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NUMERICAL AND EXPERIMENTAL VISUALIZATION OF ACOUSTIC FLOW OVER FLAT OBSTACLES

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Energy distribution images in acoustic fields, connected with the graphical presentation of the flow waves are a new element in acoustic metrology. Introduction of these possibilities have greatly changed the approach to examining many acoustic phenomena.

The new insight into the nature of acoustic field formation in real conditions of working sources may bring application of the sound intensity method in conjunction with the graphical presentation of space vector distribution of acoustic power. Acoustic conditions in these areas are much different from the theoretical assumptions ascribed to free or diffuse field. It is a frequent occurrence that the sound intensity measurements in real conditions may show great disparity between the theoretical assumptions of the acoustic fields distribution and the actual measurements. The disparity results mainly from simplifications accompanying the analytical and numerical methods due to lack of complete data concerning physical properties of an investigated object (de Rock at al. 2004).

In the paper authors have described the visualization methods in acoustic flow fields around and between a flat barriers and show how these methods may assist scientists to gain understanding of complex acoustic energy flow (vortisity and turbulent effects) in real-life acoustic field. Own proposals of the graphical form will be presented to determine the real acoustic wave distribution in 2D and 3D flow field. Visualization of research results are shown in the form of a *intensity streamlines* and as a *shape of floating acoustic wave* or *intensity isosurface*, which is unavailable by conventional acoustics metrology.

In traditional acoustic metrology, the analysis of acoustic fields concerns only the distribution of pressure levels (scalar variable), however in a real acoustic field both scalar (acoustic pressure) and vector (the acoustic particle velocity) effects are closely related. Only when the acoustic field is described by both potential and kinetic energies may we understand the mechanisms of propagation, diffraction and scattering of acoustic waves on obstacles, as a form of energy. This attribute of intensity method is very important in any industrial acoustic investigations. Based on the research with intensity technique and using selected visualizations methods (Pyła, Weyna 2010), examples of vector space distribution of the real acoustic field are demonstrated in the publication.

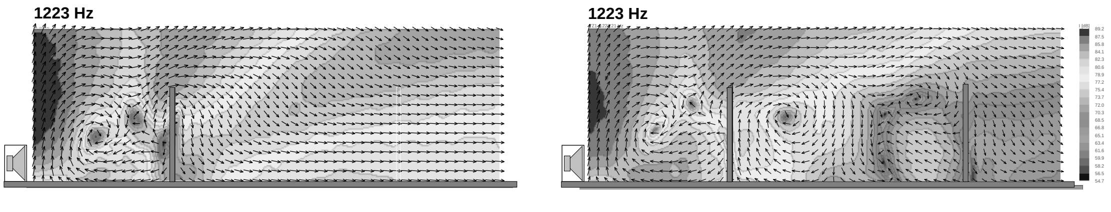

Fig. 1. Shapes of acoustic intensity vectors map describing the reaction of flow wave striking the single and double thin barriers

Analysis of the results makes it possible to obtain much new information about energetic and geometric distributions of the acoustic fields. The measurement technique described, as well as the method of graphical presentation of results, can enrich the knowledge of the mechanism of acoustic energy flux through the real partitions.

Investigated models with palisade barriers (number of flat acoustic scatterers) should imagine noise-generating rotating machinery equipped with a propeller blade. The reduction of noise by active flow control is a method sought out for practical noise abatement in many industrial fields. For simplicity, in our model we assume that the blades are distributed linearly. In our research we are interested in the energy distribution of the acoustic field around obstacles. Shapes of acoustic intensity vectors map describing the reaction of acoustic flow wave strike the thin single and double barriers shown in the Fig. 1. This is a comparative test, what sort of reaction can be observed while a running acoustic wave hits a single or two obstacles during the same excitation signal.

Numerical simulation was performed in *Acoustic Module* of COMSOL Multiphysics 4.0a. The software employs *Finite Element Method* for solving acoustic wave propagation, described by linearized fluid and solid dynamics equations. The *Pressure Acoustic Interface* and *Frequency Domain Study* was used. For modeling of acoustic phenomena, Helmholtz's equation for lossless, inhomogeneous medium was used. The frequency response was computed with a parametric sweep over a frequency range using a harmonic load.

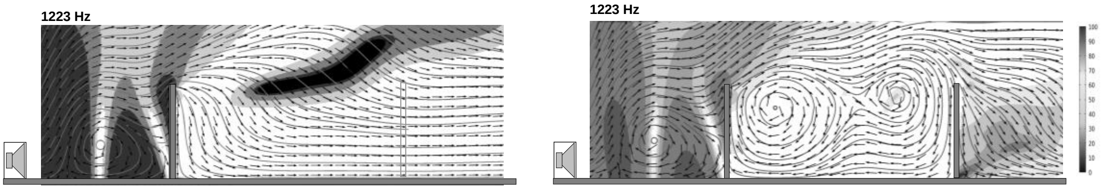

Fig. 2. Acoustic flow numerically modeled by the physical model shown in Figure 1

The model was designed as a two-dimensional structure. On the rectangular plate dipole source was placed in the cabinet (to the modeled space radiates only one side of the source) and two flat obstacles. Numerical study area was modeled in the form of a semi-circle whose base coincides with the surface of the plate. To minimize the impact of the shape of the modeled space on the phenomena occurring inside that space, the semi-ring of the PML elements was used.

Model was meshed with the use of *Free Triangular* elements. The maximum and minimum size of PML elements defined respectively as 0.02 m and 0.01 m. The rest of model was meshed with the use of elements with size in range from 0.0008 m to 0.005 m. Complete mesh of model with one obstacle consists of 89430 elements and model with two obstacles consist 89824 elements.

Although the numerical model was not very accurate, comparing the results of numerical modeling studies with results from the physical model for the same frequencies (on Fig.1 and Fig.2 -1223 Hz) we can conclude that the modeling results are encouraging. Further studies will be aimed at finding numerical modeling tools (CAA) which will be more similar to acoustic flows examined with SI method.

References

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