Analysis on Noise Reduction Method of Boiler Room in City

Yiduo Wang *, Boxing Yang, Chongzheng Zhao
College of Environmental Science and Engineering, Taiyuan University of Technology, Taiyuan, China.

* Corresponding Author email:857282544@qq.com

Abstract. Noise environment attracts people's attention constantly at present. In the city, the noise of boiler room is especially serious. Noise has not only physical but also psychological effects on human body. This paper introduces the noise reduction methods commonly used in boiler rooms and discusses the comparison of noise reduction effect and economic cost between sound insulation technology and sound absorption-insulation technology.

Keywords: boiler room, noise level, sound insulation, sound absorption, method.

1. Introduction
With the continuous advancement of urban modernization, the environment, which we rely on for survival, has become more and more important. Environmental protection has become an indispensable topic for contemporary people, and it is also one of the policies that governments attach importance to. In addition to water environment, atmospheric environment and solid waste disposal, the acoustic environment has attracted more and more attention in recent years. With the continuous development of cities, the population is more and more concentrated. Especially in northern China, central heating becomes normal in winter, so the problem of noise pollution in boiler rooms needs people to solve.

2. Noise Pollution of Boiler Room in Modern Living Environment

2.1. Impact on human health.
People will have tinnitus or even deafness when they are exposed to strong noise. If you stay in this environment for a long time, it will develop into hearing loss. High-intensity noise can even split the eardrum, causing deafness. In sleep, if affected by noise, it will affect the quality of sleep, long-term insomnia, dizziness and headache. They even have psychological problems such as depression. And the boiler room just needs to run day and night to ensure normal heating. If we receive the long-term influence of noise in our daily life, it will cause the disorder of nervous system and digestive system.
2.2. Impact on surrounding land use.
In a city with such a tight land use, the boiler room generally occupies a large area, and because of the noise, it cannot be located in close proximity to residents' living or business places. We assume that if this large area is used for commercial construction or residential residence, it will produce great value. Therefore, if the problem of noise is not solved, it will cause certain economic impact.

3. Noise Control Method for Urban Boiler House in Modern Living Environment
According to the characteristics of sound transmission, noise control is mainly divided into three aspects: source control, transmission path control and acceptance point control. The main control methods are sound insulation, sound absorption and silencing. It is also applicable to noise control of boiler room.

3.1. Design of sound insulation wall.
In the boiler room, the main noise sources are the noise generated by the boiler when working and the noise generated by the exhaust, intake and exhaust outlets. For the noise generated by the boiler, generally speaking, there are walls around the boiler room, so the walls can play a sound insulation role. Different sound insulation materials have different song effects. Firstly, for the special high temperature environment of boiler room, high temperature resistant materials should be selected. Secondly, the smaller the sound transmission coefficient, the better the noise reduction effect will be, but at the same time, the price will also increase. Therefore, when choosing wall sound insulation materials, economic aspects should also be considered.

3.2. Sound Absorption-Insulation Combination Technology.
Sound absorption-sound insulation technology refers to attaching a layer of sound absorption material to the inner surface of the wall. When the noise is emitted onto the sound absorbing material, a part of attenuation occurs first, then through the sound insulation wall, and then a part of attenuation occurs. Similar to sound insulation materials, different sound absorption materials have different effects. The greater the sound absorption coefficient, the better the effect, but there are also economic costs. When arranging sound absorption materials, we should also consider the situation of the boiler room, choose heat-resistant materials, and choose materials that are not easy to corrode, fall and so on.

3.3. Design of Muffler.
For the purpose of noise reduction, mufflers are mainly designed for smoke exhaust, intake and exhaust outlets. When calculating the muffler height, attention should be paid to the generation of air regeneration noise and the suitability of muffler height. It is difficult to install and overhaul a long muffler. At the same time, pressure loss should be calculated to ensure that the muffler meets the standard.

4. Analysis of Noise Reduction Effect
This article only discusses the sound insulation effect analysis of sound insulation technology and sound absorption-insulation technology.

4.1. Calculation of sound insulation wall.
Here, we calculate an example. There are three kinds of materials in the wall of the boiler room: brick wall (t = 240mm, plastering), clay hollow brick (t = 240mm, plastering total 30), metal plate and superfine glass wool (steel plate t₁ = 2mm, superfine cotton t₂ = 80mm). The calculated results at various frequencies are shown in Table 1.
Table 1. Calculation results of sound insulation wall

| Frequency(f/Hz) | 125 | 250 | 500 | 1000 | 2000 | 4000 |
|----------------|-----|-----|-----|------|------|------|
| Raw noise (Rs/dB) | 90  | 87  | 88.1| 88.3 | 88.4 | 83.1 |
| Composite Wall Element 1 Area (S1/m2) | 350 | 350 | 350 | 350  | 350  | 350  |
| Permeability Factor 1 | 0.0000631 | 0.0000501 | 0.0000126 | 0.0000020 | 0.0000004 | 0.0000006 |
| Composite Wall Element 2 Area (S2/m2) | 60  | 60  | 60  | 60   | 60   | 60   |
| Permeability Factor 2 | 0.0000631 | 0.0000316 | 0.0000251 | 0.0000079 | 0.0000016 | 0.0000010 |
| Composite Wall Element 3 Area (S3/m3) | 100 | 100 | 100 | 100  | 100  | 100  |
| Permeability Factor 3 | 0.0006310 | 0.0005012 | 0.0005012 | 0.000063 | 0.000006 | 0.000004 |
| Average sound transmission coefficient (qa) | 0.0001744 | 0.0001364 | 0.0000214 | 0.0000035 | 0.0000006 | 0.0000006 |
| Noise blocking (Rd/dB) | 37.6 | 38.7 | 46.7 | 54.5  | 62.3  | 62.0  |
| Raw noise (Rs/dB) | 52.4 | 48.3 | 41.4 | 33.8  | 26.1  | 21.1  |

After calculation, the weighted noise level of A is 48.8 decibels.

4.2. Sound Absorption-Insulation Combination Technology.
Under the same sound source and background conditions as sound insulation, there are three kinds of wall materials: brick wall (t = 240mm, plastering), clay hollow brick (t = 240mm, plastering total 30), metal plate plus ultra-fine glass wool (steel plate T1 = 2mm, super-fine cotton T2 = 80mm), and sound absorption materials attached to each wall are metal plate plus ultra-fine glass wool (perforated steel plate). Cover, glass wool (perforated steel sheet cover, volume density 48kg/m3) and centrifugal glass wool felt (perforated steel sheet cover, volume density 24kg/m3). The calculation results of sound absorption process at different frequencies are shown in Table 2.
Table 2. Calculation results of sound absorption

| Frequency (f/HZ) | 125  | 250  | 500  | 1000 | 2000 | 4000 |
|------------------|------|------|------|------|------|------|
| Raw noise (Rs/Db)| 90   | 87   | 88.1 | 88.3 | 88.4 | 83.1 |

| Composite Wall Element 1 Area (S1/m2) | 200 | 200 | 200 | 200 | 200 | 200 |
|--------------------------------------|-----|-----|-----|-----|-----|-----|
| Composite wall element 1 sound absorption coefficient (α1) | 0.070000 | 0.130000 | 0.100000 | 0.170000 | 0.310000 | 0.330000 |

| Composite Wall Element 2 Area (S2/m2) | 53   | 53   | 53   | 53   | 53   | 53   |
|--------------------------------------|------|------|------|------|------|------|
| Composite wall element 2 sound absorption coefficient (α2) | 0.013000 | 0.015000 | 0.020000 | 0.030000 | 0.040000 | 0.050000 |

| Composite Wall Element 3 Area (S3/m2) | 87   | 87   | 87   | 87   | 87   | 87   |
|--------------------------------------|------|------|------|------|------|------|
| Composite Wall Element 3 Sound Absorption Coefficient (α3) | 0.320000 | 0.760000 | 1.000000 | 0.950000 | 0.900000 | 0.980000 |
| Average sound absorption coefficient (αA) | 0.1250853 | 0.2732794 | 0.3178235 | 0.3477647 | 0.4188824 | 0.4526765 |

| Composite Sound Absorbing Material 1 Area (A1/m2) | 350 | 350 | 350 | 350 | 350 | 350 |
|-----------------------------------------------|-----|-----|-----|-----|-----|-----|
| Composite Sound Absorbing Material 1 Sound Absorbing Coefficient (β1/m2) | 0.850000 | 0.700000 | 0.600000 | 0.410000 | 0.350000 | 0.350000 |

| Composite Sound Absorbing Material 2 Area (A2/m2) | 60   | 60   | 60   | 60   | 60   | 60   |
|-----------------------------------------------|-----|-----|-----|-----|-----|-----|
| Composite Sound Absorbing Material 2 Sound Absorbing Coefficient (β2/m2) | 0.960000 | 0.770000 | 0.890000 | 0.930000 | 0.630000 | 0.190000 |

| Composite Sound Absorbing Material 3 Area (A3/m2) | 100  | 100  | 100  | 100  | 100  | 100  |
|-----------------------------------------------|-----|-----|-----|-----|-----|-----|
| Composite Sound Absorbing Material 3 Sound Absorbing Coefficient (β3/m2) | 1.060000 | 0.940000 | 1.120000 | 1.120000 | 1.040000 | 1.020000 |
| Average sound absorption coefficient (β) | 0.9041176 | 0.7552941 | 0.7360784 | 0.6103922 | 0.5182353 | 0.4625490 |

| Sound absorption and noise reduction (RC/DB) | 8.6 | 4.4 | 3.6 | 2.4 | 0.9 | 0.1 |
|---------------------------------------------|-----|-----|-----|-----|-----|-----|
| Absorbed noise (Re/DB) | 81.4 | 82.6 | 84.5 | 85.9 | 87.5 | 83.0 |

After the sound absorption process occurs, the calculation results of sound insulation are as shown in Table 3.
### Table 3. Calculating table of sound insulation wall after sound absorption process occurs

| Frequency (f/Hz) | 125  | 250  | 500  | 1000 | 2000 | 4000 |
|-----------------|------|------|------|------|------|------|
| Raw noise (Rs/dB) | 81.4 | 82.6 | 84.5 | 85.9 | 87.5 | 83.0 |
| Composite Wall Element 1 Area (S1/m²) | 350  | 350  | 350  | 350  | 350  | 350  |
| Permeability Factor 1 | 0.0000631 | 0.0000501 | 0.0000126 | 0.0000020 | 0.0000004 | 0.0000006 |
| Composite Wall Element 2 Area (S2/m²) | 60   | 60   | 60   | 60   | 60   | 60   |
| Permeability Factor 2 | 0.0000631 | 0.0000316 | 0.0000251 | 0.0000079 | 0.0000016 | 0.0000010 |
| Composite Wall Element 3 Area (S3/m³) | 100  | 100  | 100  | 100  | 100  | 100  |
| Permeability Factor 3 | 0.0006310 | 0.0005012 | 0.0000501 | 0.0000063 | 0.0000006 | 0.0000004 |
| Average sound transmission coefficient (qa) | 0.0001744 | 0.0001364 | 0.0000214 | 0.0000035 | 0.0000006 | 0.0000006 |
| Noise blocking (Rd/dB) | 37.6  | 38.7  | 46.7  | 54.5  | 62.3  | 62.0  |
| Raw noise (Rs/dB) | 43.8  | 43.9  | 37.8  | 31.3  | 25.1  | 21.0  |

After calculation, the weighted sound pressure level of A is 43.7 decibels.

5. Summary

Comparing the two methods, the final noise level is 48.8 decibels and 43.7 decibels using sound absorption-insulation technology, but the latter needs higher economic cost. In this case, the difference between the two methods is about 20,000 yuan. In addition, the latter needs to install sound absorption layer and often maintain and check whether the sound absorption layer is corroded or damaged, which is more labor-intensive. Therefore, when choosing denoising methods, we should choose denoising methods according to the actual requirements of denoising. If only using sound insulation technology can meet the requirements of noise reduction, it does not need to spend additional manpower and financial resources to add sound absorption technology.

### References

[1] Jierong Zhao. Physical Pollution Control. Higher Education Press, (2007).
[2] Dayou Ma. Handbook of Noise and Vibration Control Engineering. Machinery Industry Press, (2002).
[3] Ning Zhao. Approaches to control urban environmental noise pollution. Environment and development, (2017).
[4] Ji-hong Zhou, a, Jian-guo Tan, Hong-xia Wang, Hai-zhen Ma. Research on Noise Reduction in Boiler Room - an Actual Case on North Boiler Room.
[5] A. Elliott. Measurement of in-room impact noise reduction. Applied Acoustics. P.97–118, (2019).
[6] Duanqun Fang, Bin Zhang, Jiaqi Sun, Weijian Lu. Noise Control Engineering (Volume 1, Volume 2). Science Press, (2013).