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An Introduction to Sound Spectrum Level: Spectrum Analysis

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Abstract: Noise is recognized as an occupational pathogen with physical origin being studied from different types each of which has its own advantages. Since few studies have been conducted on some types of these studies, such as spectrum centroid level, the objective of this study is to provide the ground for scientific and industrial communities to promote knowledge development in this regard. For the purpose of the present study we divided Bakhtar Felez Profile and Tank Construction factory to 90 sound stations with area of 3×3 m^2. Frequency analysis is carried out with one-third octave analyzer in active stations. In the third step, we facilitated comparison of risk exposure possibility at each station through assessing spectrum centroid level and statistical analysis. The obtained data are analyzed using SPSS software (version 21). The number of active station is less than half indicating congestion of workload. Stations with high sound sound spectrum level are situated at places with bass or law audio frequency level which needs a great concern. Research findings represent a significant inverse correlation ($r = -0.54$, $p<0.001$) between spectrum centroid level and frequencies. Comparison of spectrum centroid level based on classification of frequencies is indicative of significant differences at sound spectrum levels under/over 512 and 2048. But there is no significant difference between spectrum centroid levels divided based on frequency classification or being under or over standard level. Although, in some stations, spectrum centroid level is much higher than standard level and located in places of bass and mid frequencies, sound spectrum level average is 69.42 dB which is less than standard level.

Key words: Noise · Frequency analysis · Bakhtar Felez · Sound spectrum level

INTRODUCTION

Noise is recognized as an occupational pathogen attracting scholars attention, especially after the industrial revolution and being studied from different angles including the objections of practitioners exposed to it. Nowadays, practitioners' knowledge of health problems has increased which also leads to increased complaints in this area. Consequently, professional health experts should focus on these complaints to have a fair scientific judgment based on observed facts enabling them to protect the public while answering their questions. Among actions that are usually taken in respond to practitioners complaint about noise are calculation, measurement and comparison of sound pressure level at stations where worker are working temporary or permanently. In this case, an area of sound station is determined based on several factors. Then, sound pressure level of the station is measured. The obtained data can be used for the intended purposes.

There are different ways of noise measurement in sound stations. The most common form is to measure sound pressure level, regardless of sound frequency, using sound level meter calibrate at a frequency of 1000

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Hz at sound station. Therefore, it would be difficult to compare sound stations and give fair judgment of workplace of practitioners of different stations.

Another way of noise measurement is based on sound frequency to analyze the noise which is made possible using sound analyzer. In this case, sound pressure level is measured based on sound frequency. This method owns many advantages and its judgments of sound stations of practitioners are more reliable and scientific than the first one. Yet, judging and comparison it not 100% true since comparing sound pressure level is possible only if there are different frequencies.

Mansoori *et al.* [1] performed a study grounded on railway noise in urban areas of Tehran. After analyzing noises heard in moving or stopped wagons, they realized that there is no significant difference between average sound pressure level at different frequencies depending on wagon status, either in motion or motionless ($p = 0.5$). But there was found a significant difference between average sound pressure level of motion and motionless cabins at 250 and 500 Hz ($P<0.01$). While, analyzing noise pollution at Malayer's stonemasonry and its induced hearing loss, Golmohammadi *et al.* [2] concluded that sound pressure level of granite workshop centers is 4000 Hz whereas the highest frequency level of non-granite workshops is 125 Hz.

In another study performed by Nixon *et al.* [3] (1961) on noise-induced permanent threshold shift (nipts) happens to practitioners after 10 years and 8 hour a day, they find out that those who are exposed to 2000 and 4000 Hz frequency would be affected Hay and Abel [4] analyzed one-third octave noise bands to localize industrial sound signals and sound effects on hearing loss and witnessed 100 dB mild and sever hearing loss happens at 1000 Hz.

The highest and lowest sound pressure level witnessed in an octave band analysis of a bank of transformers located near an electrical power station were 125 Hz and 8000 Hz, respectively [5]. Another one-third octave band analysis in the same center indicated that the highest and the lowest sound pressure level appears at 120 Hz (90 dB) and 10000 Hz (54 dB), respectively. In another frequency analysis performed in a factory producing refrigerator compressor it was shown that the maximum sound pressure level is 83 dB at 40 Hz while the minimum limit is 40 dc at 1000 Hz [5]. A food packing factory was investigated in another study in which the maximum sound pressure level of one of the sound stations was 93 dB at 270 Hz and the lowest measure level was 70 dB at 1000 Hz [5].

Another way is to measure, calculate, measure and compare sound spectrum level. In doing so, after analyzing frequency and measuring its sound pressure, the obtained information should be given to system called spectrometer. The system assimilates the obtained data and compares the sound pressure levels of sound stations based on audio bands. The system creates a uniformed data basis to facilitate making a comparison.

Taking into account the previous studies, no step is taken beyond frequency analysis and measurement of sound pressure level, so there is a lack of evidence on sound spectrum level measurements. Therefore, the third method of analysis, noise calculation and measurement, is of more concern since it is a comprehensive method. Thus, the researchers in this study are to analyze and calculate sound spectrum level of sound stations of Bakhtar Felez industrial factory, located at Kermanshah, hoping that it can help health experts to move a step forward.

In this factory, rolls of steel sheet, after undergoing various mechanical operations, are converted to different types of metal plate and six meter long metal profiles to be used in door and window manufacturing industry, heater wall, water storage tanks, mazut and other fossil fuels compositions to prepare needed industrial products for the manufacturer.

This industrial unit performs various mechanical operations using tools and machines like Gantry crane, guillotine, variety of fans, plasma cutters, pressing, rolling, milling and drilling. These machines facilitate transportation, cutting, bending, shaping, welding and grinding metal sheets. These operations produce lots of raspy and annoying noises which may impose acute and chronic complications upon those who are exposed to it. These people are more or less endangered by accident and hazards that may happen at the workplace.

One of the serious threats is the noise produced in profile and tank making halls in which not only raw materials are kept but also rolls of steel are shaped and converted to desired products. Therefore, at most of the sound stations, the sound pressure level is higher than the standard which is due to inappropriate distribution of raw materials, devices and products in the halls. Thus, sound pressure distribution is not even in this hall; some sound stations are under and some other are over the standard recommended level (I.S.O).

MATERIALS AND METHODS

In this study a profile and tank making hall with dimensions of 18×45 m^2 is divided to 90 sound stations with dimensions of 3×3 m^2. Then using a calibrated one third octave band analyzer (Cel 450) we analyzed noises produced in these stations following American Conference of Governmental Industrial Hygienists (ACGIH) instruction in the A selected network. 5 minute is considered for each active station to do the instruction and operations. Sound pressure level is measured based on the central frequency (f_c) filtered by one-third octave analyzer. The device is located at the height of 80 cm from the earth in the center of the stations. A microphone or a voice recorder is also devised on the device in the same direction for every station to record and measure central frequencies. Considering the central frequency and the filter type used in the analyzer, audio bandwidth of all stations can be calculated using the following formula:

$$\Delta f = f_c \times \left(2^{\frac{k}{2}} - 2^{-\frac{k}{2}}\right)$$

Where Δf represents bandwidth, f_c is the central frequency, k is octave or the filter size.

After calculating sound stations bandwidth filtered by one-third octave analyzer, spectrum frequency of each sound station can be calculated using the following equation:

$$S(f) = spli - 10 \times \log \Delta f$$

Where the parameters are spectrum frequency S(f) and sound pressure level (Spli) calculated based on the central frequency of the bands.

RESULTS

Dispersion diagram of the frequency based sound spectrum level indicates a significant negative correlation ($r = -0.54$, $p < 0.001$) between the two parameters which is can be seen clearly in the following Fig. 1.

It should be noted that the correlation is also significant when different sound spectrum levels (less/more than 85 dB A) and frequencies are considered ((P-value=0.035) (Table 1). Comparing sound spectrum levels based on classification of frequencies using ANOVA test shows that there is a more significant difference between two sound spectrum levels that is less than 512 and 2048 (p- value=0.003).

Classification of sound spectrum level based on standard level and classification of frequencies for the comparison purposes showed no significant relationship among sound spectrum levels (P-Value=0.05) (Table 2).

Table 1: Sound spectrum level distribution based on classification of frequencies

	Sound spectrum level (dBA)						
	< 85		≥ 85		Total		Sound spectrum level
Frequency	N	%	N	%	N	%	Mean ± sd
< 512	16	76.2	5	23.8	21	45.7	74.4 ± 11.8
512 – 2048	16	100	0	0	16	34.8	68.3 ± 9.6
≥ 2048	9	100	0	0	9	19.6	59.9 ± 14.6
Total	41	89.1	5	10.9	46	100	69.4 ± 12.7

Table 2: Sound spectrum level distribution based on classification of frequencies

	Sound spectrum level (dBA)							
	< 60		60 - 80		≥ 80		Total	
Frequency	N	%	N	%	N	%	N	%
< 512	2	9.5	11	52.4	8	38.1	21	45.7
512 – 2048	4	25	11	68.8	1	6.3	16	34.8
≥ 2048	4	44.4	4	44.4	1	11.1	9	19.6
Total	10	21.7	26	56.5	10	21.7	46	100

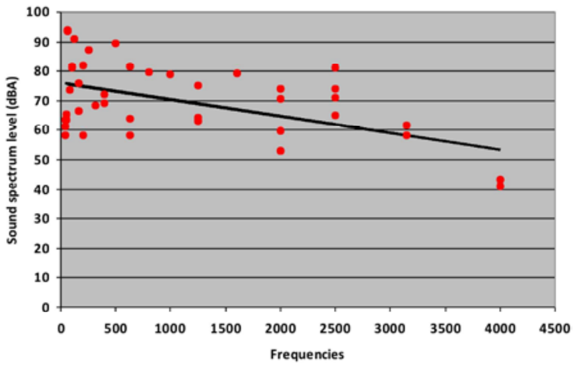

Fig. 1: Frequency based dispersion of sound spectrum level.

DISCUSSION

Sound spectrum level of 89.1% of measured sound station was more than 85 dBA. Classification of stations according to bass, mid and high frequencies indicated that 45.7% of produced noises have bass, 34.8% have mid and 19.6% have high frequencies which means disparity of sound stations in the selected industrial unit. As shown, disparity plays an important role on distribution of sound spectrum level of the stations. With regard to the fact that bass waves have longer wavelength, treble wave are more influencing and mid waves (despite having the characteristics of the two other groups) are the least destructive waves, it is easier to make a comparison and devise more scientific controlling measurements. The average central frequency measured by one-third octave band analyzer was 1175.78 Hz and the standard deviation equals 1209.59. Therefore, it is observed that audio frequency of the measured stations is moderate. The average sound spectrum level is near to standard level (69.42 dB). As a result, it may be concluded that based on the sound spectrum level, sound pressure level of the audio units at this industrial unit is nearly standard.

CONCLUSION

Given the obtained sound pressure level based upon bandwidth and spectrum frequency, comparing the sound station is easier. Now, we can give definitely scientific judgments about sound damages at this unit. Considering the sound analysis carried out in this study, we can more readily answer to questions posed on this ground.

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