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NOISE CONTROL FOR A BETTER ENVIRONMENT

Visualization of the radiation of sound for selected devices

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ABSTRACT

Registration and imaging of noise emitted by machines and devices allow to visualize of various sound parameters. Such images can be widely used in the assessment of the project, or to improvement existing machines. The appropriate techniques and measurement systems may be used for identification of primary noise sources. Created images are also a useful tool to verify the results of numerical simulations, that is why properly prepared visualizations can be widely used in industry. The article presents visualizations of noise for selected devices, obtained by means of two measurement methods, the first based on the measurement of acoustic pressure and the second based on the measurement of the acoustic particle velocity.

Keywords: Machinery noise, Working environment, Visualisation
I-INCE Classification of Subject Number: 10

1. INTRODUCTION

Noise is the most common harmful factor in the working environment in Poland. The basic and the most important method of noise protection is to reduce noise emission at source. Methods for determining the location of sources and evaluation of directional effects of sound radiation are therefore significant issue of vibroacoustics. Reducing the noise hazard is a priority objective of vibroacoustics research [1], and modern technology allow for the realization of this goal in many ways. Such studies rely mostly on measuring the values of acoustic parameters for specific points in space and using an appropriate processing algorithms to obtain the visualization of acoustic field. Visualizations of the acoustic field are primarily colored graphical information that presenting the values of acoustics parameters in specific space. This images provide a lot of information that can be used by engineers to improve their products. Two methods commonly used for this purpose are beamforming and acoustic holography. Both methods have advantages and disadvantages that define the possibility of using a given method to visualize noise emissions in various situations and for various types of objects. This paper describe the basic information about beamforming (based on the measurement of acoustic pressure) and acoustic holography (based on the measurement of the acoustic particle velocity). The measuring systems that are used in the Central Institute for Labor Protection - National Research Institute and exemplary visualizations of sound radiation for selected devices are presented.

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2. MEASUREMENT TECHNIQUES

2.1 Beamforming

Beamforming is a method based on sound pressure measurement through a microphone array. Obtained signals are analyzed by using amplitude-phase relationships. The image resolution depends on: the measurement distance between the noise source and the measuring points, on the size and structure of the microphone array, number of microphones and the distance between microphones [2]. The advantages of this method include short measurement time and the ability to measure in dynamic situations regarding both the situation (noise emitted by moving objects) and the type of noise (non-stationary noise). The fact that the method is susceptible to additional sources of noise and reflections of acoustic waves affects the method is used in free field conditions. The beamforming method have found applications in many branches of industry, among others, in automotive industry [3, 4] as well as the study of noise generated by the rail vehicles [5, 6]. Currently, many producers create microphone arrays with different geometry and numbers of microphones. In the studies described in next chapter the microphone array AC_MA_PADDLE2x24 (gfai Tech GmbH), was used. It is a rectangular microphone array with dimensions of 30 x 33 cm, containing 48 microphones mounted in two planes. Registration and signal processing is performed by using NoiseImage software.

2.2 Acoustic holography

In contrast to the above mentioned, the acoustic holography is based on simultaneous measurement of sound pressure level in two planes or directly measure acoustic particle velocity, which allow for direct determination of sound intensity level. This allow to create three-dimensional vector maps with information about the energy distribution and processes occurring in the acoustic field. Many kind of the acoustic holography method has been developed, for example: STSF (Spatial Transformation of Sound Fields), SONAH (Statistically Optimised Near-field Acoustic Holography) like also WBH (Wideband Holography). Similarly as in beamforming method, the acoustic holography found applications in automotive industry [7, 8], in the study of aircraft engines [9] as well as examination of industrial noise at workplaces [10]. In the studies described in next chapter the Microflown Technologies measuring system called Scan & Paint 3D was used. The system consists on the microphone (to measure sound pressure level) and anemometric probe that allowing direct measurement of acoustic particle velocity in three directions. The system is intended for measure stationary noise. The advantage of the system is the ability to perform measurements of noise emission for object of any geometry. The system include a probe position tracking subsystem with infrared camera and the appropriate marker. The disadvantage of the system is susceptibility to air flow around the measuring probe and long time to prepare the system for measurement. Registration and signal processing is performed by using Velo software.

3. VISUALIZATIONS OF RADIATION OF NOISE

In this chapter the results of visualization made with the two methods are presented. Measurements were carried out in semi-anechoic chamber. The objects were placed on the reflecting surface. Two sources of noise were selected. The first tested object was a laboratory function generator. During the measurements, the generator was set on the feet (Figure 1a). The second object was a rotary vane vacuum pump (Figure

1b) used mainly at industry for food processing and packaging and in many different environmental application.

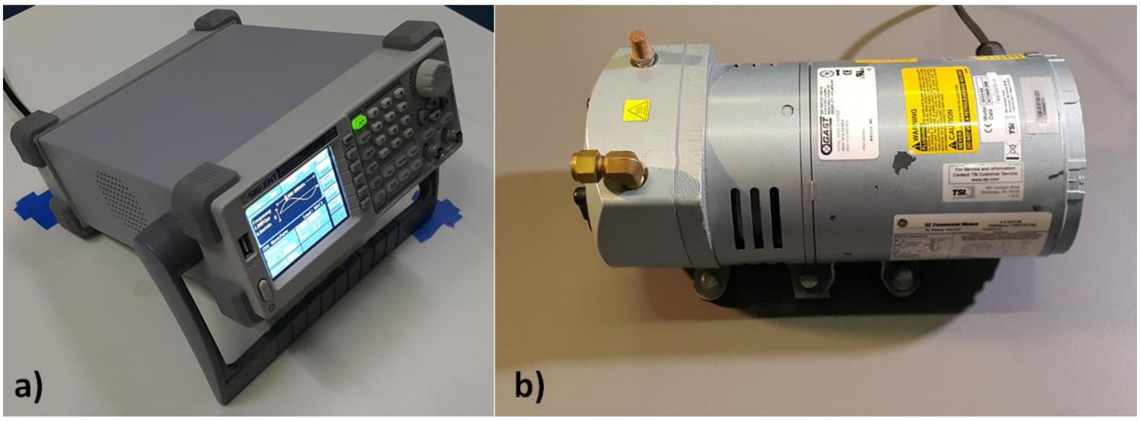

Figure 1. Research objects a) Function generator b)Vacuum pump

For the beamforming method, the total measurement time was 2 seconds for both tested objects, function generator and vacuum pump. The distance between microphone array and object was 15 cm. In the case of the acoustic holography method the duration of measurements was: 12 minutes and 30 seconds for the function generator and 15 minutes for the vacuum pump. Measurements were carried out at a distance of 2 cm to 20 cm from the object.

In the first step the spectrum of the signals has been determinated. Spectrum calculations have been made for 4096 points of FFT and Hanning window type. The spectrum of noise generated by function generator was determinated by both (NoiseImage for the beamforming, Velo for the acoustic holography) software. The results are shown in Figure 2.

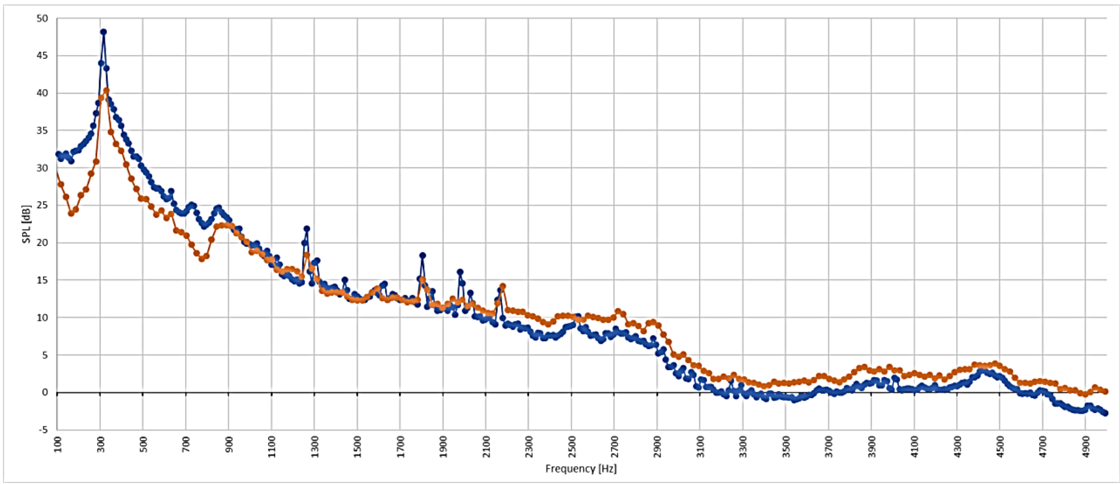

Figure 2. Spectrum of the signal generated by the function generator (orange - AC_MA-PADDLE2x24, blue – Scan & Paint 3D)

The spectra of the signals are similar for both methods. Maximum amplitude of signal occurs at 330 Hz and it is related to the work of the fans. The visualizations created for frequency 330 Hz (for both systems) are shown below in Figures 3-6.

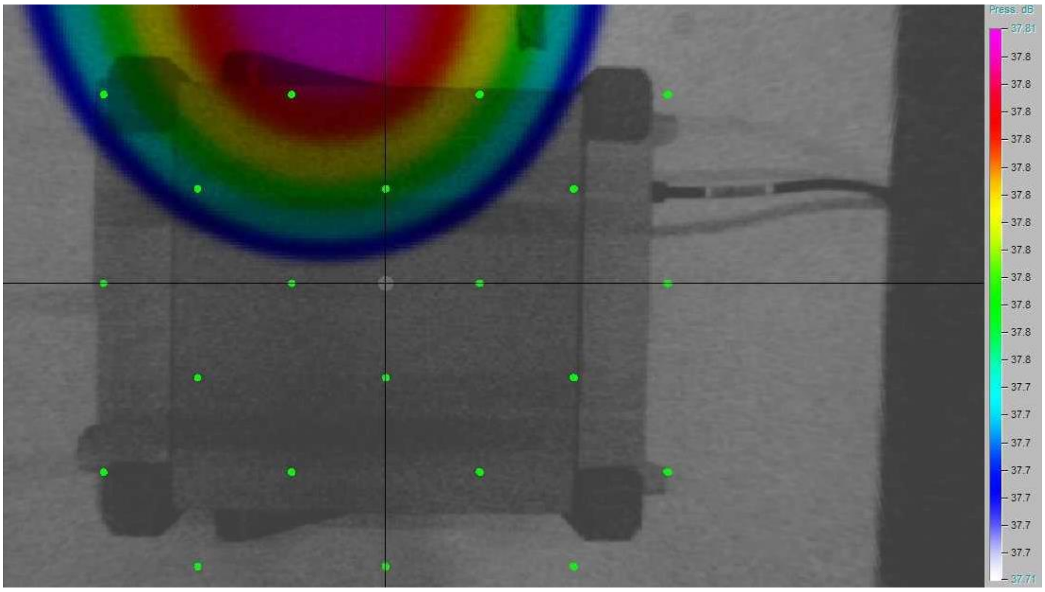

Figure 3. Visualization of noise emission in horizontal plane (by using beamforming)

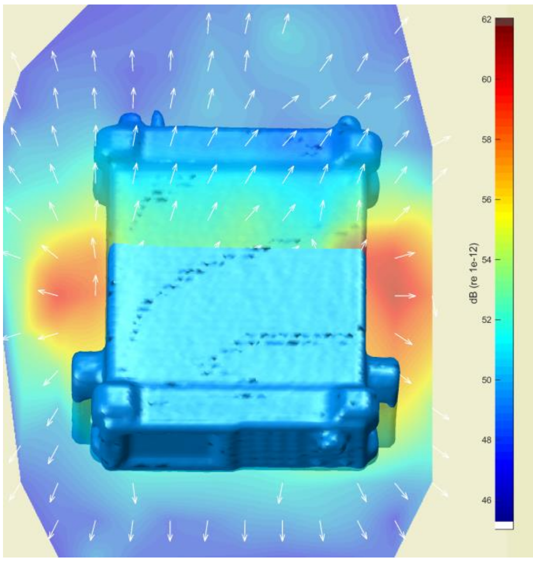

Figure 4. Visualization of noise emission in horizontal plane (by using acoustic holography)

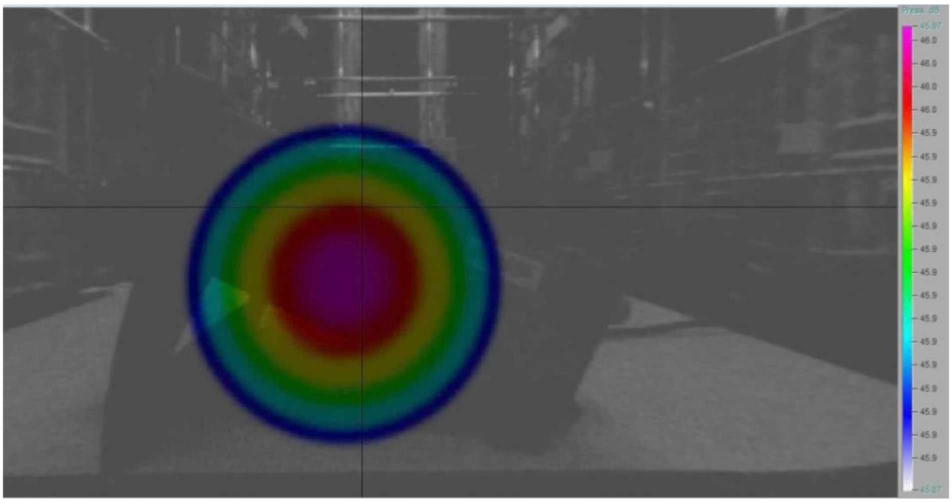

Figure 5. Visualization of noise emission in vertical plane (by using beamforming)

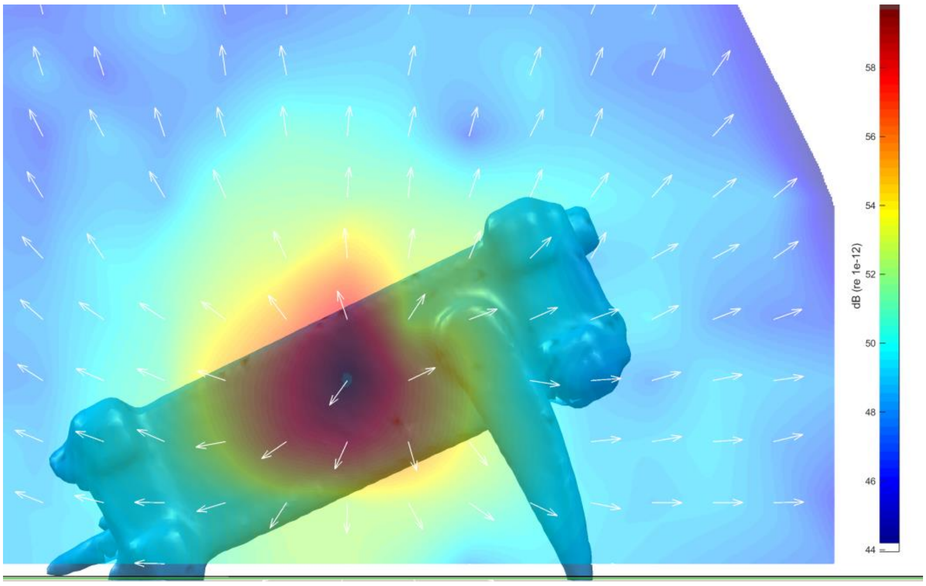

Figure 6. Visualization of noise emission in vertical plane (by using acoustic holography)

In the case of the measurement carried out by using microphone array AC_MA_PADDLE2x24 and beamforming method sound pressure level distribution was presented. The results of measurements performed with Scan & Paint 3D system present the sound intensity with vector distribution. For vertical plane both systems shown the main source of noise emission near ventilation holes where the fans were working. For the horizontal plane the beamforming method indicate only one source of noise emission. Visualizations obtained by using acoustic holography were illustrated for a horizontal plane passing through the center of ventilation holes area and clearly indicate two sources of noise emission.

The second example of measurements concerns the noise emmision of vacuum pump, the spectral analysis are shown in Figure 7.

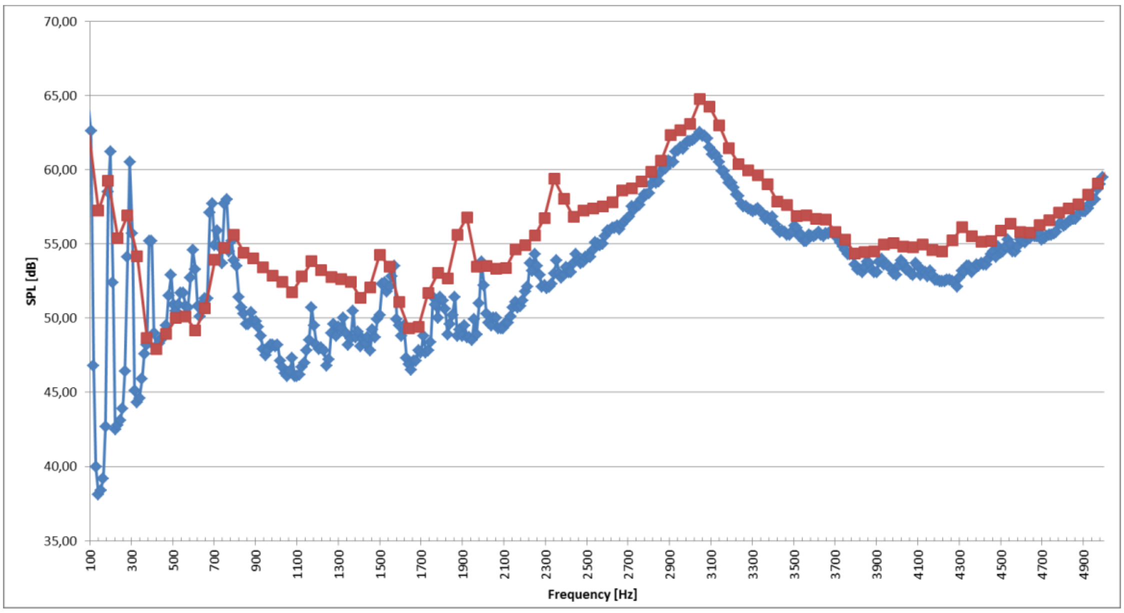

Figure 7. Spectrum ofthe signal generated by vacuum pump (red - AC_MA-PADDLE2x24, blue – Scan & Paint 3D)

For this case the spectra indicate bigger differences between both methods than first example. This may be due to proportion of time in which the measurements with using USP-probe were carried out in more distant than 15 cm. Frequencies 750 Hz and 3100 Hz were selected to visualization and the images were created for two planes.

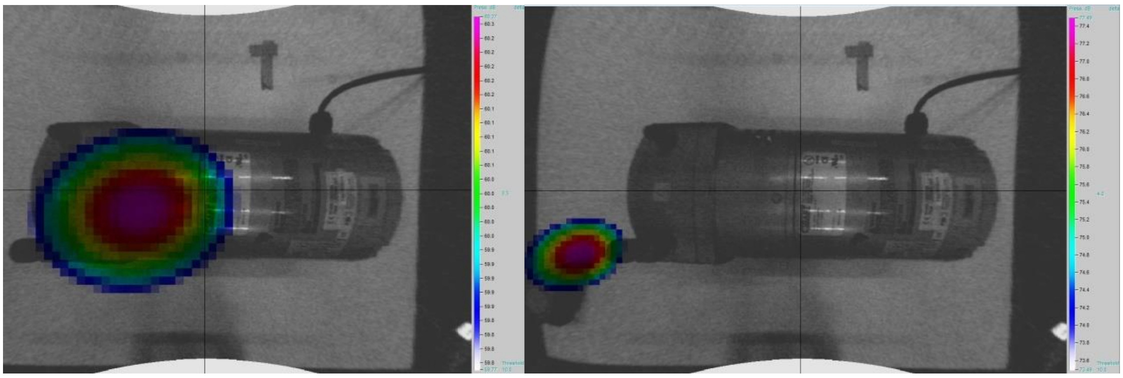

Figure 8. Visualization of noise emission in horizontal plane for frequency: 750 Hz – on left, 3100 Hz on right (by using beamforming)

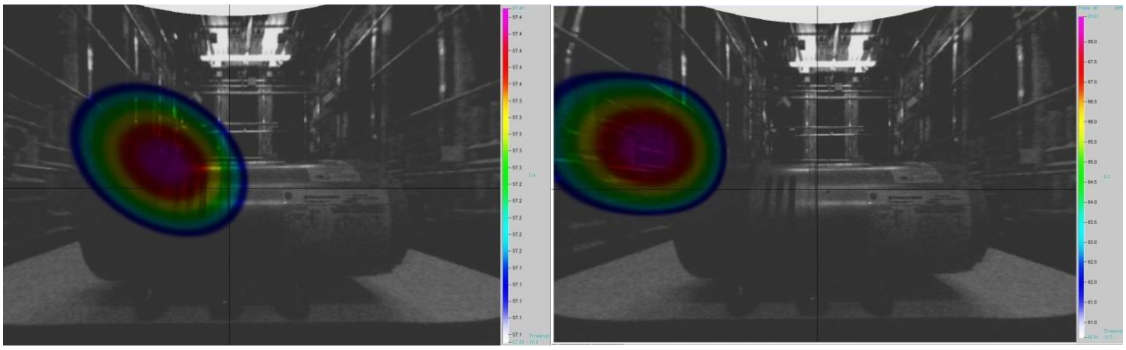

Figure 9. . Visualization of noise emission in vertical plane for frequency: 750 Hz – on left, 3100 Hz on right (by using beamforming)

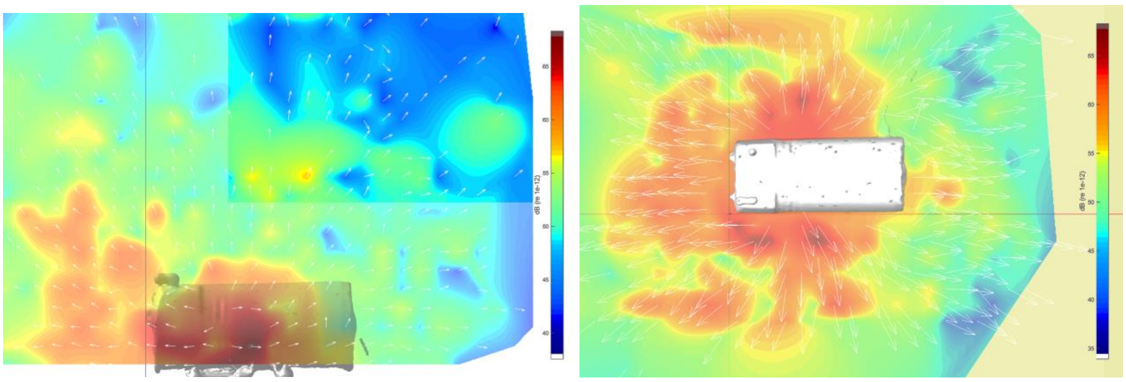

Figure 10. Visualization of noise emission for frequency 750 Hz, in two planes (by using acoustic holography)

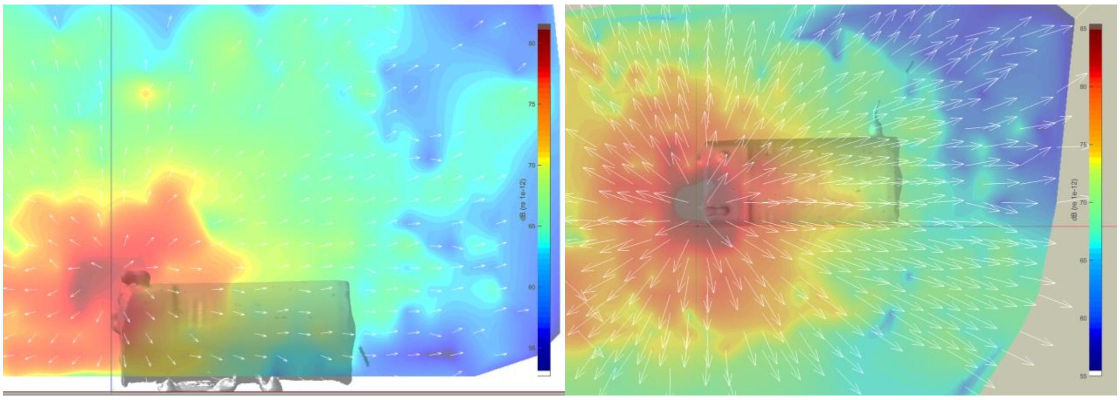

Figure 11. Visualization of noise emission for frequency 3100 Hz, in two planes (by using acoustic holography)

The presented visualizations illustrate the main sources of noise emission for given frequencies in similar places. Visualizations for 750 Hz indicate the element with the ventilation holes of the blade guard. In the case of visualization prepared for the frequency of 3100 Hz, the pump valve were indicated as the main source of noise by both methods.

4. CONCLUSIONS

The measurement of noise emission of two objects (the function generator and the vacuum pump) by using two alternative measuring methods – beamforming and acoustic holography has been carried out. The comparison of spectral analyzes of the measurements and the visualizations of noise emission for two measurement planes was made. In most cases the beamforming and acoustic holography gave consistent results and identify the source of the noise emission in same place. The exception was the lack of indication of one place of the fan noise emission for microphone array and beamforming method. The reflecting surface or incorrect postprocessor settings could been a reason of this mistake.

5. ACKNOWLEDGEMENTS

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