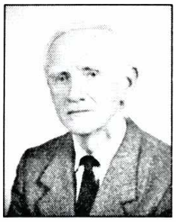

STEFAN WEYNA, Assoc.Prof.,D.Sc.,E.E.
Technical University of Szczecin
Faculty of Marine Technology
Department of Applied Vibroacoustics

An experimental research on the noise energy radiated from ship partitions

SUMMARY

The paper presents an application of the sound intensity (SI) technique to assessing the effects of ship vibrations on the noise energy radiated by ship partitions. Example measurement results are given to illustrate the application of the SI technique to practical problems of the noise abatement on ships. The results are shown in the form of a two and three-dimensional flow map of active intensity vectors, graphically interpreted for the heterogeneous cabin partitions. The measurement technique as well as the way of graphical presentation can enrich the knowledge of the mechanism of acoustic energy flow through the real ship partitions.

SOUND INTENSITY RESEARCH IN VECTOR ACOUSTIC FIELD

The spatial distribution of acoustic energy in a field restricted by partitions depends mainly on the ratio between the room dimensions and length of wave radiated by a source placed inside it or by acoustically active partitions of the room (structure-borne noise). In order to determine the parameters of an acoustic field by means of computational methods one of the methods based on geometrical or statistical wave models can be used [1 to 5]. Each of the methods has different usability ranges, and serious simplifications usually are necessary to apply them in practice. Hence it seems that no contemporary theoretical method of modelling acoustic fields in acoustically small rooms can give a proper description of the acoustic energy field distribution.

Attempts to applying field modelling to small parallelepiped rooms (e.g. to problems connected with acoustic protection of ship living quarters) also face many difficulties and limitations. The literature seldom provides publications in which the results of analytical model calculations are verified by experimental tests. At best, such an analysis concerns only a distribution of pressure levels i.e. a scalar parameter of an acoustic field. However, a close connection between scalar and vector effects exists in a real acoustic field. It is a scalar-vector description of an acoustic field, represented by two forms of mechanical energy : potential and kinetic energy that fully explains the physical meaning of wave phenomena, and makes it possible to consider the mechanisms of sound propagation, radiation, diffraction or scattering.

A good form of illustration of the scalar-vector phenomena occurring in real conditions is the application of the SI technique (for tests in which the product of the pressure and particle velocity of the acoustic wave is measured by means of a proper measurement probe : of *p-p* or *p-v* type). The visualisation of the distribution of the active and reactive parts of the acoustic field makes it possible to fully analyze an acoustic travelling wave. The properly used SI method ensures the chance of measuring the vector distribution in any place of the restricted space even within a near field. Simultaneously it is convenient for empirical verification of the field parameters determined by means of a computational method. Such verifying tests have shown how much a theoretical image of an acoustic field distribution may differ from those obtained from measurements in real conditions. The differences mainly result from the applied simplifications or because of the impossibility to determine the real physical features of the tested area. The degree of discrepancy between modelling results and the real structure of the field formed in the room tested grows proportionally with the degree to which simplifying assumptions in the calculations differ from the conditions encountered in reality.

The contemporary computer techniques make it possible to take into account interaction of many factors shaping the acoustic field in closed areas. However there is no complex theory that would fully explain the acoustic phenomena taking place in them.

Nevertheless most analytical relationships describing the phenomena occurring in an acoustic field refer to a free and diffusive field, or an acoustic field in homogeneous ducts at frequencies below the cut-off ones. In reality, however, there are no compartments which could be fully qualified as containing free or diffuse fields.

The geometrical approach to room acoustics, although very useful in certain applications, is not a satisfactory method for explaining the behaviour of sound within an acoustically smal enclosure. A more adequate, but difficult, approach is based upon wave acoustics, i.e. upon the motion of sound waves within a three-dimensional enclosure. This method is characterized by the establishment of boundary conditions which describe mathematically the acoustical properties of the walls, ceiling, and other surfaces in the room [6].

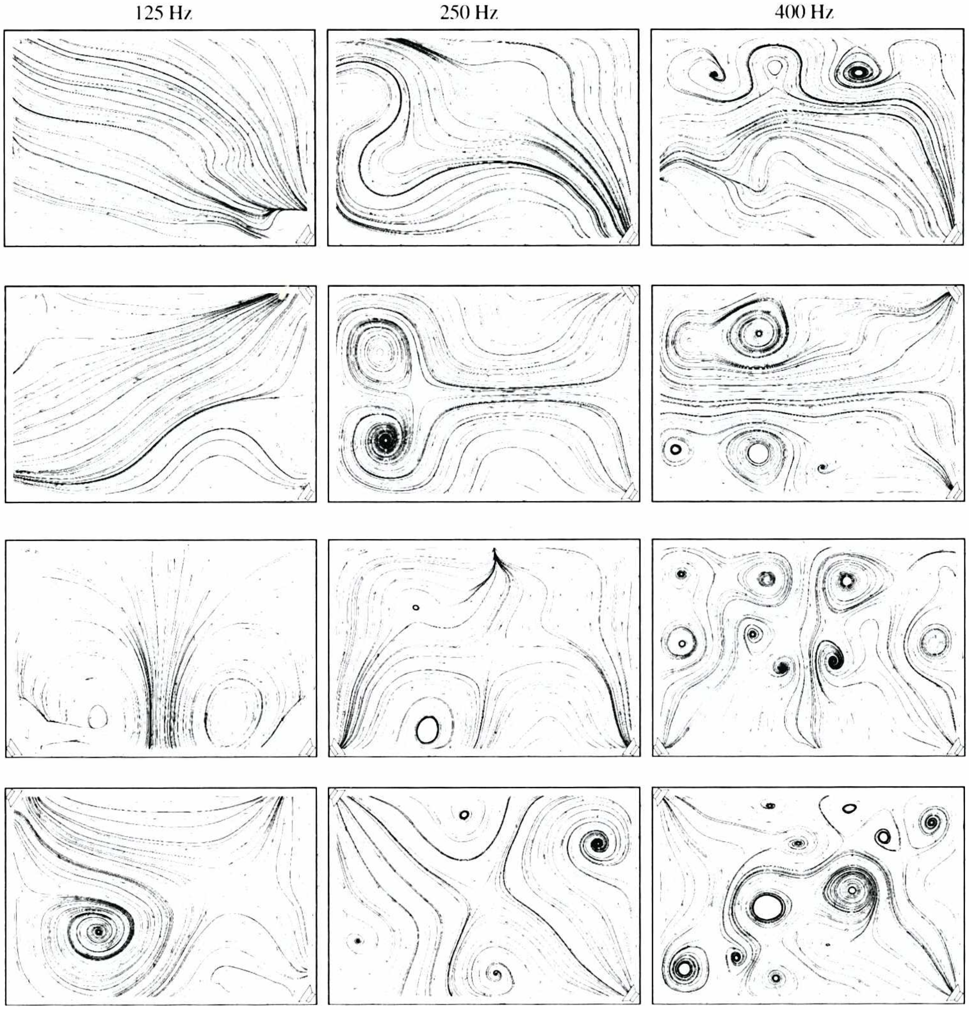

Fig. 1. *Vector field distributions in a model of ship cabin with acoustic source inside (loudspeakers in the corners), frequency 1/3 octave bands: 125, 250 and 400 Hz*

One of the biggest limitations in using classical wave theories for acoustic field analysis in real rooms is great variety of the inside shapes of rooms and the heterogeneity of the absorption properties of partitions [7]. In most rooms the floors are made of materials of much higher absorption coefficient than that of the walls. The furniture and other equipment cause irregularities in the acoustic field. For such kind of rooms it is not possible to use directly Sabine's theory, or its modification [8]. It results from the fact that their basic assumption is field isotropy, i.e. they refer to fields in which energy density is the same at each point (*diffuse field*). However there are no fields of purely diffusive nature in practice. The attempts to overcome the difficulty [9,10] refer only to limited frequency ranges corresponding to wave lengths comparable with the room dimensions, which results in neglecting interference phenomena.

Application of the SI method, including the presentation of space vector distribution of acoustic power, may bring new insight into the nature of acoustic field formation wihin small limited areas. Acoustic conditions in such areas are much different from the theoretical assumptions ascribed to free or diffuse field. The sound intensity measurements in real conditions very often show great disparity between the theoretically determined acoustic field distribution and that measured.

One of the main advantages of the SI method is the ability (unavailable to conventional methods using microphone) of identifying the structure-borne noise energy transmitted through different parts of vibrating structure, which is very useful in studying acoustic field phenomena inside crew cabins.

The SI measurement technique is also applicable to measuring directly the sound power output of individual noise sources.

In the last decade the SI method has become one of the most interesting measurement techniques, effectively replacing classical methods [12,13]. In contrast to the latter, the measurements carried out in field conditions are not less accurate than any laboratory tests. Measurements can be conducted in the near field and in the presence of secondary and parasitic noise. This is a crucial asset for industrial acoustic tests and that is why the method is significant for both practical and scientific investigations.

The aim of the paper is to present applications of the SI technique to in-situ measurement of the acoustic radiation efficiency of non-homogeneous ship bulkheads, as well as to vector analysis of acoustic power radiated from those partitions. In result, a two or three-dimensional flow map of time-averaged active intensity vectors propagating along curved streamlines is obtained.

The application of the SI method may bring new insight into the nature of acoustic field formation in small and limited areas as ship accommodations. Acoustic conditions in the areas are much different from the theoretical assumptions ascribed to free or diffuse field. In ship acoustics it stands to reason that sound intensimetry should be more effective than a sound pressure measurement in terms of acoustic radiation efficiency and sound reduction incidence in the presence of flanking transmission and parasitic noise [14,15].

The example results of sound intensity measurements, shown in Fig.1 in the form of the vector distributions in the areas for which it is difficult to make a theoretical analysis (direct field and near field), can explain many details of the acoustic flow field. The tests carried out on model enclosure systems [11] and the presentation form of their results show that the theoretical methods in acoustic field modelling should be applied with a great care. The investigations showed that in reality the turbulent character of the field may cover all the compartment space, extending beyond the area attributed mainly to the acoustic near field.

DESCRIPTION OF INVESTIGATION TECHNIQUE

The presented research aims at explaining the mechanism of transference of structure-borne sound into the surroundings, by using a graphical presentation of the space distribution of intensity (or power) vector within the acoustic field inside cabins in the vicinity of ship accommodation partitions and even in the entire space of the cabin. The solution of the problem is vital for the protection of accommodations against noise and for creating a suitable acoustic climate in enclosures.

The described measurements were carried out in real-size crew cabins arranged on second deck of a full-scale, mock-up superstructure. The superstructure was built to serve as a ship acoustic laboratory for carrying out research in conditions close to the real ones. To simulate the excitation from a ship engine, an electrodynamic exciter acting on the steel structure under the cabins was used.

The measuring equipment included RTA-830 NORSONIC two--channel, real-time analyzer working with NE-216 SI *p-v* probe, and computer-controlled robot system provided for moving the probe within the field region determined by the measurement plane. Controlling the measuring process, data collection and graphic presentation of results were performed with the use of the integrated software SIwin. A special care was applied to an appropriate presentation of the measured acoustic field distributions.

The problem involved a way of presenting the vector field in a two-dimensional or three-dimensional form. The vector was analyzed at each point of the enlarged measurement grid by measuring the three mutually perpendicular vector components x, y, z. During the rotation of the SI probe the acoustical centre was kept in the same position. The field distribution was presented by using *arrows* as a projection of the spatial vector xy on the measurement plane, and *circles* as the component z - vectors perpendicular to this area. Size of the arrows and circle radii were kept proportional to the intensity amplitudes.

Additionally, the acoustic energy flow streamlines was used to bring a new insight into the interpretation of the results of measuring the radiation of acoustic sources acting in limited spaces (Fig.1). The intensity vector at any point is tangent to the streamline passing through that point. Such presentation of the acoustic energy flow can be very useful for visualizing the radiation of complex acoustic sources (machines, technical equipment, vibrating heterogeneous plates, etc.) and can show their action also in limited spaces. This is a form of qualitative analysis of stationary fields, which consists in a complex evaluation of the paths along which the acoustic energy of a radiating source is transferred.

The intensity measurements were carried out by means of a fixed point method [1,15]: each point was placed in the middle of a sub-area of 0.1m x 0.1m, into which the main measurement area was divided . The vector field distribution within the measurement plane, defined for each measurement point as the vector sum of three mutually perpendicular intensity components, was examined in one-third octave bands, from 25 Hz to 6300 Hz. In this paper, however, only some results of 1/3 octave frequency range are shown in the figures below.

Summing up, it can be stated that the SI technique makes it possible to evaluate the final effect of the interference of direct and reflected waves at each point of the measurement grid. As the frequency increases, the mutual amplitude and phase relations between the waves create field areas of a circulation nature. The rotational character of the field can be observed also at high frequencies for which such model can be treated, in acoustical terms, as a big room. In the theoretical description it is usually assumed that a non-linear character of an acoustic field with prevailing rotational waves can be encountered only in near fields, i.e. at distances from the source lower than one wave length [16,17]. Direct measurements, however, point to some differences as regards the theory [18,19].

Acoustic field in the vicinity of ship partitions

One of the major difficulties in carrying out acoustic measurements in ship spaces is the complex wave distribution in the acoustic field inside the crew accommodation. The field distribution is affected by the small dimensions and complicated shapes of the spaces, as well as the specific sources of noise influencing the acoustic climate of the ship living and working quarters. In general, it is structure--borne noise generated by vibrating cabin partitions, with *acoustic leaks* (door and windows), which largely contributes to the total noise of the ship's interior spaces.

However, air-borne noise may be also encountered on ships, which gets into their interior. The acoustic processes occur in a wide frequency range and can cause operational harm in technical and health terms. The technical aspect of the problem deals with vibration effects resulting from the design and fixing technique of ship installations.

A dynamic state of the partitions forming the cabins plays an essential role in the interior noise evaluation of ship's accommodation. Depending on the mechanism of noise transmission to the inside, the partition may be a source of airborne noise (transmitted from an area behind the partition) or structure-borne noise (radiated from vibrating structures). In practice, the noise occurring in the ship living area is mainly due to structural sounds emitted by typical ship machines (Fig.2).

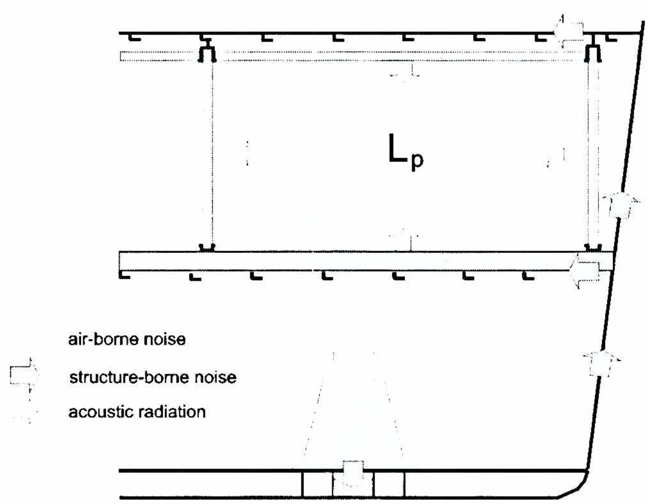

Fig.2. Transmission of vibroacoustic energy into ship accommodations (L_p - pressure level)

Usually, the main engine is considered as the only mechanical source of noise and vibration on a ship. However also other sources, such as the propellers, auxiliary engines and exhaust and ventilation systems, should be taken into account.

Not all partitions which make up a separate ship accommodation, radiate the same amount of acoustic noise to the inside. The contribution of a partition depends on many factors such as material properties of partition, its size, position relative to the steel structure and local acoustic sources, as well as the technique of building. Identification which partition is dominant is the basis for any effective action aimed at the reduction of the noise which exceeds the permissible levels. Detail experimental tests showed that walls with windows and doors are frequently the dominating sources of the noise within the ship cabin [20 to 23].

The example results presented below in the form of the distribution of space intensity vector within the acoustic field in the vicinity of ship partitions can be employed to explain the transfer mechanism of structure-borne sound into the surroundings ; this way a new insight into the interpretation of measuring the radiation from the acoustic sources acting in limited spaces can be obtained.This enables one to obtain significantly new information related to acoustic energy fields in the vicinity of vibrating ship partitions which, in turn, affect the noise distribution inside the cabin.

For instance, the analysis of an acoustic field shape produced near the windows of a ship's cabin before and after installing the shipboard wall makes it possible to estimate local radiation sources and regions of vibroacoustic bridges through which the energy is passed over to the shipboard wall of the cabin and influence the noise being radiated into the cabin. The sound radiation pattern of a ship's hull with windows are shown as a vector (arrow), isoline separating the

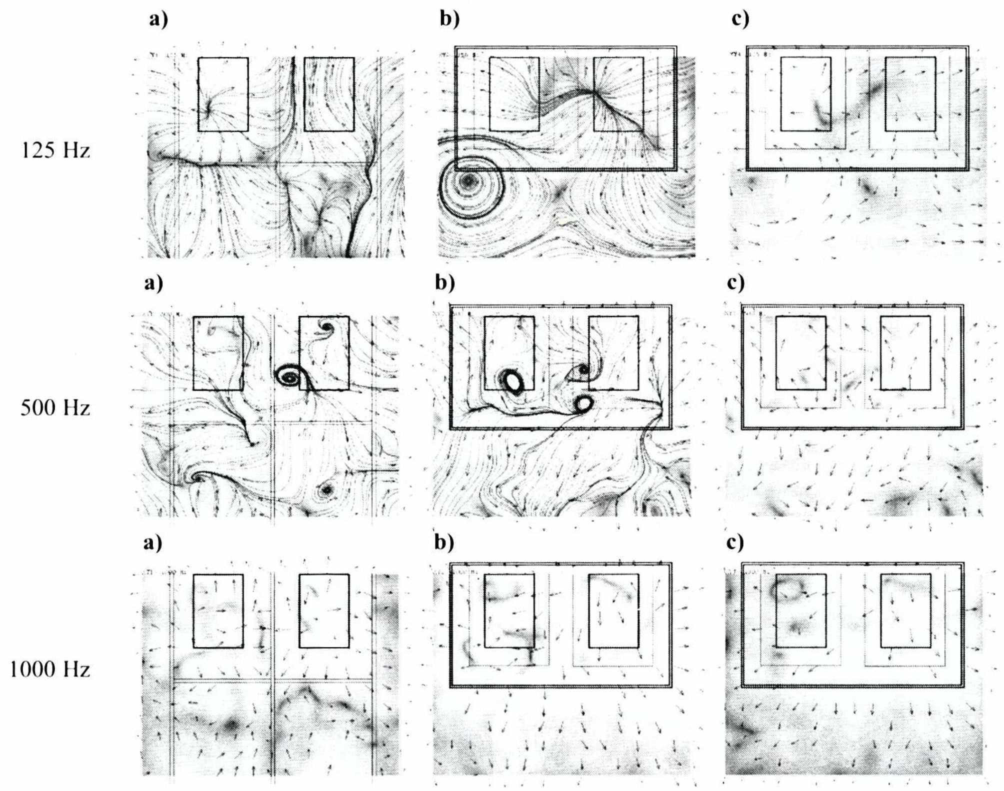

Fig.3. Vector field distribution in the vicinity of the shipboard wall with windows :
(a)-before fixing the inside wall, (b)-after rigid fixing of the wall and window box, (c)-after flexible fixing of the window box

intensity field (in gray scale) and streamlines. The flow of acoustic energy presented by the intensity streamlines shows the paths it is transmitted along. This stands for quantitative analysis and appeals to our idea of acoustic waves.

Acoustic radiation through shipboard wall with windows

The goal of the test was to estimate a degree of possible reduction of the noise level radiated into the passenger cabin through the shipboard wall with a window box. The tests consisted of three stages :

- **1st** , the measurement was taken on a part of the steel shipboard structure (with windows) before fixing the inside wall and window box of the cabin (Fig.3a).
- **2nd**, the acoustic radiation within the region was estimated after fixing the inside wall and the window box rigidly to the shipboard structure and the wall (Fig.3b).
- **3rd**, the measurements were taken after fixing the window box flexibly to observe its effect on the noise inside the cabin (Fig.3c). The flexible fixing was assumed to eliminate all vibroacoustic bridges and hence to reduce the noise radiated by the box.

A comparison of the noise levels inside the cabin of the wall with the rigidly fixed box and that with flexibly fixed one, showed noise reduction by 8.4 dB(A) where A - noise correction curve.

Acoustic field around single cabin window

The next example is a field vector distribution around the single cabin window, shown in Fig.4. with the vectors lying on the measurement plane, and the streamlines of acoustic energy flux on the plane. The vector analysis of the field within the test frequencies (1/3 octave band) made it possible to estimate which parts of the window construction had the largest share in radiation, and how the window box caused the *niche effect* in the process of the acoustic field rotation appearing in the vicinity of the window.

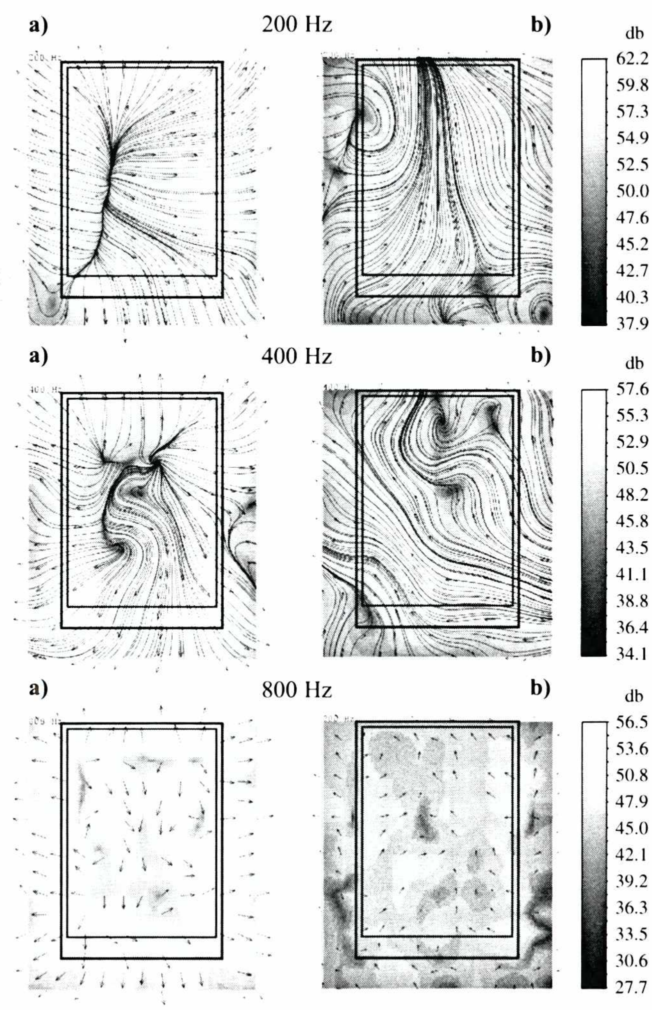

Fig.4. Noise radiation through single cabin window :
(a)- of normal construction, (b)-with additional pane in window box

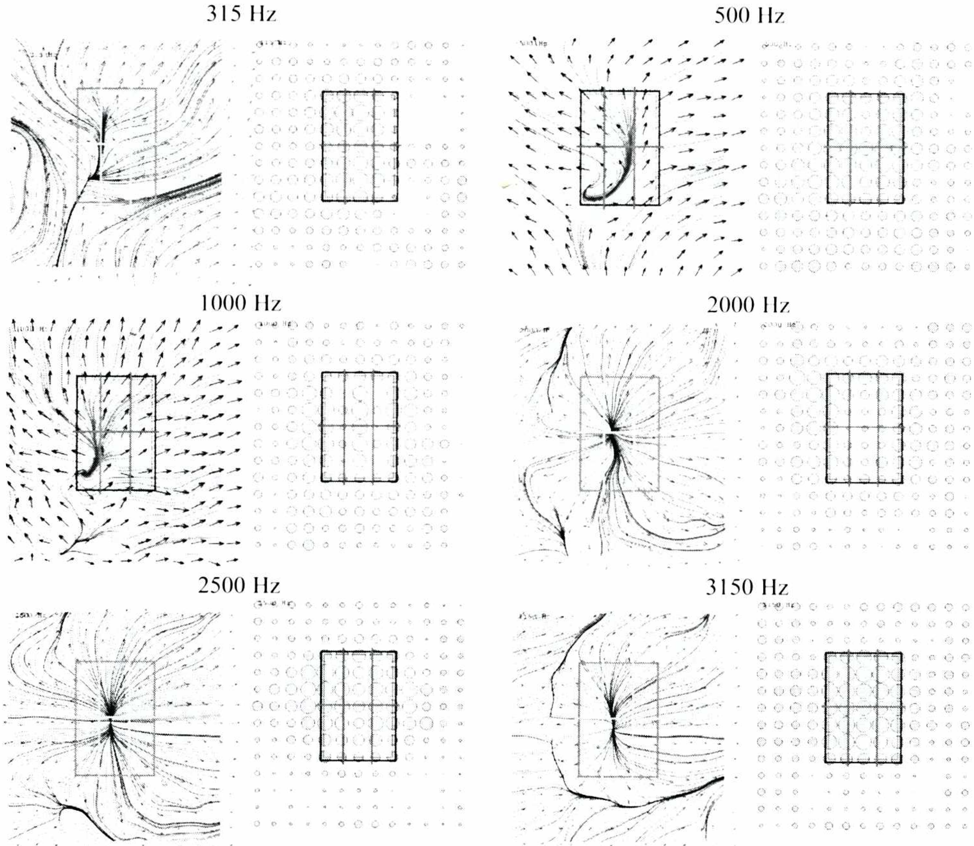

Fig.5. Acoustic field distributions outside the window fixed in the steel board : streamlines - on a plane parallel to the board and vector component - perpendicular to the board

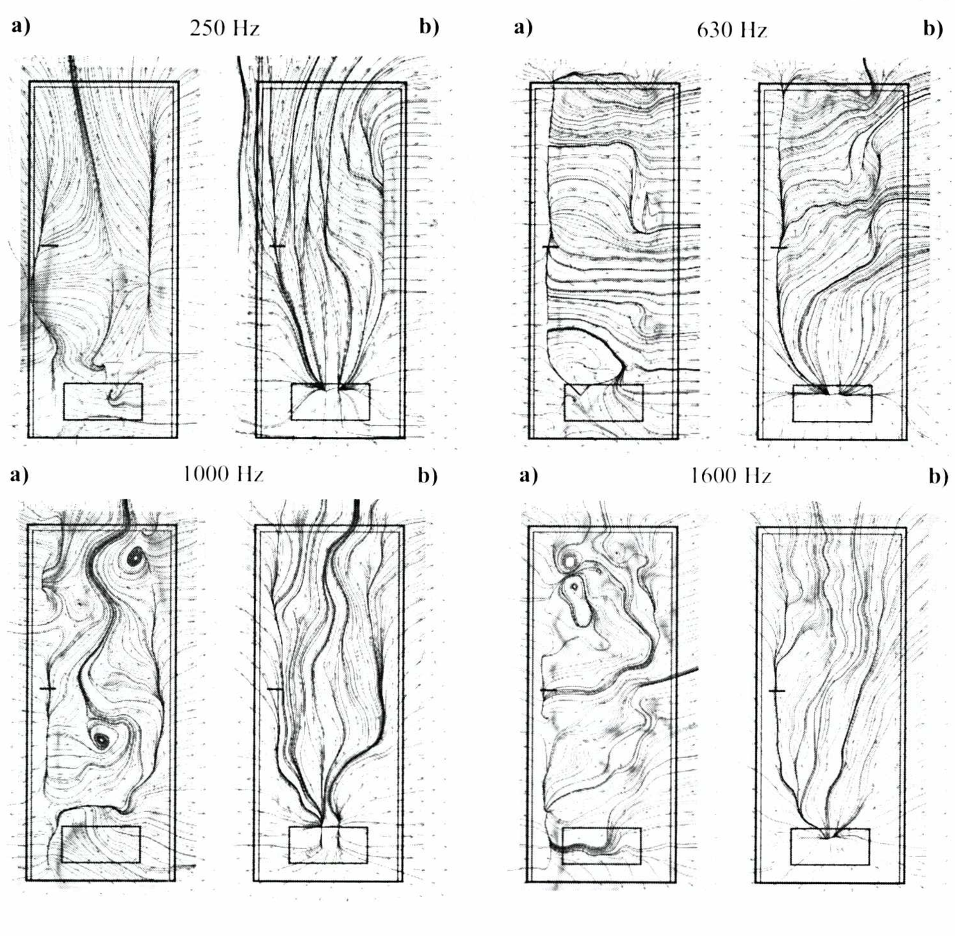

*Fig.6. Acoustic energy flow through the cabin door with the ventilation duct at the bottom : **(a)** - closed duct, **(b)** - opened duct*

The initial results showed that cabin window placed centrally on the wall, was the main noise source in the investigated cabin (80% of total noise power). As shown in Fig.4b, the addition of the pane fixed inside the widow box changed the field distribution, and the noise level close to the window radically decreased by about 12 dB(A).

Acoustic radiation through the window into cabin space

The third example refers to the acoustic radiation into cabin space through the window built into shipboard wall, so the shape of the field in the vicinity of the window could not be affected by reflections which might take place inside the accommodation. The window under consideration is built into a steel ship structure. The excitation, in the form of broad-band noise made by loudspeakers arranged inside, directly affected the steel wall and window. Some results of the outside acoustic field distribution in the vicinity of the window are shown in Fig.5, in the frequency range from 315 Hz to 3150 Hz. The vector field distribution illustrates how particular elements of the window structure (pane, frame) radiate the acoustic energy. In addition, the normal components of intensity vector are shown in the form of circles. The form of spatial character of the field can be recognized by comparing the quantitative distributions of the field in the direction perpendicular to the measurement plane with the picture of the acoustic energy streamline distribution.

Ship accommodation door with closed or opened natural ventilation duct

The next acoustic tests were performed on a ship accommodation door with closed or opened natural ventilation duct. The problem was to find the flanking transmission paths in the cabin door structure. The vector field distribution and the acoustic energy streamlines, within selected frequency ranges, are shown in Fig.6.

By applying the closed ventilation duct and using the proposed presentation of field distribution, it is easy to detect any leaks on the door wing and to estimate how the acoustic energy flow through the slight slit acts on the field in the door region. The leaks create the rotations within the acoustic field in the vicinity of door, which can be clearly observed both in the higher and lower frequency ranges.

The field distribution is radically changed by opening the ventilation duct. Much more energy then flows through the duct, and the effect of frame leaks is masked by the main energy transfer path. In spite of this, the waves propagating through the leaks on the door wing are clearly noticed.

ACOUSTIC ENERGY FLOW INSIDE THE CREW CABIN

A very common phenomenon in small rooms at a low frequency range (a few hundred Hz) is the appearance of spatially arranged standing waves. For a rectangular room a simple relationship exists between the room dimensions and the frequencies. Three types of normal modes in the room, i.e. axial, tangential and oblique one, provide the permissible frequencies corresponding to the normal vibration modes of room partitions. Mutual superposition of those waves brings about the resultant space field which is very difficult to be defined analytically. Thus while attempting to describe a distribution of standing waves, it is common practice to accept some simplifications which imply the consideration of a two-dimensional field model including only axial and tangential waves.

In the proposed research method the presentation of acoustic energy propagation showing the paths along which it is transferred may be particularly useful for visualizing the radiation of complex acoustic sources, and showing their behaviour in restricted spaces. It makes it possible to carry out energy tests of the acoustic field areas in which the phenomena display acoustic vortices. In such regions there is no regular correlation between the acoustic pressure and the intensity. Some vortex effects appear, and the phase differences of higher components stimulate additional interference effects. It mostly appears in the area considered as an acoustic near field, but not only there.

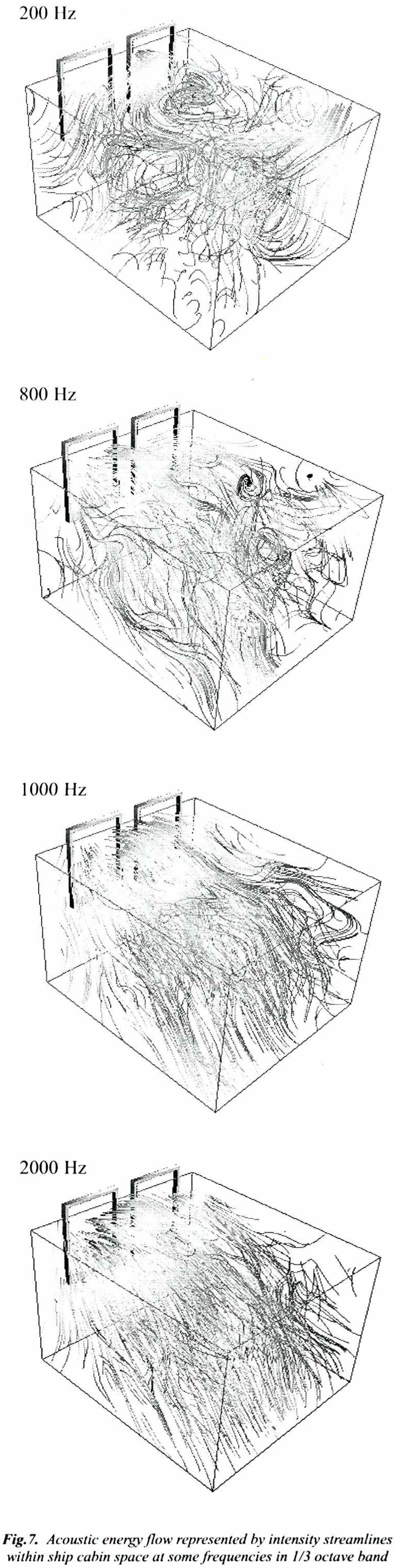

***Fig. 7.** Acoustic energy flow represented by intensity streamlines within ship cabin space at some frequencies in 1/3 octave band*

The noise occurring in the ship's accommodation results mainly from structural sounds emitted by vibrating partitions. The ship's partitions characterized of high constructional heterogeneity (partitions made of sandwich panels, walls with windows and doors), are surfaces of heterogeneous distribution of vibration. And, the acoustic power radiated by such surface can be determined experimentally. In this case the SI technique is a very useful research tool.

The aim of the study of the acoustic phenomena inside crew cabins is to assess applicability of the SI technique for the in-situ measurement of acoustic energy radiation from non-homogeneous cabin bulkheads, and for vector analysis of acoustic power radiated inside the cabin from these partitions. In result, a three-dimensional flow map is obtained of time-averaged, active intensity vectors presented along curved streamlines. The test results of the spatially distributed acoustic field (3D) inside the full-size crew cabin are shown in Fig.7.

The selected results comprise frequencies from 200 to 2000 Hz in 1/3 octave band. The vector field distribution shows the acoustic energy streamlines making it possible to read a form of space character of the field. Its shape confirms the fact that directions of radiation from the real cabin partitions towards its inside may be disturbed far more than it could result from the numerically simulated models.

The tests with the use of SI technique demonstrate that it is possible to obtain new information about space distribution of the acoustic energy fields in the vicinity of the ship windows greatly influencing the noise distribution and intensity inside the cabin.

CONCLUSIONS

- The presented method of ship vibroacoustic control by means of SI analysis enables : to identify the airborne and structure-borne energy transmitted through the different parts of the cabin partition, to find the flanking transmission paths and the vibroacoustic bridges (*hod points* or acoustically weak areas) on the considered partitions, which could not by possible with the use of the classical measurement method.

- The presented experimental results of the distribution of acoustic energy penetration through the ship partition with door and windows show that acoustic fields occurring near non-homogeneous partitions are rotational, i.e. typical of the acoustic near-field region. For ship accommodation the rotational character of the intensity field is stronger in the near field close to the vibrating partitions, but also the rotation can be observed within the whole enclosure, which is caused by reflections from the walls or because of interference between the direct radiation fields from the cabin partitions.

- The analysis of the distribution of discrete values of the sound intensity of three-dimensional vector fields formed in a real crew cabin also indicate that some difficulties can occur in verifying a system model by means of theoretical predictions. The picture of the produced stationary field points to a complex dynamic relationship which shapes the field in question. Its rotational character is observed in the areas usually regarded as far-field regions. Moreover, the acoustic vortices can be observed even in rooms of a simple geometrical shape.

Appraised by Zbigniew Engel, Prof.,D.Sc.Eng.

BIBLIOGRAPHY

1. Kuttruff, H. : *Room Acoustics*. Applied Science Publishers Ltd. London 1979
2. Fahy, F. : *Sound and Structural Vibration. Radiation. Transmission and Response*. Academic Press. London 1985
3. Barron, M.: *Growth and Decay of Sound Intensity in Rooms According to Some Formulae of Geometric Acoustic Theory*. J.Sound Vibr., 27(2), 1973
4. Gensane, M., Santon, F.: *Prediction of Sound Fields in Rooms of Arbitrary Shape: Validity of the Image Source Method*.J.Sound Vibr., 63(1), 1979
5. Beranek, L. L.: *Acoustics*. American Institute of Physics. New York 1988.
6. Gibbs, B. M., Jones, D. K.: *A Simple Image Method for Calculating the Distribution of Sound Pressure Levels within an Enclosure*.Acustica, 63(1), 1979
7. Hirata, Y.: *Geometrical Acoustics for Rectangular Rooms*. Acustica, 43, 1979
8. Schroeder, M. R., Hackman, D.: *Iterative Calculation of Reverberation Time*. Acustica, 45, 1980
9. Fujiwara, K.: *Steady State Sound Field in an Enclosure with Diffusely and Specularly Reflecting Boundaries*. Acustica, 54 , 1984
10. Kosten, C. W. : *The Mean Free Path in Room Acoustics*. Acustica, 10, 1960
11. Weyna S. : *An Image of the Energetic Acoustic Field in a Parallelepipeded Room Models*. Acta Acustica, Vol.82(1), 1996
12. Fahy F. : *Sound Intensity*. Elsevier Applied Science. London. New York, 1989
13. Crocker M. ; *Direct measurement of sound intensity and practical applications in noise control engineering*. Inter-Noise'84, 1984
14. Weyna S. : *Application of SI technique in research of flanking transmission and noise source identification*. Noise-Control'98, 1998
15. Weyna S. : *The visualization of energetic acoustic field inside cabins*. Int. Conf. on Urban Transport. Perugia, 1997
16. Mann, J. A. : *Acoustic Intensity Analysis: Distinguishing Energy Propagation and Wave-Front Propagation*. Journal of Acoustic Society of America, 90, 1991
17. Tichy, J. :*Sound Radiation and Sound Fields Studies using Intensity Technique*. Graduate Program in Acoustics, The Pennsylvania State Univer. Pennsylvania 1986
18. Weyna, S. : *Acoustic Radiation in Ship Partitions Estimated by Sound Intensity Method*. Proc. Int. Conf. „Theory and Practice of Shipbuilding. Zagreb 1988
19. Weyna, S. : *Radiation Efficiency Characteristics Estimated by Sound Intensity Method*. Archives of Acoustics, 18(2), 1993
20. Weyna S. : *Measurement of acoustic power radiation by cabin partitions in-situ using intensity method*. Noise-Control'88, 1988
21. Weyna S. : *Graphical presentation of acoustic energy transferred through partition with door*. Energy Methods in Vibroacoustics. Krynica, 1993
22. Weyna S., Hojbjerg K. : *Acoustic power radiated by the hull partition on ship accommodation measured with spatial intensity vector*. Inter-Noise'90. 1990
23. Weyna, S. : *The Applications of Sound Intensity Technique in Research at Noise Abatement on Ships*. Proc. PRADS'92. Newcastle 1992

Conference

A SOLEMN SEMINAR

On 28 March another scientific seminar of the Regional Group of Utility Foundations Section, Mechanical Engineering Committee, Polish Academy of Sciences (PAN) was held at the Institute of Fluid Flow Machinery, PAN.

The seminar was given specially solemn character as it was devoted to celebration of the 80th birthday of Prof. Tadeusz Gerlach who rendered great services as academic teacher of many machine designers and as author of unique machine designs for various economy branches.

He held also managing positions at the Technical University of Gdańsk and the Institute of Fluid Flow Machinery, PAN, where he greatly contributed to development of important the scientific research centres.

The scientific part of the seminar consisted of presentation of the paper on *„Standard and deep-water diving – sea bed exploration, servicing ocean technology objects, sea rescue"* by Mr Skrzyński, M.Sc., of Polish Naval Academy in Gdynia and 4 other papers prepared by scientific workers of the Institute of Fluid Flow Machinery (IFFM), Gdańsk, namely :

- *„Investigations on condensation process with the view of improving the efficiency of thermodynamic cycles"* by Prof. M.Trela and D.Butrymowicz, D.Sc.
- *„Determination of flexibility of bearing supports of a research stand by means of harmonic excitation method "* by J.Rybczyński, D.Sc.
- *„Determination of dynamic flexibility of the structure supporting laboratory rotor bearings by applying computer simulation"* by S. Banaszek, M.Sc.
- *„Investigation of the influence of bevel of bearing sleeves for two-support rotor"* by M. Łuczak, M.Sc.

as well as one paper on *„Computer aided analysis in diagnostics of large power plant objects – investigation of turboset sensitivity to the change of support stiffness"* prepared by A. Prońska, D.Sc., of the IFFM and P. Kabaciński, M.Sc., of Gdynia Maritime Academy.