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DETECTION OF BUILDING ACOUSTIC DEFECTS BY THE SOUND VISUALIZATION TOOLS

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Abstract: Sound visualization tools are powerful tools for identifying and locating noise sources. They are widely used in various sectors of industry. Noise visualization tools are often used for comprehensive knowledge of noise sources, which serves as a basis for subsequent implementation of noise reduction measures. They are also often used to optimize the acoustic properties of household appliances. A new area in the application of noise visualization tools is the area building acoustics. Acoustical defects in buildings are just as important to recognize, diagnose and remedy as common building defects. Both types of defects occur in buildings for similar reasons and these range from design and constructional errors to the breakdown of building materials or elements. At present, demands on acoustic parameters of building structures are increasing. Many people complain about the inadequate acoustic quality of the partition walls even in new buildings. Using visualization tools, it is possible to detect deficiencies in building structures such as perimeter walls, partition walls, roof structures and windows. This method is non–destructive and produces fast results. The result of such visualization is the precise identification of the critical points and their location. The most commonly used visualization tool is acoustic camera.
Keywords: sound visualization, building acoustic, defects, acoustic camera

1. INTRODUCTION

Noise visualization makes it possible to find a connection between vision and hearing [2]. The results of noise visualization are acoustic images [3], where the color noise fields show noise emissions from individual parts of the visualized object. Noise visualization is done through noise visualization tools [1, 16, 20]. The basic design elements of these instruments are sensors [6], especially microphones. Microphones are arranged in microphone arrays and include a camera. Noise visualization tools currently use different principles. The basic principles of noise visualization are beamforming, focalization, acoustic holography and direct methods [4]. These basic principles of noise visualization have their advantages and limitations. Manufacturers apply these methods to noise visualization tools. The design of these tools is different depending on the visualization principle used. The main differences between these devices are their application area. The main differences are the frequency ranges, measuring distances and the size of the examined object [18, 21].

The application areas of these devices are diverse and apply in different areas of industry. The basic task of these visualization tools is identification and localization of partial noise sources [24]. Results are presented by the acoustic pictures and acoustic videos [5]. The result of noise visualization allows a comprehensive knowledge of the source and subsequently forms a suitable basis for noise reduction measures [23]. Other tools for understanding acoustic properties of sound are psychoacoustic methods and subjective noise assessment methods. These methods make it possible to assess the sound quality parameters [19].

2. NOISE VISUALIZATION TOOLS

Noise visualization tools are nowadays available from different producers. Noise visualizations tools are often also called acoustic cameras.

Noise visualization tools consist of three basic components (Figure 1) [7]:

- microphone array,
- data recorder unit,
- notebook with post processing software.

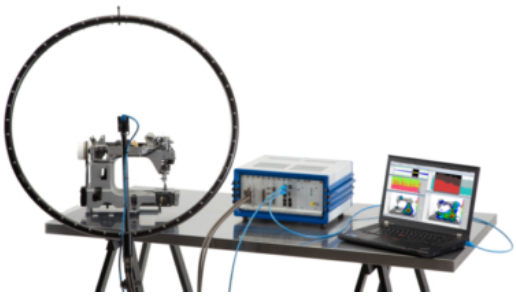

Figure 1. Basic component of noise visualization tools [15]

Noise visualization tools that are using beamforming principle are suitable for measurement distances from 1 m up to 300 m and frequency range from 300 Hz – 10 000 Hz. The measuring distance depends on the design of the microphone array. Figure 2, Figure 3 and Figure 4 present different construction of beamforming microphone arrays [10, 14]. Focalization is method very similar to beamforming, but the main difference is in distance field. Focalization technique use near field and microphone array is located close to sound source [12, 13] Microphone array based on near field acoustics present Figure 5.

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Figure 2. Microphone arrays of noise visualization tools – Ring72 AC Pro [11]

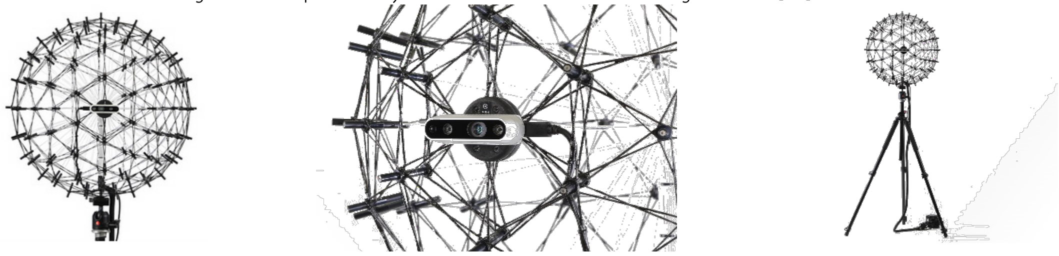

Figure 3. Microphone arrays of noise visualization tools – Sphere80/120 AC Pro [11]

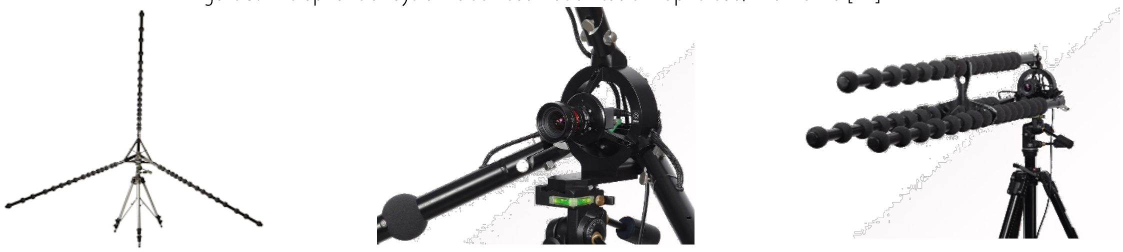

Figure 4. Microphone arrays of noise visualization tools – Star48 AC Pro [11]

Figure 5. Microphone arrays of noise visualization tools – Evo AC Pro [11]

Direct methods of sound visualizations require using of special combined sensors [8]. Principle is based on the direct measurement by this sensor. Sensor is measuring sound pressure level and particle velocity [9]. Position of the sensor is very close to measured surface and surface is manually scanned [22]. Also, these process is recorded by the camera. Combined sensor for noise visualization presents Figure 6.

Figure 6. Combined sensor for noise visualization [17]

3. DETECTION OF BUILDING ACOUSTIC DEFECTS

The quality of building structures is often discussed. Standards specify requirements for airborne sound insulation of perimeter walls or partition walls. Customers often complain about the poor quality of partition structures. The reduced acoustic quality of the building construction can be caused by the material used and is manifested as a whole element of low acoustic quality.

Often the cause of the reduced quality of building structures is their weakened part. Weakness can be caused by several reasons. One of the possible causes is insufficient connection of partition structures to floors and ceilings, poor installation of windows, disruption of the integrity of the walls due to wiring and other installation components. Detecting these defects is very difficult as it is inside the building structure and these parts are not visible and difficult to access.

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One of the possible solutions to detect these defects is the use of noise visualization tools.

The measurement procedure consists of visualizing the transfer points through the building structure, with an omnidirectional loudspeaker generating white noise on the other side of the building structure. Figure 7 presents the installed acoustic camera during the measurement.

For noise visualization of building elements was used acoustic camera with ring array. Principle of detection of building acoustic defects in the creation of acoustic images and their analysis. Based on the created color fields and the position of the omnidirectional loudspeaker, it is possible to detect building acoustic deficiencies of the partition walls. In the case of a wall without defects, the colored noise fields will be centered with the position of the noise source located behind the wall. Figure 8 presents the noise visualizations of the wall without the defects.

Figure 7. Installed acoustic camera during measurement

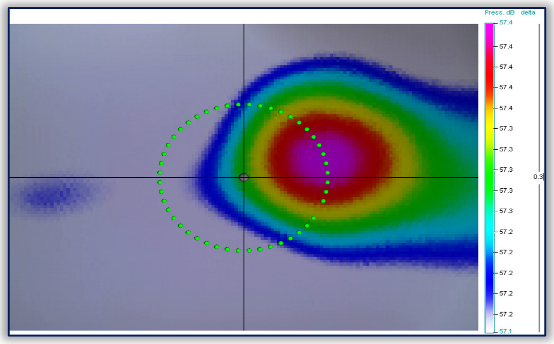

Figure 8. Noise visualization of the wall without defects

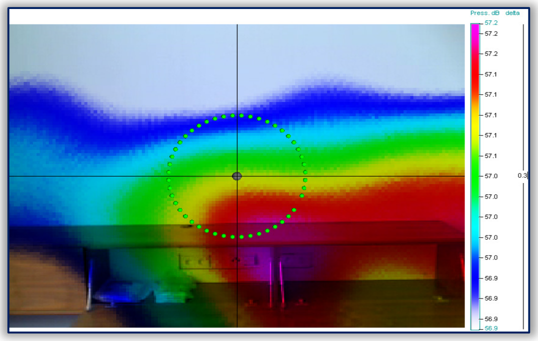

Figure 9. Noise transfer through electrical installation elements

In the case of structural acoustic deficiencies, the colored noise fields indicate the areas with the greatest acoustic energy transfer. Figure 9 presents noise transfer through electrical installation elements. In these parts the partition walls were weakened and the electrical outlets were improperly fitted.

Another example of possible noise transmission is poor connection of partition walls to perimeter walls presents Figure 10.

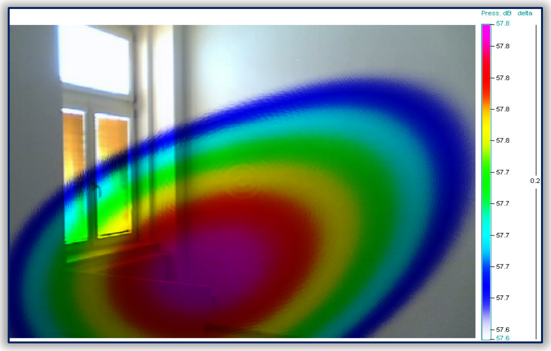

Figure 10. Noise transfer through the wall connection

Figure 11. Noise transfer through the window elements

Windows are another example of possible noise transmission into rooms. The windows are the weakest element of the perimeter walls, but it is the visualization of the noise that it is possible to detect the deficiencies of the windows. The shortcomings are mainly due to poor window fitting or damaged seals. By visualizing the transfer of noise through windows or their mounting, it is possible to detect these defects. Figure 11 presents the noise transfer through the window.

4. CONCLUSIONS

The use of visualization tools is widely used in various fields. It provides fast results and development times. It provides these noise visualization bases to improve the acoustic properties of noise emitting devices. One of the new areas of application of visualization is building acoustics. Such disturbances can be detected by noise visualization methods. Detecting these disorders is very difficult by other methods. Noise visualization methods are non–destructive methods, so there is no disturbance to building structures. By detecting these disorders, it is then possible to propose measures to eliminate them. These measures will

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increase the acoustic quality of partition structures and ensure that the sound insulation requirements of building structures are met in accordance with applicable standards.

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