of the existing sound pressure level and frequency spectrum analysis. When all the machines were running normally, the noise level was horizontally tested at 1.5 m above floor and 1.0 m away from the conductor. Each point measured three times, and finally took the average. Then we opted the strongest point for frequency spectrum analysis. After sounding absorbing panel installation, we once again measured the noise intensity and frequency spectrum at the same workplace.

Statistical methods

Noise level statistical analyses were performed with Statistical Package for Social Science (SPSS) 13.0. And paired t test was applied to evaluate differences between the measurements before and after the workshop was treated with sound absorbing panels. The level of $P < 0.05$ was considered statistically significant.

RESULTS

Noise levels before and after panel addition

Workplace noise intensity was measured at 7 filter tip shaping machines 21 points. Table 1 showed the result of test before and after sound absorbing materials installation on the ceiling and walls. The sound pressure levels were attenuated after installation of sound absorbing panels. It could drop 6.5 dB(A) on average and 10.0 dB(A) at most. So it could reduce the intensity of sound by 8.0%. Significant differences were found before and after treatment ($t=14.606$, $P=0.000<0.05$). Therefore, the sound absorbing panels could dramatically reduce noise levels and provide sound reduction.

Frequency spectrum analysis of CX5 central before and after panel addition

Based on the analysis of frequency spectrum (Table 2 and Figure 2), acoustic noise was broadband and evenly distributed, peaking at frequency 500 Hz. After installation of sound absorbing materials, the sound pressure level of each frequency was lowered and the noise was reduced at most 9.3 dB(A). The high frequency noise (1000, 2000Hz) was decreased more sharply than low frequency noise. By comparison of these two groups of data, significant differences were found ($t=7.878$, $P=0.000<0.05$). Therefore, the sound absorbing panels prove to be true and could provide sound absorption as expected.

Figure 1. Ecophon acoustic panels installed on the ceiling and walls.

Table 1. Noise reduction before and after treatment (dB(A)).

Test location	Before treatment	After treatment	Reduction
CX1 east	77.8	70.2	7.6
CX1 central	81.5	78.8	2.7
CX1 west	80.5	76.8	3.7
CX2 east	77.7	69.3	8.4
CX2 central	83.5	79.7	3.8
CX2 west	80.6	75.6	5.0
CX3 east	76.9	69.7	7.2
CX3 central	81.7	78.6	3.1
CX3 west	79.5	73.3	6.2
CX4 east	81.8	71.8	10.0
CX4 central	84.5	77.5	7.0
CX4 west	83.4	73.8	9.6
CX5 east	82.0	73.5	8.5
CX5 central	86.2	79.7	6.5
CX5 west	83.7	76.1	7.6
CX6 east	81.0	74.3	6.7
CX6 central	80.7	74.7	6.0
CX6 west	81.9	76.8	5.1
CX7 east	79.6	71.4	8.2
CX7 central	80.5	74.8	5.7
CX7 west	81.7	74.6	7.1
Average	81.3	74.8	6.5

DISCUSSION

Due to the machinery used, noise in cigarette factories is obviously a prominent problem. Even though there are several methods to reduce or control the noise transmitted to the workers and the most effective of these is the engineering controls; that is, remove the noise at the source. However, applying this technique is relatively expensive and may not always be feasible or practical or may be insufficient to reduce noise to an acceptable level

Table 2. Spectrum analysis before and after treatment (dB(A)).

Center frequency (Hz)	Before treatment	After treatment	Reduction
125	80.5	77.5	3.0
250	86.9	81.5	5.4
500	88.7	82.2	6.5
1000	85.6	76.3	9.3
2000	83.4	74.4	9.0
4000	81.2	73.7	7.5
8000	78.1	72.6	5.5

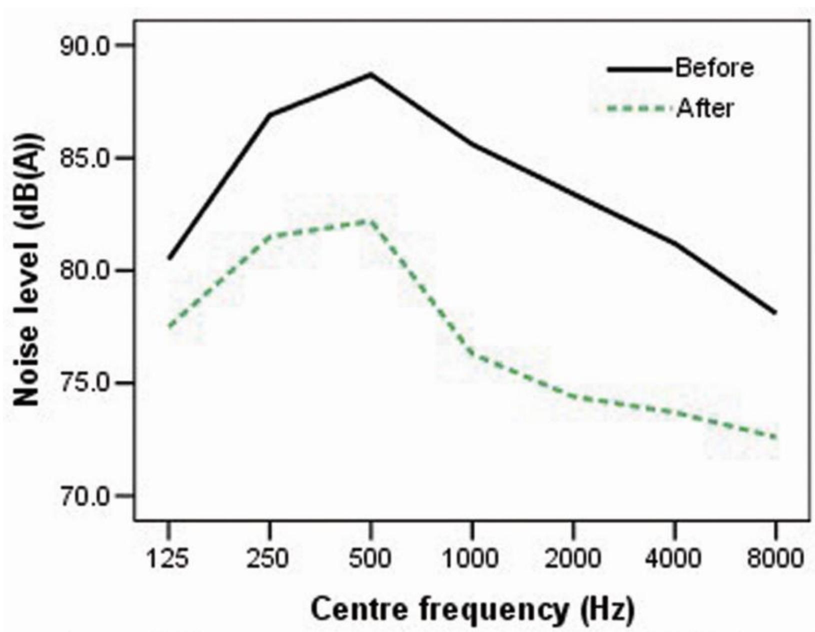

Figure 2. Frequency spectrum analysis of CX5 central.

(Lusk et al., 2003; Sahin, 2003). Hearing protection devices are known to be very effective, but they have two major problems: the inability to communicate and discomfort (Davis, 2008; Reddy et al., 2012). Therefore, most of the workers do not properly use these protective measures. In every effort to reduce the workshop noise, this study proposes an approach that add sound absorbing panels on ceiling and walls to attenuate noise transmission.

Prior to the noise treatment implementation, the maximum noise point (CX5 central) was 86.3 dB(A) which exceeded the International Labor Organization (ILO) recommended level in workplace. After treatment, the noise level dropped from 81.3 dB(A) to 74.8 dB(A) on average. And this was similar with the study (MacLeod et al., 2007) carried out in hospital. The different cavity depth, different arrangement type and its application may account for the difference. Thus one may be possible to gain even greater noise reduction than achieved in this study (6.5 dB(A)). As a qualitative and exploratory study, when the engineering and administrative controls are not feasible we strongly recommend it as an example for others to copy in noise reduction in cigarette factories.

Although the sound absorbing panels are proved to reduce noise to a relatively safe level, we should always pay attention to the chronic low level noise exposure on workers and protect their health. The effective method is occupational health examination once a year. With annual health examination, it is possible to detect a slight change before significant clinical symptoms appear.

Conclusion

Our findings indicate that the sound absorbing panels had a dramatic effect. Through the frequency spectrum analysis, the noise in the cigarette factory was broadband and evenly disturbed. And the frequency (1000, 2000Hz) noise was sharply attenuated, which was in consistent with materials' characteristics.

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