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Original Article

Assessment and Control Design for Steam Vent Noise in an Oil Refinery

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ABSTRACT

Background: Noise is one of the most important harmful agents in work environment. Noise pollution in oil refinery industries is related to workers' health. This study aimed to determine the overall noise pollution of an oil refinery operation and its frequency analysis to determine the control plan for a vent noise in these industries.

Methods: This experimental study performed in control unit of Tehran Oil Refinery in 2008. To determine the noise distributions, environmental noise measurements were carried out by lattice method according to basic information and technical process. The sound pressure level and frequency distribution was measured for each study sources subject separately was performed individually. According to the vent's specification, the measured steam noise characteristics reviewed and compared to the theoretical results of steam noise estimation. Eventually, a double expansion muffler was designed. Data analysis and graphical design were carried out using Excel software.

Results: The results of environmental noise measurements indicated that the level of sound pressure was above the national permitted level (85 dB (A)). The Mean level of sound pressure of the studied steam jet was 90.3 dB (L). The results of noise frequency analysis for the steam vents showed that the dominant frequency was 4000 Hz. To obtain 17 dB noise reductions, a double chamber aluminum muffler with 500 mm length and 200 mm diameter consisting pipe drilled was designed.

Conclusion: The characteristics of steam vent noise were separated from other sources, a double expansion muffler was designed using a new method based on the level of steam noise, and principle sound frequency, a double expansion muffler was designed.

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Introduction

Noise pollution is one of the important harmful physical agents in industrial environments. From industrial viewpoint, the existing noise and vibration in sets is related to their poor performance or amortization. Most part of energy in equipment malfunction is wasted and emitted by noise and vibration. Beside waste of energy, set amortization and their noise pollution could make several physical complications [1,2]. According to prediction of Sulkowski, more than 35 million workers are exposed to excessive noise (more than 85 dB) in Europe where only in Poland, with 5 million workers; 650 thousand workers are exposed to hearing loss risks [3]. The statistics of those industries with more than 10 workers (in 1999) has shown that 15% of working places have noise pollution problems and 20% of workers were exposed to harmful level of noise [2]. The noise exposure problem in workers of oil industries is pervasive [4]. The results of sound pressure level around Tehran Oil Refinery Center indicated that the sound pressure level due to different sources was from 84.4 to 91.7 dB (A) and the Crest Factor was between 13.7 and 16.7 dB (A) [5, 6]. A part of such noise in the studied oil fields is related to the point sources such as steam vents.

The high-pressure fluid discharges from vents and ducts as well as industrial systems exhaust are considered as one of the significant noise sources, because of their nature and characteristics. Different studies were conducted to investigate the high pressure fluid discharges in Iran and other countries. The noise control of pneumatic hammer in car industry was evaluated in 1990 [7]. By installing a muffler sound made of steel in the device, a 15 dB reduction in the sound level was obtained. Furthermore, in another study, a module in the air outlet was applied to estimate a 20 dB reduction in the sound level [8]. Another study showed that a micro pore muffler, consisted of a pipe drilled with many holes could damp the noise emission [9]. Moreover, Min stated that a 40 dB noise reduction could be reached by using multi-chamber perforated muffler [10]. Results of controlling noise of air filtration system in broadband revealed that the noise reduction of a muffler with 800 mm diameter composed of an absorptive aluminum could achieve 14 dB [11].

Based on Tehran Oil Refinery demand, the present research was performed to investigate and present a noise control plan in one of its units. It is known that the noise point sources such as steam vent are important noise propagation sources in industrial areas which can make several complaints in such environments. The main objective of the present study was to determine the level of noise pollution level, frequency analysis, and to estimate dominant noise frequency of steam vent and to present a noise control solution in a unit of Tehran Oil Refinery.

Methods

This study was performed in control unit of Tehran Oil Refinery in 2008. Control unit was organized in three parts including: a) distillation subunit involving atmospheric distillation and vacuum distillation, b) viscous abatement subunit, and c) liquid gas production subunit. In this unit, furnace and steam vent were the main sources of noise propagation.

In this experimental study, basic data such as plans, steam vent place, and their characteristics like steam pressure, steam vent dimensions and some other technical data were collected by cooperating with HSE department of Tehran Oil Refinery Center. At the next stage, the environmental sound parameters, firstly in large meshes and then in small meshes, were performed around the considered source according to lattice method. At the third stage, in order to determine the dominant frequency of each set, it was necessary to measure the sound pressure level of each set individually (furnaces and steam vents) was measured. The common method for measurement of noise sources is sound pressure level difference technique; where there is need to turn off some sources. However, it was not possible to silent the sources simultaneously. Thus, a new method was used to separate the various sources of sound. The noise propagation measurement and frequency analysis led to determine the dominant frequency of steam noise. In this method, 10 measurement points with short distances (below 0.5 meter) were chosen separately at three various paths between the steam vent and other sets in order to measure the level of sound pressure variation and dominant frequency. In the fourth stage, technical information of steam vent such as vent type, pressure, diameter and dominant frequency of the device were assigned by the theoretical method. Then it was compared with the results of field measurements. The TES-1385 sound level meter was used for all measurements. It was calibrated based on the standard method [12, 13] in work place at frequency of 1000 Hz and sound pressure level of 94 dB [1-2, 14-15]. The area measurement results have shown that the sound pressure level is higher than the permitted level (85 dB (A)) for workplaces [16-17].

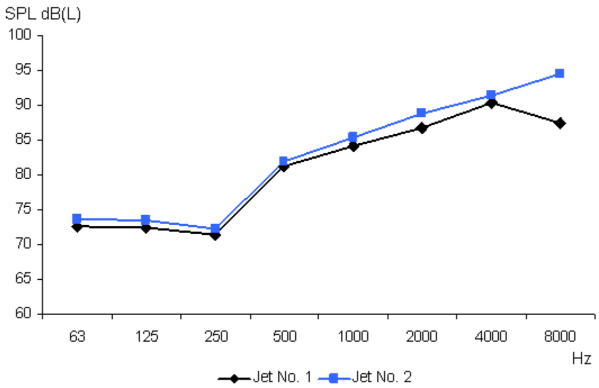

Figure 1: Sound pressure level in the frequencies octave band center close to steam vent

In the final stage, based on previous researches [6-10] and scientific principles [1-2, 14-15] a double expansion muffler with the desired abilities was designed relying upon measurement results and data analysis when technical control for jet noise with acoustic module design methods was achieved. Data analysis and graphical design were carried out using Excel software.

To confirm the results, frequency analysis of steam vent were performed near the steam vent (Figure 1). It was shown that the level of sound pressure were about 93 dB (L) and 4000-8000Hz close to steam vent and the dominant frequency respectively. As in this innovative method, the background noise was considered in this innovative method. However, it was necessary to compare the results with other methods. The dominant frequency range of steam vent with consideration of the technical details was estimated by the following method of Barron [14]:

$$f_p = \frac{C}{5D}$$

where f_p is the exhaust dominant frequency (Hz), C and D are the velocity of sound wave in air (m/s) and the exhaust diameter (m) respectively.

Based on the above equation, the dominant frequency of steam vent was 5912 Hz. If we compare the result of net method, innovative method and computational method, a harmony can be observed where the dominant frequency is in the range of 4000 Hz (in one octave band noise frequency analysis) and the level of sound pressure adjacent to vent was 94 dB (L).

After our primary survey and noise technical control at steam vent, an appropriate strategy for technical control of expansion muffler was assembled. Considering the characteristics of process, humidity, exhaust pressure, steam temperature and other factors, the possible plans were reviewed.

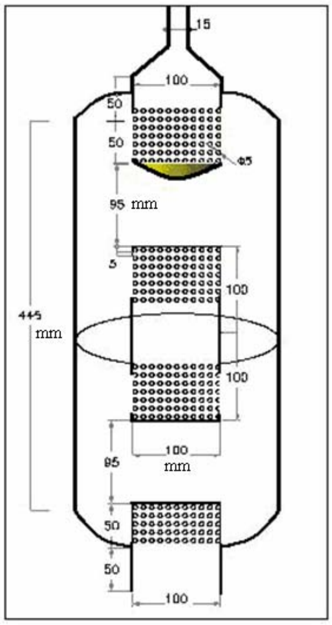

Figure 2: Cross section of the designed double muffler for steam vents noise (dimensions are in mm)

Based on previous researches and scientific principles, an appropriate expansion muffler was designed, which was resistant to corrosion and rust and can endure the steam vent pressure, to decline jointly the pressure and the sound pressure of steam vent.

The proposed expansion muffler is a double muffler with an inside pipe drilled [14]. According to calculations, the designed aluminum muffler was consisting of 500 mm length, 200 mm diameter and 2.6 mm thickness in which the length and the diameter of inside pipe were 200 and 200 mm. Figure 2 shows the cross section of this muffler. To increase the efficiency of the last part of entrance canal of this expansion muffler, the aluminum wool absorbent covered by a sheet with 5 mm holes was considered. In addition, to obtained the best performance, pores with 5 mm diameter at 7.4 mm distance from each other were predicted on the body of the inside pipe.

Results

The results of area noise measurements around the sources are shown in Table 1. The dimension of the areas under investigation and net place were 6 by 8 m and 2×2 m respectively. Figure 3 indicates the location of steam vent, furnace and GIS based noise measurement results. According to the results of previous studies, it was anticipated that steam vent noise would be in the range of high frequencies. The environmental measurements showed that the sound pressure level in stations near to steam vent was in the range of high frequencies and those stations close to furnace were in the range of low frequencies.

Table 1: Results of one octave band frequency analysis t in 10 successive stations (from vent 1 to furnace 1)

Stations	Frequency SPL dB (L)								
	63	125	250	500	1000	2000	4000	8000	Total
1	88.9	86.7	83.5	77.9	78.8	80.1	81.9	83.4	93.2
2	88.4	86.4	85.2	78.0	78.1	80.3	81.2	81.0	92.9
3	89.7	87.6	85.7	77.8	77.1	78.7	81.1	81.0	93.7
4	89.8	86.1	85.7	79.1	77.5	78.8	80.4	81.0	93.4
5	88.7	87.5	84.9	77.9	76.8	78.4	79.1	79.9	93.0
6	89.8	85.8	84.4	78.6	77.3	78.1	79.4	80.1	93.0
7	89.5	89.0	85.3	78.4	79.8	81.5	80.1	80.0	94.0
8	89.6	87.9	86.6	78.4	76.1	77.7	79.1	80.3	93.7
9	90.0	88.2	86.0	77.8	76.3	77.0	78.8	80.3	93.8
10	91.7	88.6	86.3	80.2	75.8	76.5	78.6	79.3	94.7

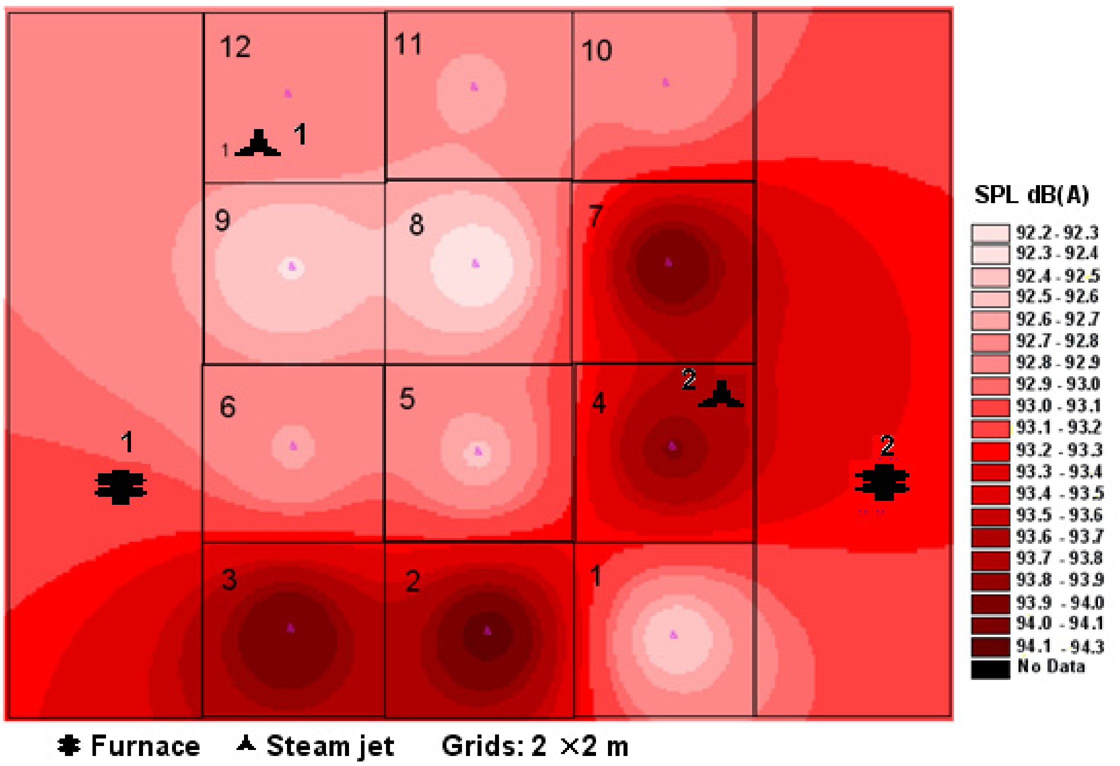

Figure 3: The grid location plan of noise measurement stations, furnace and steam vent based on ISO- TC/211 series [18]

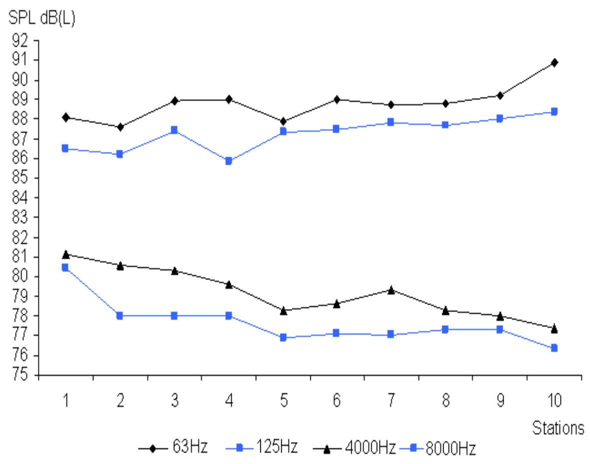

Figure 4: Comparison of sound pressure level in 10 successive stations (from vent 1 to furnace 1) at frequencies 63, 125, 4000, and 8000 Hz

The number of measurement stations between the sources (vent to vent and vent to furnace) was increased. In each station, the level of sound pressure variation trend including 63, 125, 4000 and 8000 Hz were evaluated in four important frequencies and then compared with theoretical findings. Selection of these frequencies was based on the field noise frequency analysis in which the results of these 10 stations from steam vent to furnace are shown in Table 1. Figure 4 shows sound pressure level variation trend between vent and furnace. It can be seen that the main frequency was decreased by the distance from the vent.

Discussion

The results of frequency analysis of environmental noise measurements on L frequency weighted showed that the level of sound pressure from the station near to steam vent at dominant frequency of 4000 and 8000 Hz and near to furnace station increased at frequencies 63 and 125. The noise frequency analysis on L-weighted also revealed that the sound pressure level at frequency 4000 and 8000 Hz decreased when moving away from the steam vent and coming near to the opposite steam vent. The consequence of one octave band frequency analysis of steam vent at elevation level above the ground and at a 20 cm distance from the steam vent indicated that level of sound pressure had the highest value close to steam vent at the center frequency of 4000 and 8000 Hz. The computational results of the main frequency of steam vent based on technical information have confirmed the above results. Thus, it is possible to use the mentioned method to calculate the sound pressure level and the frequency characteristics of noise sources for similar environments. This technique is a new method for consideration on noise distribution between point sources in the same industrial sites.

The results of measurement and main frequency of steam vent were compared with the computational values. In the calculation section, it was shown the analysis revealed that the dominant frequency was 5912 Hz which confirm the center octave band frequency range of 4000 and 8000 Hz. This method is appropriate for those sites where noise sources should not be turned off.

According to the dominant frequency of steam vent, a double expansion muffler was designed. Since the exhaust of this device is vapor and the vapor will be liquefied by decreasing the pressure, based on the exhaust sound pressure level and dominant frequency, an aluminum expansion muffler was designed. The thickness of this muffler not only provides the minimum density for transmission loss of an enclosure but also provides the appropriate differences from the critical frequency in mass law [1, 2, 14].

With regard to all technical considerations (type of material, thickness, dimension of muffler and noise characteristics) of this double muffler, a 17 dB reduction in the sound level can be calculated. This muffler, according to previous similar researches, could supply the effective sound pressure level reduction. If the dimension of muffler and the number of enclosures will be changed either series or parallel, the performance of muffler could be increased. However, this operation is not necessary considering the exhaust pollution level. Similar results of exhaust sound control in fluids were shown in [6-10]. Maa et al [9] proposed a muffler with small holes to control the exhaust noise. The sound pressure level reduction of the suggested muffler according to previous investigations and the knowledge of the authors are suitable.

Conclusion

The noise characteristic of sources should be reviewed in a contiguous process using GIS based appropriate methods and then a noise control plan should be presented. The performance of the muffler is not reliable without considering the noise characteristics of steam vents separately. By controlling the source of noise in this research, the level of sound pressure of the mentioned area will be decreased where the workers were faced lower levels than permitted values. In this study, a double expansion chamber aluminum muffler for obtaining a 17 dB noise reduction was designed. It is estimated that the level of sound pressure due to various sources including furnace and steam vent might reduce to occupational permitted threshold levels.

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Conflict of interest statement

The authors declare that they have no conflicts of interest.

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References

1. Bell LH, Bell DH. Industrial Noise Control. New York: Marcel Dekker; 1994.
2. Golmohammadi R. Noise and Vibration Engineering. 3rd edition. Hamadan: Daneshjoo; 2006 [Persian].
3. Sulkowski WJ, Szymczak W, Kowalska S, Sward MM. Epidemiology of occupational noise-induced hearing loss (ONIHL) in Poland. *Otolaryngologia pol*. 2004;58(1):233-236.
4. 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 [Persian].
5. 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. *JRHS*. 2010;10(1):22-30.
6. Golmohammadi R, Monazzam MR, Nourollahi M, Nezafat A. Noise Characteristics of Pumps at Tehran's Oil Refinery and Control Module Design. *Pakistan Journal of Scientific and Industrial Research*. 2009;52(3):167-172.
7. Golmohammadi R. Measurement and control of impact noise and segmental vibration in pneumatic hammers in an automobile assembly [MSc thesis]. Tehran, Tehran University of Medical Sciences; 1990 [Persian].
8. Hakimi HA. Modeling and providing noise pollution control methods for Sarcheshme Copper mine applying software. 6th Conference of Environmental Health and Safety in Mine and related industries; 2000 November 5-Novemver 8; Kerman [Persian].
9. Maa DY. Pressure dependence of jet noise and silencing of blow-offs. *Noise Control Engineering*. 1981;17:104-112.
10. Min CC, Ying CC. Numerical studies on venting system with multi-chamber perforated mufflers by GA optimization. *Applied Acoustics*. 2008;69(11):1017-1037.
11. Grosveld FW. Design of an acoustic muffler prototype for an air filtration system inlet on international space station. 2010 [cited 25 September, 2010]; Available from:
http://www.grosveld.com/publications/NoiseCon2003muffler.pdf.
12. ISO, Determination of occupational noise exposure and estimation of noise-induced hearing impairment, international standard organization, ISO-1999, 1990.
13. ISO, Guidelines for Measurement and assessment of exposure to noise in working environment, international standard organization, ISO-9612, 1997.
14. Barron FB. Industrial Noise Control and Acoustics. New York: Marcel Dekker; 2003.
15. Bies DA, Hansen CH. Engineering Noise Control. London: E&FN Spon Ltd. 1996.
16. American Conference on Governmental Industrial Hygienists. Thresholds limit values and biological indexes. New York: ACGIH; 2010.
17. Ministry of Health and Medical Education. Occupational Exposure limits (OEL). Tehran: MHME; 2003 [Persian].
18. ISO, Geographic information systems, International Standard Organization ISO- TC/211 series 2004-2009.