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THE THEORY OF A LOW-NOISE POWER FACILITY

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The operation of power facilities (boilers, thermal power plants and other) is the cause of the sanitary norms noise excess in the surrounding area. Many power facilities are in locations near residential areas. Theoretical problems of creating a low-noise power facility are discussed in this manuscript. Limiting factors for the creation of a low-noise power facility have been identified. The energy facility mathematical model allows us to consider the effect of the limiting factors in the creation of low noise object. There are the number of noise sources, the noise characteristics of the sources, the location of sources on the premises, equipment operation modes, the orientation of the energy facility in relation to the residential area and other factors. The location of noise sources in the energy facility at a height above the ground level has a significant impact on noise levels in the surrounding area and the ability to create low noise object. It is shown as the type of energy facility affects the ability to create low noise object. The influence of power energy facility on the possibility of low-noise power facility creation.
Keywords: mathematical model, low-noise power facility

1. Introduction

Operation of power objects (boiler plants, thermal power plants, transformer substations and others) is the reason of sanitary standards noise excess in the surrounding area. The federal laws "On Protection of Atmospheric Air" and "Concerning the Protection of the Natural Environment" oblige implementation of actions for noise decrease from noise sources to sanitary norms which are established by Sanitary norms 2.2.4/2.1.8.562-96 [1] for jobs and the residential area.

For example, the thermal power plants (TPP) with an equivalent electric power of 600 MW and above, using as fuel the coal and fuel oil, are the first class enterprises with sanitary protection zone (SPZ) not less than 1000 m. TPP using gas and oil-gas fuel have the SPZ belong to of the second class and it must be not less than 500 m. The Central Heating and Power Plant (CHPP) and regional boiler rooms with a thermal power of 200 Gcal and above, using coal and fuel oil, belong to the second class with the SPZ not less than 500 m, using gas and black oil fuel (the last — as reserve) belong to the enterprises of the third class with the SPZ not less than 300 m [2].

2. Features of creation of a low-noise power facility and the limiting factors

Feature of low-noise power facility creation is that many power facilities are in the cities near residential areas. A large number of the operating equipment is characteristic of power facility. These are steam and gas turbines, boilers, fans, smoke exhausters, different type of pumps, the fuel preparation equipment (gas distribution substation (GDS), coal crushers, etc.), compressors, transformers, cooling towers, systems of local cooling, etc. [2]. The combination of noise sources and

their quantity is characteristic of each power facility. The sound power levels of the same type equipment depends on its power and can significantly differ and make up to 130 — 150 dBA. The most intensive source will create the SPZ territory. The quantity of sources can reach for large objects hundreds of units. Noise from sources located in buildings (turbines, boilers, pumps, etc.) will determine by the soundproofing properties of building walls. The frequency range of emitted noise strongly differs from sources from low frequency (compressors, the pulverizing equipment) to high-frequency (steam-laden emissions). Locations of sources in the territory also influence how their noise isolines will pass.

Layout of noise sources on power facility can be at height of h1 to h2 over earth level. At the same time the sources placed at height will exert more strong impact on the region, than sources on the earth. Noise level is influenced by equipment operation modes, also, as well as a directivity index, orientation of power facility in relation to the residential area. These and some other factors have significant effect on noise levels in the region and a possibility of low-noise power facility creation. The task in a general view is three-dimensional.

The limiting factors hinder supports to achievement of $L_{i\ san}$ permissible norms for each compound frequencies:

$$\sum_{i}^{n} L_i \leq L_{\text{san}^l}$$

We will divide the limiting factors for low-noise power facility creation conditionally into two groups.

The first group of the limiting factors are factors which can be changed. For example, due to change the placement of noise sources it is possible to achieve noise reduction in reference points. The most perspective is use the shielding properties of buildings and other constructions for noise reduction. Silencers, acoustic barriers and other measures for noise reduction allows to reduce noise from sources [3-10].

The second group of the limiting factors which can't be changed.

The equipment (noise sources) settles down in the enterprise territory according to certain requirements (fire safety, reliability of work, etc.).

At the same time for sources from *1* to *i* coordinates x_1, y_1, z_1.....x_i, y_i, z_i are the sizes fixed relatively each other. For example, the fans placement is rather rigidly connected with the capital equipment placement and a chimney.

For sources from *i+1* to *n* coordinates aren't are rigidly interconnected.

Other parameters depend on from each other.

The task comes down to volume minimum finding, the limited isolines of permissible norms at the set noise sources quantity.

The power facility mathematical model allows to consider mutual influence all groups of factors on a possibility of low-noise power facility creation.

3. Mathematical model of a power facility

The power facility mathematical model can be created by the existing software. For these purposes, for example SoundPLAN (USA), Predictor (Holland-Germany), "Acoustics" (Russia), "Ekolog-Shum" (Russia), etc. can be used.

Power facility mathematical models allow to visualize noise pollution from it. In addition, mathematical models allows to consider most fully and precisely land relief influence, surface condition, arrangements of industrial and housing estates on noise distribution in three-dimensional measurement from a large number of different sources relatively each other.

Results which were get using mathematical model possibilities are shown below. Calculations are performed according to the international ISO 9613-2:1996. The power facility mathematical model can be created by the existing software. For these purposes, for example SoundPLAN (USA), Predictor (Holland-Germany), "Acoustics" (Russia), by "Ekolog-Shum" (Russia), etc. can be used.

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Results which were get using mathematical model possibilities are shown below. Calculations are performed according to the international ISO 9613-2:1996.

The TPP with rather small energy power, typical for many cities, is chosen. On TPP two boilers TGM-84 and three boilers BKZ-320-140GM are established. At the station steam turbines PT-60/75-130/22, PT-70/80-130/13, PT-80/100-130/13 are installed. Air supply to boilers is carried out the four fans VDN-24 and six VDN-20. Evacuation of combustion gases is carried out by four D-21,5x2 smoke exhausters, four DN-21,5x2U smoke exhausters and two DN-24x2-0,62. It was take into account that noise from the fans is radiated from the case, from fans air intakes and from mouths of chimneys by forced draft fans, besides when calculating was considered noise from six transformers, GDS, two cooling towers, and also other sources. In total, fourteen power plant constant noise sources were considered.

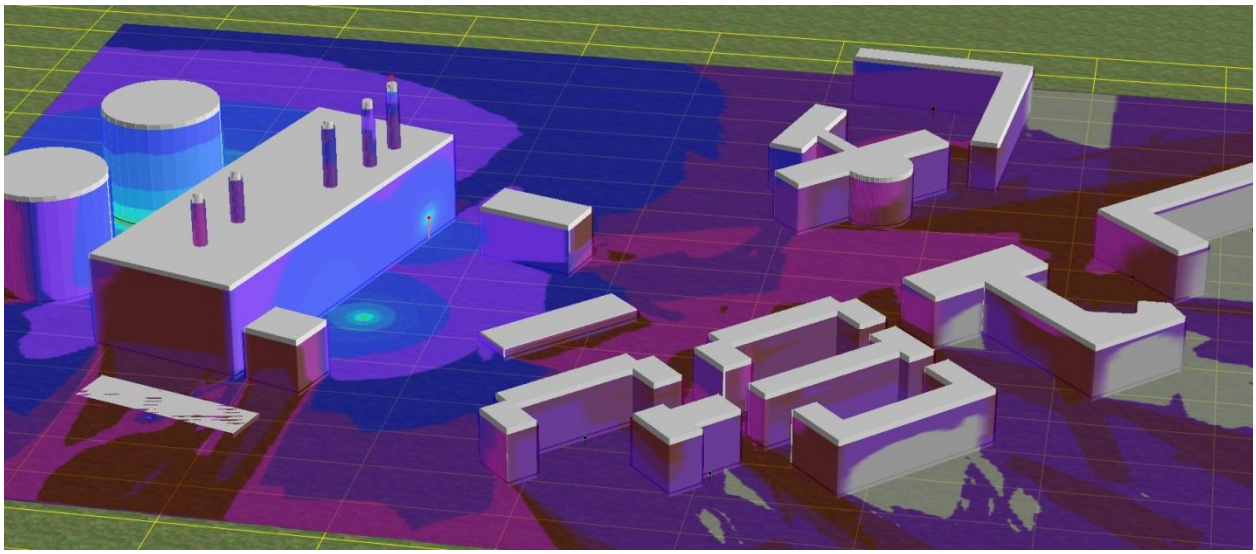
In figure 1 visualization of acoustic calculations results during the operation of one boiler is given (figure 1 *a*) and during the operation of five boilers (figure 1 *b*) with the residential area arrangement in the east from power plant. Acoustic calculations visualization results for the same equipment operating modes, but only for the residential area located to the west from power plant are provided on figure 2. Calculations of sound levels in figure 1 and figure 2 are presented in three-dimensional measurement. These calculations feature is existence of very large number of factors which influence in formation of the general background for the enterprise territories and the surrounding area. Steam emission as a temporary noise source is absent.

In figure 1 and figure 2 is seen that power increase to increase sound levels in the enterprise territory and the surrounding area. In general, takes place of sound level increase on 6-12 dBA. Buildings in the territory and the surrounding area render essential effect on sound level attenuation. Sound level decrease can make 20-23 dBA.

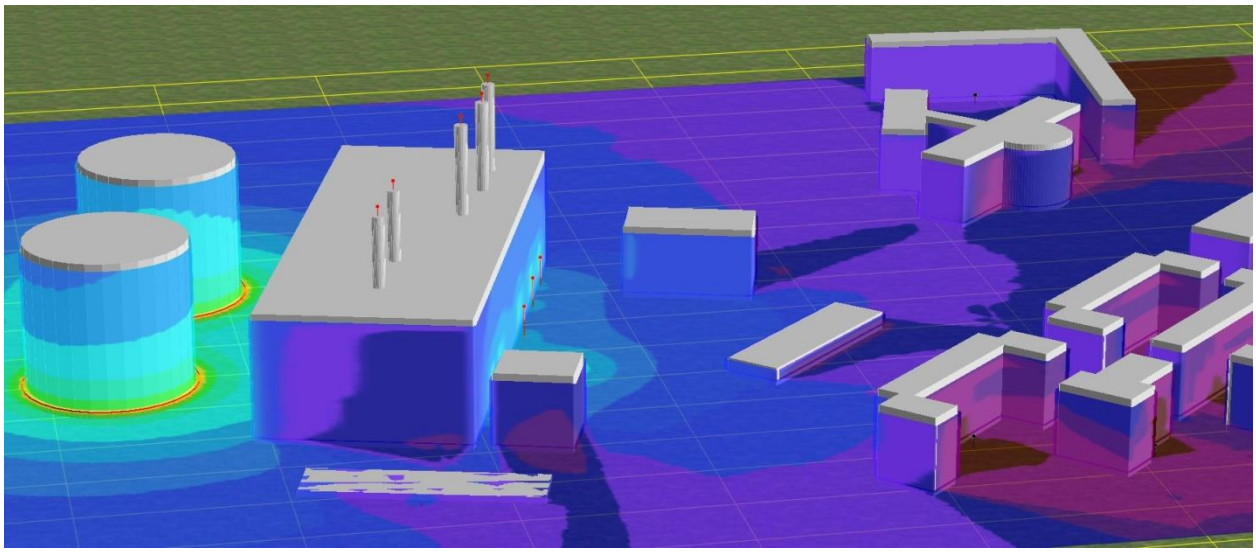
From figure 1 and figure 2 is seen that sound levels at identical distance significantly differ and depend on reference points location. This difference can reach more then ten decibels. Acoustic calculations visualization allows to determine sound levels at various height that is very important for high-rise buildings construction.

The residential area placement concerning power plant has significant effect on calculations results at various power plant operation mode (figure1 *a* and figure 2 *a* and figure 1 *b* and figure 2 *b*). The difference in sound levels can reach 5-27 dBA. This results from the fact that noise from the fans, transformers and GDS is shielded by the power plant building.

Calculations with mathematical model applying allow to analyse noise levels at distance from a power facility considering all listed above factors. Besides the mathematical model allows to choose correctly necessary actions for noise reduction from power facility and to define as noise levels on SPZ border after their introduction will change. It is almost impossible to make such analysis without mathematical model application.

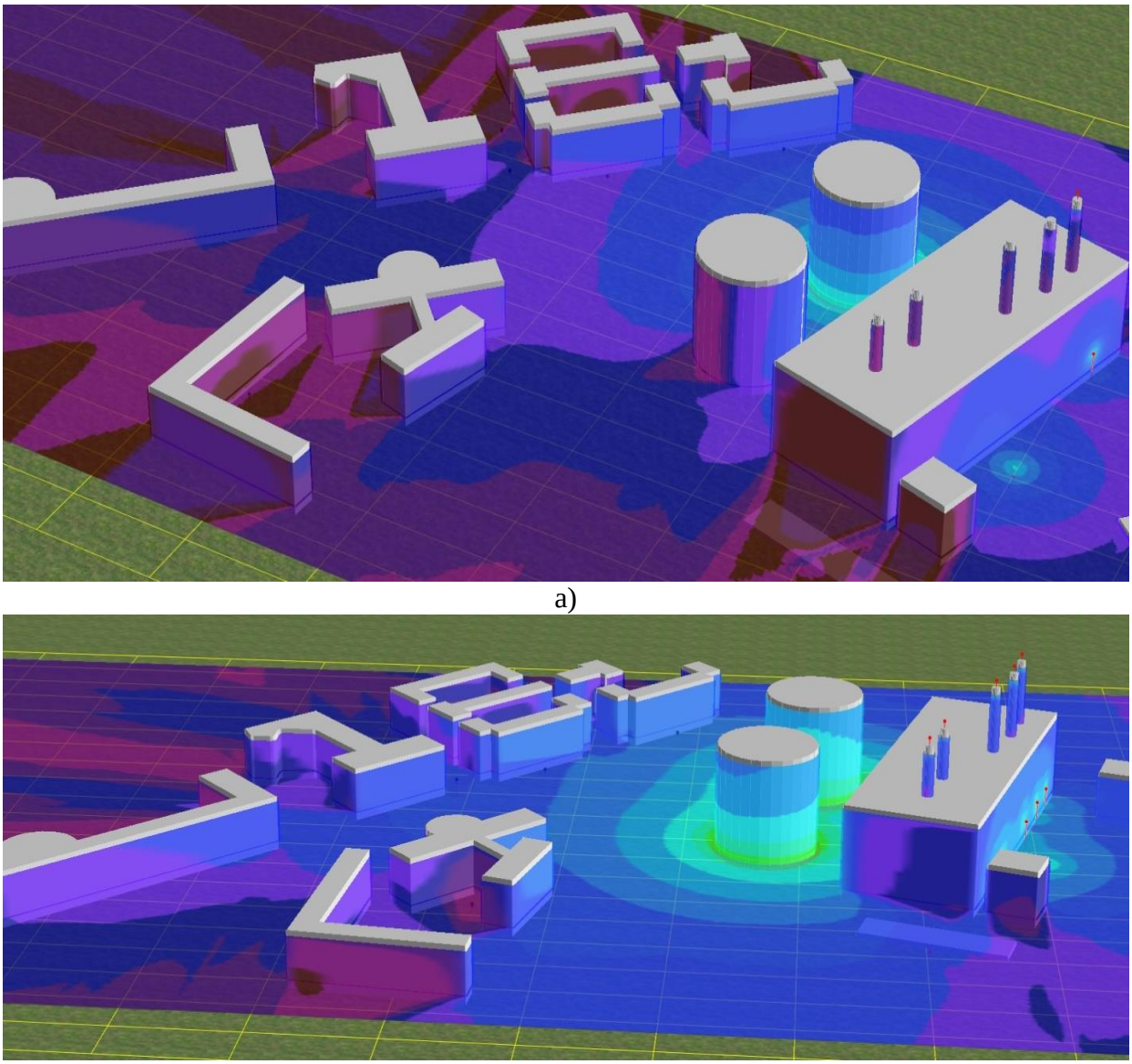


a)



b)

Figure 1: Visualization of sound levels in the surrounding area at various operation mode of power plant at placement of the residential area in the east from power plant: a — in operation one boiler; b — in operation all boilers.



a)

b)

Figure 2: Visualization of sound levels in the surrounding area at various operation mode of power plant at placement of the residential area in the west from power plant: a — in operation one boiler; b — in operation all boilers.

4. Conclusion

1. Creation of a low-noise power facility is a complex challenge at which solution many limiting factors should be considered.

2. It is expedient to carry out creation of a low-noise power facility with apply of 3D mathematical model which allows to visualize noise pollution from it both for the enterprise territory, and for the surrounding area.

3. Mathematical model apply allows to analyze various factors influence on noise level in the enterprise territory and in the surrounding area, and in case of sanitary standards excess to choose necessary actions for noise reduction.

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