SOLUTIONS TO REDUCE THE NOISE GENERATED BY AN AIR CONDITIONING SYSTEM

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Abstract: This paper presents a study of noise level generated by the operation of air-conditioning in an amphitheater. Noise level generated by it was too high for the specific activities developed in this enclosure. For noise level reduction in enclosure was identified as constructive solution use a frequency converter. Noise level values recorded ranged according to frequency of the motor. At the same time was studied the influence of the outside temperature on the ambient temperature of the amphitheater.

Keywords: noise level measurement, noise propagation, noise attenuation.

1. INTRODUCTION

Noise distracts usually not only to effective thinking, but also interferes with the audition, so the language is difficult and the audition is sometimes impossible [1]. The complexity of sounds gives the multidimensional character of their perception both in terms of acoustic and human [2, 3]. Thus, the quality and clarity of sounds in the environment is represented on the one hand, of a set of acoustic qualities or attributes that are related to the dimensions of sensors [2], and, on the other hand, the issues related to the understanding and reception of the heard message [4].

As the trend is that human activities to be conducted in silent environments, it is necessary to use active noise control methods in enclosures (called ANC) [3, 5-8]. The local control and global control are part of the active noise control strategies. Global control is one of the most effective methods for treating noise in an enclosure, especially for the low frequency noise. The global control involves the reduction of sound pressure level in all points within an enclosure [5-7]. In a chamber with high modal density or in free sound field, the global control can only be achieved if the distance between the noise source and the sources of control is less than half of the wavelength. In some situations, it is difficult to control devices located near the source of noise. Sometimes the local noise control strategies are considered to be the objective which can create quiet areas in the desired area instead of the global control methods [1, 5-7, 9].

The noise in closed halls can be minimized by reducing noise at source, by screening the noise source, or using sound absorbing materials [4, 8, 10]. The most effective means to avoid the noise are those that ensure that the noise sources are soundproofed. This involves from the beginning establishing the elements in which the acoustic of enclosure is optimal according to the destination and specifics of this enclosure [4, 5, 7, 9, 11].

Determination of the sound power equipment which operates in an enclosure involves performing measurements of noise with specialized equipment [4, 6, 8, 10, 12]. Determination of background noise is useful for the correct...
assessment of the noise level generated by the equipment and to identify the best ways to reduce the noise level in analyzed inside into according it’s their specificity [4, 12].

The paper analyzes the noise generated by air conditioning in an amphitheater and the modality to reduce the noise level so that audition activities to can be conducted. In the analyzed academic amphitheater are organized conferences, presentations of PhD thesis, festivities granting titles, plenary sessions of the university. Given the specificity of these activities is required as the acoustical climate in this amphitheater to be one favorable for these activities.

2. METHOD OF WORK

Measurements of the sound pressure level were made in an amphitheater located in building D, first floor of the "Vasile Alecsandri” University of Bacau. The building in which the measurements were made was opened in 2010 and the amphitheater meets acoustics parameters required for the use of such rooms.

To ensure optimal climatic conditions for the performed activities in this amphitheater was designed and built an air-conditioning system to meet the needs of this room. The air conditioning system is new and operating with an air flow rate of 12,500 m$^3$/h, and speed rotations of 1000 rpm. The analyzed amphitheater has an area of 198 m$^2$ and dimensions l = 14.5 m x 14.5 m, h = 2.31 --> 4.58 m and a capacity of 185 seats (Figure 1.a and Figure 1.b). The air conditioning system is in an adjoining room of amphitheater, with the dimensions L = 3.67 m, l= 1.93 m and h = 2.89 m. The conditioned air is transmitted through seven vents located on the upper level of the amphitheater (Figure 1.a).

![Fig. 1. The amphitheater image, positioning of the ventilation holes and the measurement points of the sound pressure level (a and b).](image)

Measurements on the noise level generated by the functioning of the air conditioning were made. Because the destination of amphitheater is one of the audition was necessary as the level of noise generated by the air conditioning to be reduced.

Because the operation of the air conditioning system generate a noise level that makes it impossible communication or lectures in the amphitheater was imposed a solution by which noise is reduced. Thus was adopted as a constructive solution the use of a frequency converter. The frequency converter was of type VLT 2800 (Figure 2), and with it was reduced up to 35 % of the operating frequency of engine of the air conditioning system. The functioning converter frequency influences the rpm, frequency and voltage of the motor.

Also the initial determination to the background noise level in amphitheater has been made to identify the amphitheater acoustics. Measurements of the noise level after attaching the frequency converter were made using a noise monitoring station in nine points of the amphitheater (Figure 1.a and Figure 1.b). Registration points have been set in front three, three point in the middle of the amphitheater and three points on the back, on both sides and in the middle of the amphitheater, at a height of 1.2 m, an average height of a person in the sitting position.
The determinations concerning noise generated by air conditioning system operation was performed for various frequency of engine working, i.e. 100 %, 70 %, 50 % and 35 % power of operation.

Fig. 2. The control panel and frequency converter.

3. RESULTS AND DISCUSSION

The recorded results in amphitheater have shown that (Table 1) at an operating frequency of engine 100 % the noise level generated by air conditioning system operation exceeds the permitted limit, the more a person's speech cannot be heard under conditions in which the installation operates.

The results for the values A-weighted sound pressure level, \( L_{Aeq} \), generated by air conditioning system at frequencies working specified are shown in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>The value of the A-weighted sound pressure level, ( L_{Aeq} ) [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement point</td>
<td>1</td>
</tr>
<tr>
<td>Background noise</td>
<td>29.1</td>
</tr>
<tr>
<td>Frequency 100 %</td>
<td>72.3</td>
</tr>
<tr>
<td>Frequency 70 %</td>
<td>66.5</td>
</tr>
<tr>
<td>Frequency 50 %</td>
<td>58.8</td>
</tr>
<tr>
<td>Frequency 35 %</td>
<td>49.9</td>
</tr>
</tbody>
</table>

The measurements for noise background level shows that enclosure acoustics are in the limit values laid down by law (35 dB) for such spaces, the limit values recorded were below 30 dB. Analyzing the values for background noise was observed that they fall within a small range of variation, 26.4 dB - 29.4 dB, their variation is due to the noise from outside of the amphitheater.

After analyzing the data it is seen that the sound pressure level generated by air conditioning system at a frequency of 100 % engine, the variation domain of the noise values level were between 77.8 dB - 67.2 dB.

For a working frequency of 70 % engine the values of noise level recorded are within the range of variation of 69.7 dB - 59.3 dB, the lower values of noise level were recorded in the back of the amphitheater.

The noise level values at the operating frequency of 50 % engine are between 60.5 dB - 50.1 dB, and also was observed a decrease in these values with the increase of distance from the place of the air conditioning system.

The variation of the noise values At the working variant with a frequency of 35 % of the motor are between 52.1 dB - 43.1 dB, situation in that can perform the specific activities intended this amphitheater.

By the method chosen, by the gradual reduction of frequency of the engine it is reduced and noise level generated of the air conditioning system. Attenuation values of the sound pressure level were calculated by reporting the noise values at frequencies of 35 %, 50 % and 70 % at engine operation on the air conditioning system with the operating frequency of 100 % for all nine measurement points. The values of noise attenuation are represented in Figure 3.
The noise level attenuation, $L_{Aeq}$ (dB)

Frequency (Hz)

Fig. 3. Graphical representation of the attenuation variation of sound pressure level by reporting to the operation values of the air conditioner system at working frequency of 100% for the nine measurement points: 1 to 9 - measuring points.

As can be seen in Figure 3 by reducing the working frequency engine of the air conditioning system the noise generated by that one is reduced with values between 26.4 dB - 17.4 dB for case where it a reduction in frequency working at 35%, with values between 17.3 dB - 9.8 dB for case where it is reduced the engine working frequency at 50% and values only between 8.1 dB - 3.3 dB in case where is reduced the engine working frequency at 70%.

As a result of the working frequency decrease is increased the time in which the ambient of the amphitheater is brought to desired temperature. In this sense measurements were performed for four days on the indoor and outdoor temperature environment, between the hours 8.30 to 4.30 p.m.

By monitoring for four days the values of the amphitheater temperature and temperature of the external environment it was determined the dynamic of variation of these values depending on the working frequency of the motor (Figure 4). Thus, measurements were made for the working frequencies of the engine specified above (100%, 70%, 50% and 35%).

Fig. 4. Graphical representation of the variation of temperature values on the indoor and outdoor of amphitheater reported at the frequencies of the engine working for the air conditioning system.
As can be seen in Figure 4, the outside temperature values have an increasing dynamics. The range of these values are between 16 °C - 18 °C at 8.30 in the morning and in the range 19 °C - 27.5 °C at 16.30 in the afternoon. The value of 19 °C was recorded on the fourth day, when the temperature abruptly decreased with 5 °C at the last hour of monitoring.

In regards temperature values recorded in the amphitheater can be observed a gradual decline for the first two hours of operation of the air conditioning system for all four working frequency of the engine.

Temperature between the hours 10.30 - 13.30 it was kept constant with values between 19.9 °C - 20.9 °C for the engine working frequency of 100 % and 70 %. The other time intervals have a increasing the temperature value to 21.7 °C for a frequency of the engine 100 % and at 20.8 °C at the 70 % frequency of the engine. This fact demonstrates that the indoor temperature is influenced by the temperature of the outdoor environment, due to the fact that the air conditioning system works with air supply from the outside.

Temperature between the interval time 10.30 - 13.30 it was maintained constant with values between 19.9 °C - 20.9 °C for the engine working frequency of 100 % and 70 %. The other time intervals have an increasing of the temperature value to 21.7 °C for a frequency of the engine 100 % and at 20.8 °C at the 70 % frequency of the engine. This fact demonstrates that the indoor temperature is influenced by the temperature of the outdoor environment, due to the fact that the air system works with air supply from the outside.

A constant temperature was observed at the engine operating frequency of 50 %, in time interval 11.30 - 15.30. An increase of indoor temperature values was observed at the last measurement because the outdoor temperature was around 24 °C. At engine operating frequency of 35 % in the time interval 10.30 - 14.30 was observed a constant temperature and the last two time intervals was observed a small increase by 0.2 °C, due to the outdoor environment temperature of about 24 °C.

4. CONCLUSIONS

The measurements for noise level generated by functioning of air conditioning system have revealed that noise level of the amphitheater did not allow the specific activities in the amphitheater. Was imposed the adopting a constructive solutions whereby noise level to be reduced, so was used a frequency converter.

The background noise measurements have shown that the amphitheater has specific characteristics for such enclosures, the values of the background noise level below 30 dB.

By analyzing the noise values obtained as a result of monitoring the operation of air conditioning system at different working frequencies it has been observed that these values are reduced to values up to 26 dB, depending on the operating frequency and the distance to the location of the registration point to the air conditioning system.

The attenuation values of the sound pressure level in the nine monitoring points have shown that the air conditioning system can function at working frequency of 35 % and it may perform specific activities to the amphitheater purpose.

By monitoring the outdoor temperature of the amphitheater was observed that the temperature of the indoor environment is influenced by the ambient temperature outside because the air conditioning system works with outside air input.

REFERENCES