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RESEARCH AND MAPPING OF LOW FREQUENCY NOISE GENERATED BY POWER PLANTS OF INDUSTRIAL ENTREPRISES

Andrey Vasilyev

Samara State Technical University, Samara, Russian Federation, avassi62@mail.ru

***Abstract**: Environmental noise level from industrial enterprises is constantly increasing, especially in low frequency range. This paper presents the results of research and mapping of low frequency noise generated by power plants of industrial enterprises. Environmental noise mapping results of urban territory of Samara region of Russia are also presented. Results of noise measurements during industrial enterprises operation (on the example of "KuibyshevAzot" company) are showing that in some measuring points there were exceeding values compared with Russian sanitary norms requirements. The most serious problem is low frequency noise impact.*

***Keywords:** noise, power plants, industrial enterprises, mapping, low frequency*

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1. INTRODUCTION

Presently negative impact of different noise sources in conditions of urban territories is constantly increasing. Noise in towns is increasing every year. More than 60% of population of large cities is living in exceeding noise conditions. Damaging influence of intensive noise to the human's health is not restricted only by impact to ears. It is known, that noise is affecting to the human's central and vegetative nervous systems, influencing to the human's psychological condition etc. In Russia more than half of population is impacted by increased noise levels.

Analysis is showing that significant noise level is generated during operation of industrial enterprises [1-4]. This is especially dangerous for population health when enterprises are situated near to the living areas.

Low frequency noise impact is especially dangerous due to the spreading for a long distances. Power plants as the sources of low frequency noise of industrial enterprises are investigated.

This paper is devoted to the problem of research and mapping of low frequency noise generated by power plants of industrial enterprises.

2. POWER PLANTS OF INDUSTRIAL ENTERPRISES AS A MEAN OF LOW FREQUENCY NOISE REDUCTION

One of the main sources of noise impact to environment and to the living areas in conditions of modern industrial town are industrial enterprises of mechanical engineering, chemical industry, energetic objects etc. Power plants emitting to environment gas air mixtures (compressor mounts, stationary internal combustion engines, ventilation systems etc.) are generating intensive acoustical radiation, especially in low frequency range [1-6].

Widely power plants may be subdivided into the following main kinds: stationary (ventilators, pumps, compressors, stationary internal combustion engines etc.) and moving (engines of automobile and other transport, e.g. automobile internal combustion engines etc.).

Let us consider some typical kinds of power plants as noise sources during industrial enterprises operation.

Ventilation mounts are widely used in industry and in domestic conditions. Ventilation mounts are subdivided into the general purposes ventilators, fans for blast boilers, boiler house smoke pumps, shaft fans etc. According to direction of air flow in operation wheel ventilators may be subdivided as Axial, radial (centrifugal), diagonal, diametrical, according to construction – single and multi-stage, reversible, single and double suction, fans on the status of the impeller – horizontal and vertical etc.

Compressors. Depending on the kind of compressor mounts, conditions of operation and of noise and vibration generation compressors have different acoustical characteristic. E.g., in the intake spectrum of turbo-compressors (high-speed aggregates) high frequency sound harmonic are dominating. Volume compressors are subdivided as piston, rotor and membrane types. In the intake spectrum of rotor compressors, the frequency of shaft rotation and it harmonic are dominating. Due to the fact that rotation speed of rotor compressors usually is high, again we have high frequency sound domination. The most of piston and membrane type compressors are low-rotating machines, so in its spectra low frequency sound harmonic are dominating. Sound level, radiated to environment by piston compressor, is higher when oscillated gas dynamic

processes in compressor are high. Gas pressure pulsations in pipelines of compressors are the main noise and vibration source in low frequency range.

Pumps. Pumps are machines using for transportation of liquids and for transmission of energy to it. Pimps are subdivided to blade (centrifugal, vortex, axial, diagonal), volume (piston and rotor), pneumatic, stream. The most often used are blade pumps. Noise spectra of pumps are widely different and complicated. Low frequency components may reach significant values.

Engines. Engines are devices transforming some kind of energy to mechanical operation. The most often used kind of engines is heat engines, transforming heat energy to mechanical operation. Engines are subdivided to stationary and moving kinds. Moving machines are often using in industrial cites of chemical enterprises. Noise spectra of engines are widely different and complicated. Low frequency noise, which is generating during intake and exhaust processes of automobile internal combustion engines, is one of the main sources of acoustical discomfort of urban territories.

Thus, from the point of view of acoustical pollution of living areas, the most dangerous is low frequency noise generated during power plants operation.

3. EXPERIENTAL RESEARCH OF LOW FREQUENCY NOISE GENERATED DURING POWER PLANTS OPERATION

Experimental research of low frequency noise generated by power plants of industrial enterprises was carried out. Using sound level meter „Octave 101AM" more that 30 noise level measurements along the external board of industrial site of «KuibyshevAzot» company situated in Togliatti city of Russia were carried out. As a measuring parameter equivalent sound levels and maximal sound levels L_{Amax} (dBA), octave and 1/3 octave spectra of sound pressure (dB) were used. Measurements have conducted in daytime in weekdays mainly in rush hours and during the lunch-time; and in night time (since 23.00 till 7.00). Measured noise levels were evaluated according the valid Russian requirements. Measurements of noise levels in places of living territories adjoining to noise dangerous zones have been conducted in strict correspondence with sanitary requirements. Measurements were conducted during weekdays' daytime mainly in rush hours and also during to the lunchtime. Measured noise levels evaluated according to hygiene requirements, stated by valid Russian sanitary norms SN 2.2.4/2.1.8.562-96, according to requirements of which normative parameters for unstable noise are equivalent sound levels L_{Aecv} and maximal sound levels L_{Amax}, dBA. For evaluation of obtained results following normative values of equivalent and maximal sound levels were used:

$$L_{A\,ecv\,norm} = 55\,dBA + 10\,dBA = 65\,dBA \quad (1)$$

$$L_{A\,max\,norm} = 70\,dBA + 10\,dBA = 80\,dBA \quad (2)$$

The scheme of points of measurements of external noise measurements for industrial site of «KuibyshevAzot» company is shown in figure 1. Examples of presentation of measurements data are shown in the figures 2 and 3.

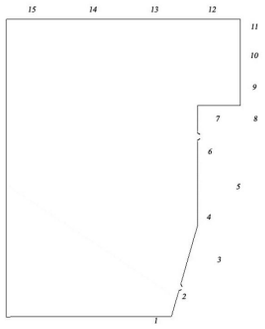

Fig. 1: Points of external noise measurements for industrial site of «KuibyshevAzot» company of Togliatti city of Russia

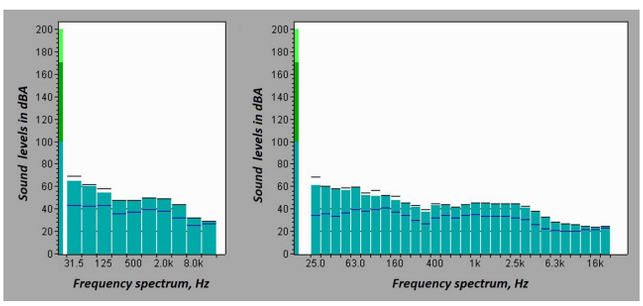

Fig. 2: The diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) for external noise measurement for industrial site of «KuibyshevAzot» company of Togliatti city of Russia (point 5)

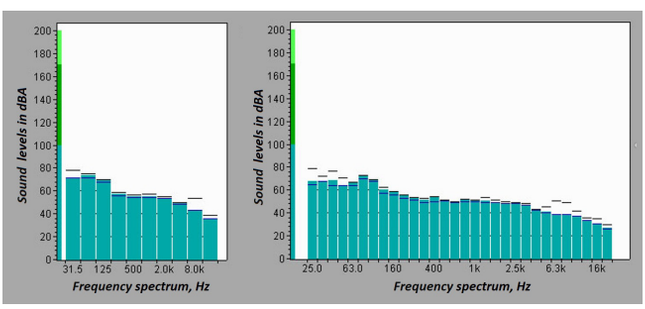

Fig. 3: The diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) for external noise measurement for industrial site of «KuibyshevAzot» company of Togliatti city of Russia (point 6)

Analysis of measurements results is showing that the most significant equivalent level of sound is in points of measurements 5 and 6, exceeding sanitary norms and reaching the value 68 dBA.

Calculations of sound levels of industrial cite to the nearest living houses of the Central district of Togliatti city have been provided.

Sound pressure level (dB) of the point source on the distance r (m) in homogeneous medium without the absorption is equal to:

$$L(r) = L_p + 10\,lg\,\Phi - 20\,lg\,r - 10\,lg\,\Omega \quad (3)$$

where

L_p - source sound power level (or sound level), dB (dBA);
ϕ - factor of source directivity for the point of observation;
$\Omega=4\,\pi$ - full space angle, in which the sound is radiated, 10 lg {4} π=11.

Results of calculations are showing that normative requirements in living area are not exceeded.

4. MODELING AND MAPPING OF ENVIRONMENTAL NOISE OF POWER PLANTS

For estimation of propagation of environmental noise, it is necessary to modeling propagation in the open space. In fact, it is difficult task due to the numerous acoustical effects like diffraction, refraction, reflections, superposition etc. That is why it is necessary to select appropriate methodical approaches for environmental noise modeling. For example, concerning transport low frequency noise evaluation it is better to model not noise of separate cars, but transport flow noise. Formalization and modeling of transport flows it is convenient to do by using of influence diagrams. Such diagrams are usually describing some formalized presentation of modeled categories (objects, processes, properties etc.) in a form of multitude of graphical symbols (assemblies, vertexes) and relations between it [1, 7-8]. In Russia the types of influence diagrams are the most popular to use in a form of flow graphs, trees of events and functional nets [2, 5-6, 9-10]. Flow graphs are including the variety of vertexes and a set of regulated and of unregulated couples, using for visual presentation of modeling process.

During last time semantic or functional nets are rapidly developing, which are present graphs, but with additional information in it assemblies and rib. Carriers of information about city street-road net geometry may be automobile road schemes, road atlases, drawings etc. But for sound mapping it is necessary to convert graphical information to analytical [10].

Rapid development of computing technique allows to automate the process of noise maps creation [1-2, 6-9, 11-12]. Modern computers with high velocity proceeding huge volume of information as static, as graphical. As result, a lot of companies are suggesting different types of city noise mapping. Widely Geographic Information Systems (GIS) are used to provide accurate visual information about noise in city. It should be noted that existing noise mapping tool only showing the acoustical situation only in some defined period. Peculiarity of transport noise mapping is the fact that only transport noise is considered and such sources as industrial noise, internal noise of living areas are not taking to consideration. From the other hand, transport noise map is necessary to include all transport noise sources: automobile transport flows, aircraft noise, railway noise etc. In Togliatti city there is only one main transport noise source: automobile transport.

It is very important that noise mapping software is to allow carry out the storage of database on noise levels. This allows to carry out more efficient evaluation of transport noise in compare with traditional methods. Software „Sound City Test" have been developed allowing to save in database the results of transport noise measurements for the all period of measurements. It is possible to add the data and to show on the map all the results of measurements and their dynamics. All the points are presented in special form with network. Such kind of software allows to store all the measured data and to make a conclusion about the dynamics of noise time variations in nearest and far prospect. We named our software as „Dynamic noise mapping".

Using software «Physic City Test» and sub-program «Sound City Test», dynamic noise maps are created during operation of the enterprises of the North Industrial Unit zone of Togliatti city and in abutting living areas of Central district of Togliatti city.

Dynamic noise map of the North Industrial Unit zone of Togliatti city (fig. 4) have been developed taking into account the fact of exceeding of sanitary norms in the points of measurements. Orange color was used for the points with equivalent noise level in the range from 65 to 70 dBA, red color – points with equivalent sound levels over 70 dBA.

Also spectral noise maps of the territory of Samara region of Russia were developed. In figure 5 the map of low frequency sound levels in octave band 63 Hz of the territory of North Industrial Unit Zone of Togliatti city is shown.

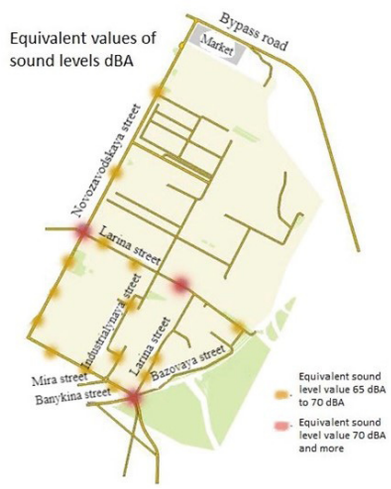

Fig. 4: Noise Map of the North Industrial Unit Zone of Togliatti city

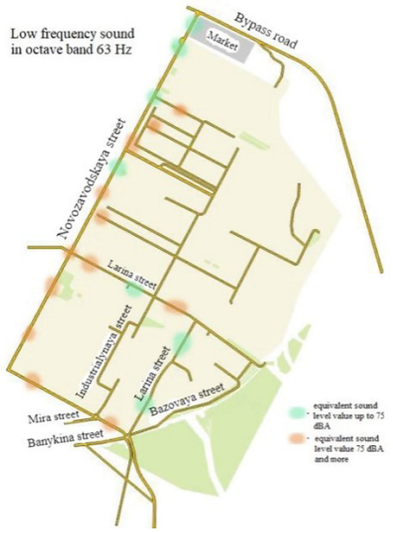

Fig. 5: Map of low frequency sound levels in octave band 63 Hz of the territory of North industrial unit zone of Togliatti city

Using the results of measurements, the map of noise levels around of the territory of "KuibyshevAzot" company of Togliatti city is developed, see Fig. 6.

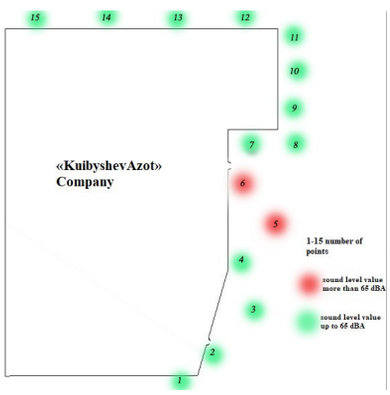

Fig. 6: Map of noise levels around of the territory of "KuibyshevAzot" company of Togliatti city

5. CONCLUSIONS

Analysis of measurement results of external noise levels generated by power plants of industrial enterprises in living territory of Togliatti city of Russia is showing that there are noise dangerous zones of dwelling territory. Results of noise measurements in the zone of North Industrial Unit during enterprises operation (on the example of "KuibyshevAzot" company) are showing that in some measuring points there were exceeding values compared with Russian sanitary norms requirements. The most serious problem is low frequency noise impact. Thus, it is necessary to develop the measures to reduce low frequency noise of power plants.

Different methods of noise evaluation and mapping have been investigated and described. Using software «Physic City Test» and sub-program «Sound City Test» dynamic noise maps of the North Industrial Unit zone of Togliatti city and of the separate enterprises have been created.

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Andrey Vasilyev *is Doctor of Technical Science, Professor, honorary worker of higher education of Russia. Presently he is director of the Institute of Ecology of Volga Basin of Russian Academy of Science – Branch of Samara Federal Research Center of Russian Academy of Science and professor of Department of Chemical Technology and Industrial Ecology of Samara State Technical University, head of Povolzhsky Resources Center of Industrial Ecology and Chemical Technology of Samara State Technical University. Author of over 15 books (ecology, environmental protection, acoustics), over 900 scientific papers. Main organizer and scientific manager of ELPIT congresses since 2003 (http://elpit-congress.ru). Editorial and scientific member of a number of famous Russian and foreign scientific journals and editions. Expert of Russian Academy of Science, of Russian scientific fund, of scientific-technical field of Ministry of education and science of Russia etc., grant-holder of DAAD (Germany), Open world program (USA) etc.*