ACOUSTIC METHOD OF VALUATION OF SHIPS' DRIVE MECHANISM OPERATION

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The paper is presented the method of valuation of ships drive mechanism operation by comparison of noise level in ship's rooms, vibrations in selected places of drive fastening and acoustic disturbances generated by a ship to water environment. Selected researches results are presented in form of graphs.

INTRODUCTION

In first stage were carried out measurement of noise levels in ship's rooms where influence of vibrations of drive mechanisms was highest; in second stage were carried out measurements of vibrations in selected places of drive system and was examined influence of vibrations on acoustic emission to water. In the paper is presented comparison of measurement results and archive data.

1. NOISE MEASUREMENTS IN ROOMS

In first stage were carried out measurements of noise levels for main engine rotational speeds: 1000, 1200, 1250, 1300, 1400, 1500 and 1950 rpm.

Additionally were carried out measurements of noise levels during smooth increase of cruising speed from minimum to maximum. Due large number of results from these tests only one spectrogram (Figure 1) is presented. It shows change of sound intensity [dB/A] versus change of rotational speed of the main engine and frequency. This analysis was made using constant bandwidth filters of 4 [Hz] in frequency band from 6 [Hz] to 1600 [Hz].

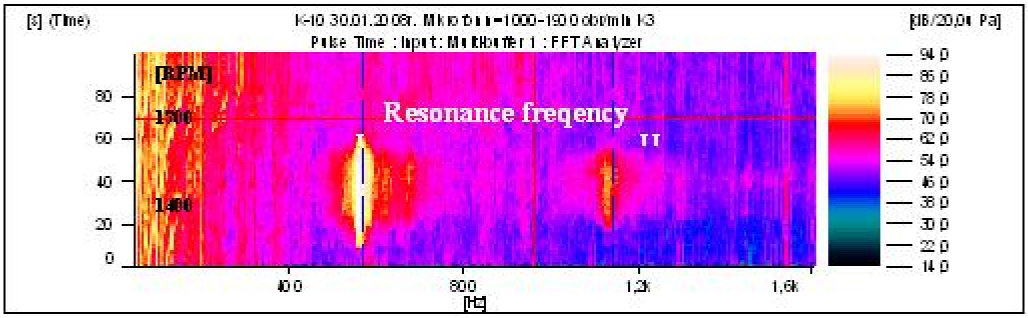

Fig.1 Spectrogram of recorded noise of a ship at rotational speed n = 1000 - 1900 rpm

The presented spectrogram one may see two distinct zones of increased acoustic pressure in two frequency bands; first from approx. of 530 to approx. of 570 [Hz]. The second band occurs in band from approx. 1120 [Hz] to 1140 [Hz]. This second band is the second harmonic of first band. Basing on the presented spectrogram was carried out the graph of relation between acoustic pressure level and main engine rotational speed (Fig. 2).

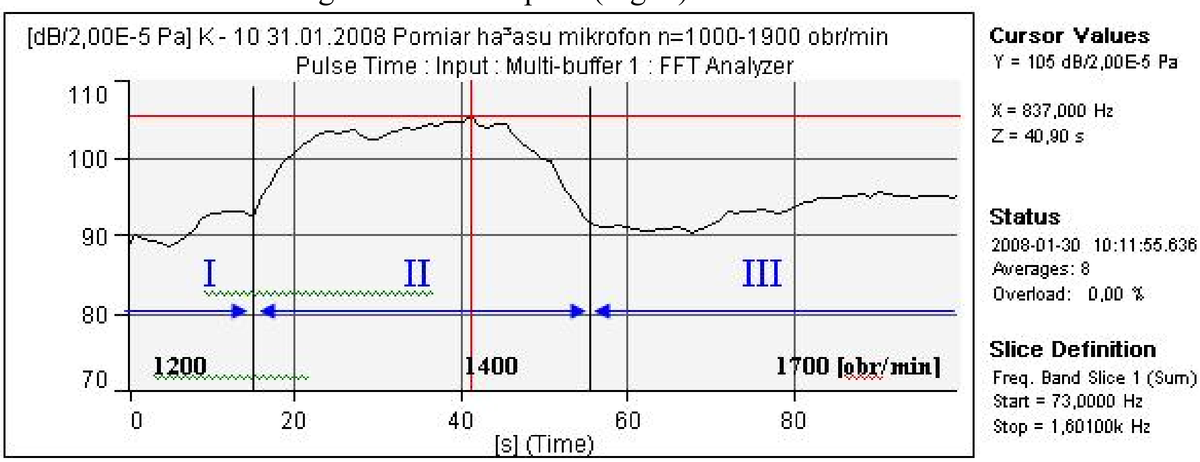

Fig.2 Acoustic pressure level depending of time at change of rotational speed n = 1000 - 1900 rpm

In the presented drawing are visible three zones designated as I, II and III. Zone I presents change of noise levels in rotational speed change range from 1000 to 1250 rpm. The second zone was performed for rotational speed from 1250 to 1450 rpm. Third: from 1550 to 1950 rpm. In the second zone one may see distinct increase of noise level.

2. MEASUREMENTS OF VIBRATIONS

Together with noise measurements also vibrations measurements were performed. These measurements were recorded in the following places:

- at the foundation frame of the main engine;
- at the shaft's thrust bearing;
- at the frame in the stern room.

Additionally were made measurements of vibrations in the stern room for entire range of ship speed. The spectrogram from these tests is presented in the figure No 3.

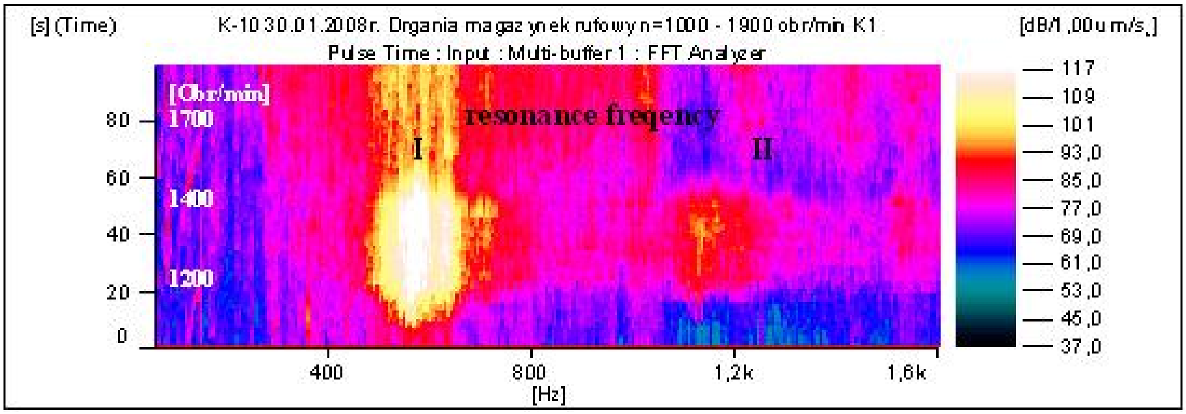

Fig.3 Spectrogram of vibrations recorded in the stern room. n = 1000 - 1900 rpm

In this spectrogram are also visible two zones as in the spectrogram presented in figure 1, for the same frequency ranges. In order to determine vibrations level and exact location of the source of vibrations acceleration has been carried out the spectral analysis for individual rotational speeds of main engines. These analyses were carried out for measurements recorded at the foundation frame of the main engine, at the shaft's thrust bearing and at the frame in the stern room. The exemplary spectrum of vibrations recorded in the foundation frame of the main engine did not show zones of increased vibrations in the entire range of main engine rotational speed. Therefore it excludes the main engine as the source of excessive noise.

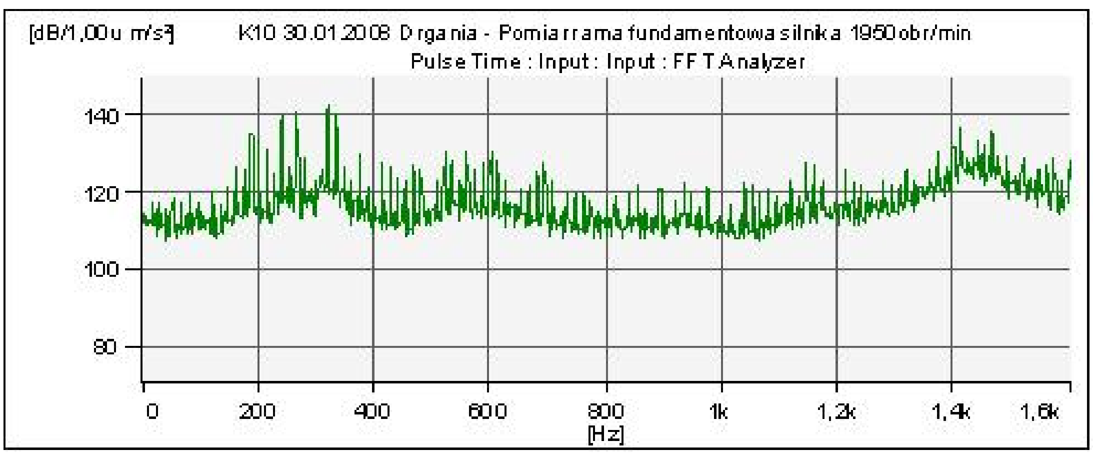

Fig.4 Spectrum of accelerations recorded in the foundation frame of the engine, n = 1950 rpm

Spectra of vibrations in the shaft's thrust bearing are presented in figures 5, 6 and 7.

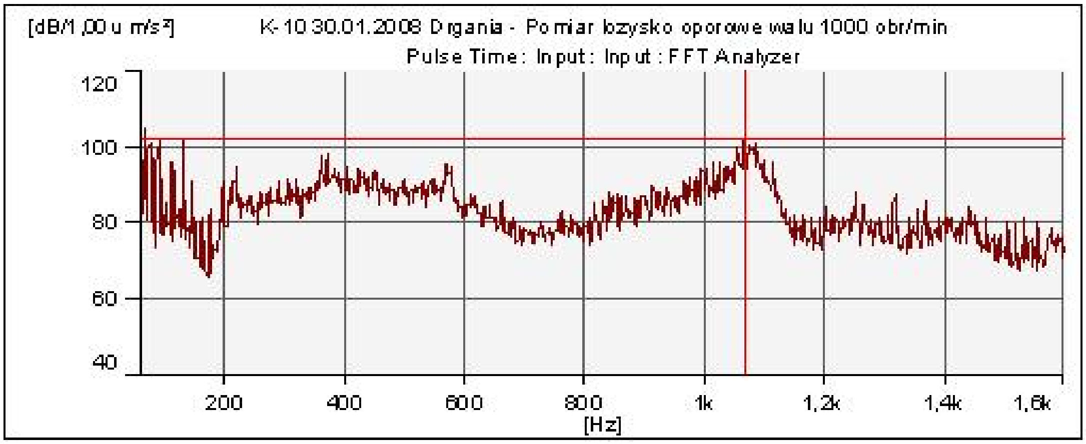

Fig.5 Spectrum of accelerations recorded in the shaft's thrust bearing; n = 1000 rpm

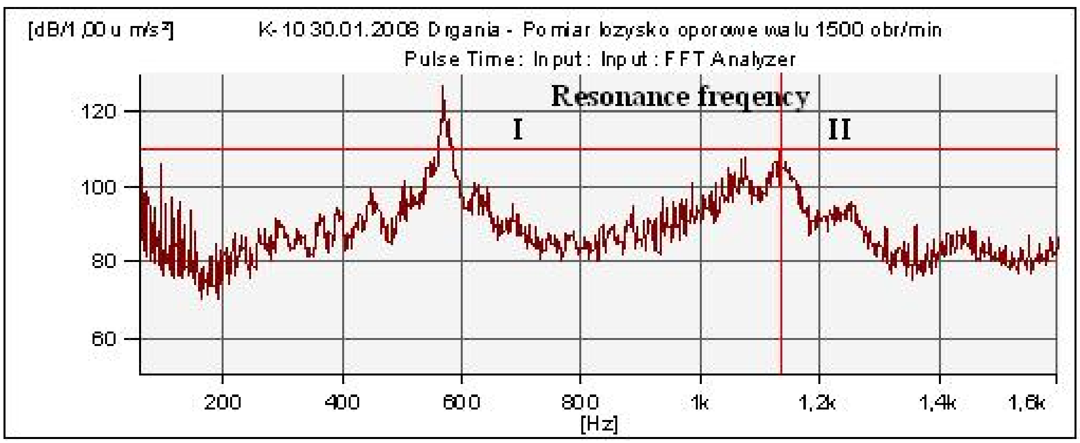

Fig.6 Spectrum of accelerations recorded in the shaft's thrust bearing; n = 1500 rpm

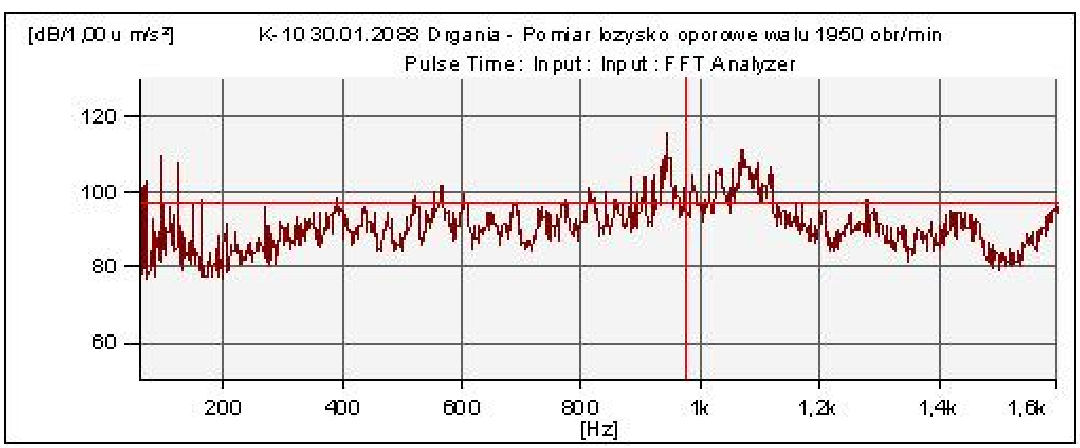

Fig.7 Spectrum of accelerations recorded in the shaft's thrust bearing; n = 1950 rpm

The analysis of presented spectra (figures 5 – 7) of accelerations recorded in the shaft's thrust bearing for engine's rotational speeds n = 1000, 1500 and 1950 rpm shows zones of increased vibrations levels.

They are also visible in the spectrogram of noise; figure 1 and 3. Spectra of vibrations recorded in the frame in the stern room are presented in figures 8, 9 and 10.

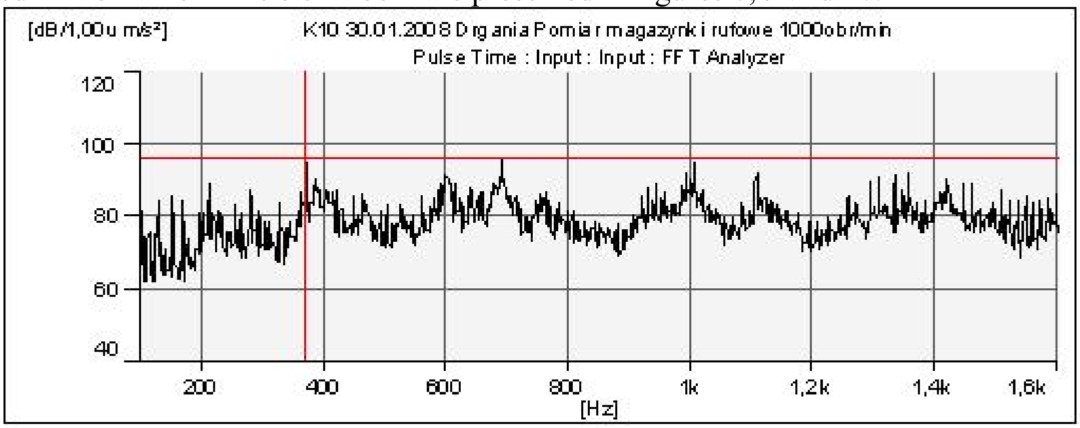

Fig.8 Spectrum of accelerations recorded in the stern room n = 1000 rpm

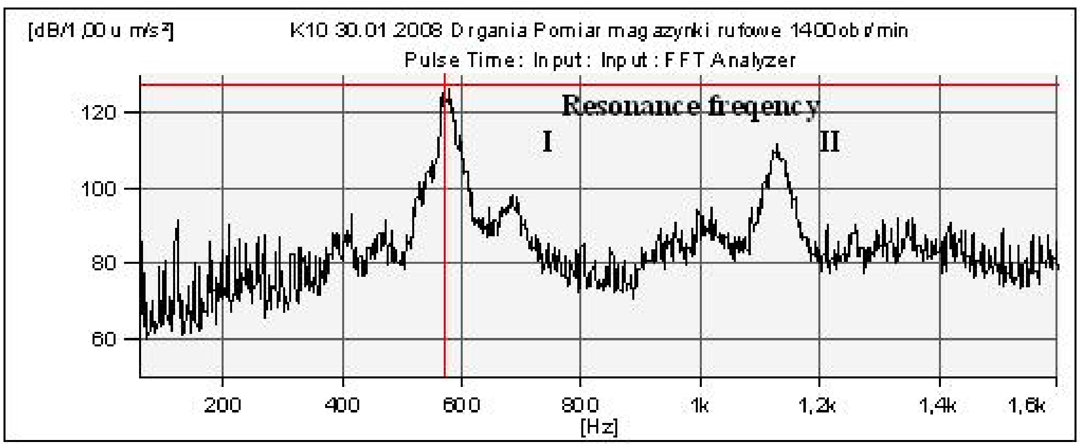

Fig.9 Spectrum of accelerations recorded in the stern room n = 1400 rpm

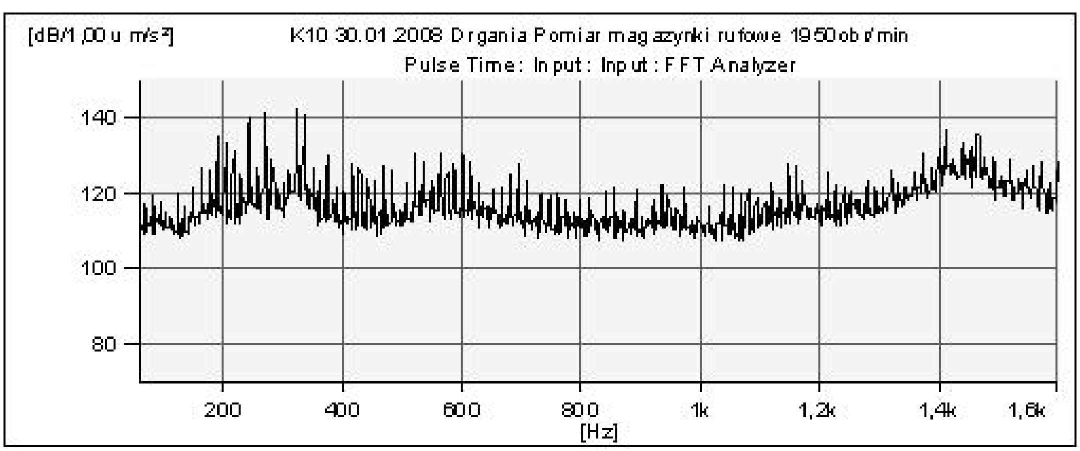

Fig.10 Spectrum of accelerations recorded in the stern room n = 1950 rpm

In presented spectra (figures 8 to 10) one may see that in vibrations recorded in the stern room and in the shaft's thrust bearing are visible mentioned earlier zones of increased vibrations for the same rotational speeds of main engines.

The analysis of presented spectra shows that the probably place of increased pressure in discussed zones is the screw propeller. In order to unequivocally indicate the source was necessary to make a cycle of hydro-acoustic measurements. These measurements were carried out in the proving ground.

3. HYDRO-ACOUSTIC MEASUREMENTS

Measurements of hydro-acoustic pressure of the ship were carried out in the proving ground. Recorded ship's noise are presented in form of a chart with hydro-acoustic pressure level versus time of ship passage through the proving ground and versus frequency. Additionally for each tested speed of ship was carried out the spectrum of hydro-acoustic pressure depending of frequency. This spectrum was selected from the presented spectrogram (figure 11) in place where most loud part of the ship was directly over the acoustic sensor. The exemplary spectrogram and the spectrum of ship cruising through the proving ground is presented in figures 11 and 12.

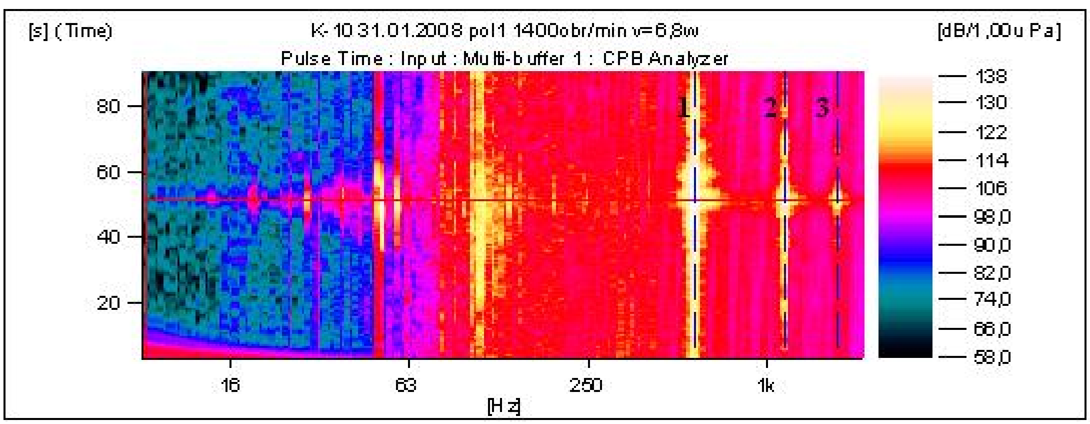

Fig.11 Spectrogram of hydro-acoustic pressure of the ship n = 1400 [rpm]

In figures 11 and 12 are visible characteristic components related to operation of the main engine, the power generating unit, with rotational movement of the marine screw propeller and the set of shafts.

where: 1 – basic frequency related to operation of the marine screw propeller; 2 – II harmonic; 3 – III harmonic.

In the spectrogram (figure 11), in the frequency range up to 250 [Hz] are visible characteristic components related to operation of ship mechanisms and devices. Above this frequency is visible the basic frequency related to loud operation of the marine screw propeller with its second and third harmonic. From this spectrogram was separated spectrum recorded in 38.69 [s] of measurement, presented in figure No 12. In this spectrum is marked by blue cursors basic frequency, second and third harmonic. From the description of the figure one may exactly determine frequency of first harmonic – f = 561.5 [Hz] and calculate frequency of second and third harmonic.

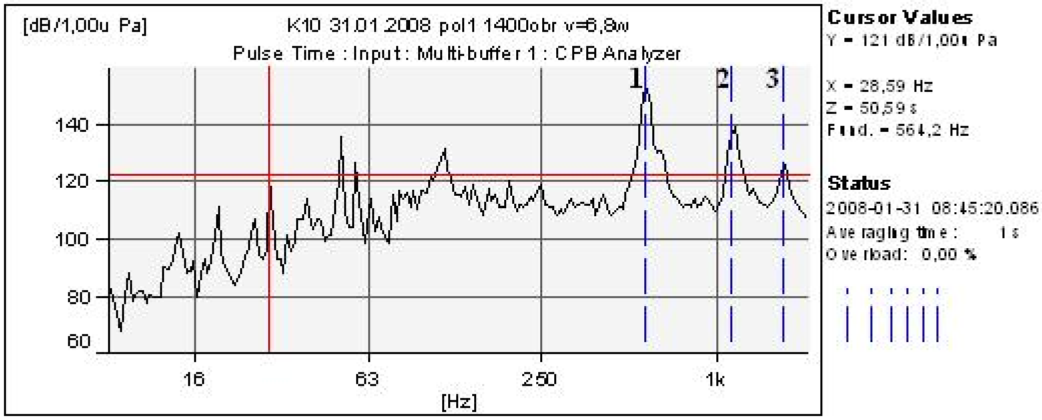

Fig.12 Spectrum of hydro-acoustic pressure of the ship; n = 1400 rpm, v = 6.8 ktn

4. CONCLUSIONS

The measurements and analyses of recorded signals was aimed at identification and location of a source (sources) of excessive noise in the acoustic fields structure of the ship.

In spectrograms and spectra obtained from the measurements one may see zones with increased noise levels in frequency bands from 530 to 570 [Hz] and from 1120 to 1140 [Hz]. Processed signals of vibrations recorded for the foundation frame of the main engine did not contain vibrations within above frequency bands. Lack of these bands in spectra suggests that the main engine is not the source of searched noise.

In carried out analyses of hydro-acoustic pressure signals recorded in the proving ground also the zones of increased pressure were found; in the same frequency bands. This disadvantageous phenomenon is connected with hydrodynamic processes occurring at marine propeller blades. These processes caused increase of hydro-acoustic pressure by 10 [dB] to 15 [dB], depending of ship speed. The set of shafts and construction elements of the ship transmit these disadvantageous vibrations. Effects of this phenomenon were visible in spectrograms and spectra of vibrations and noise signals recorded in:

- the stern room,
- the engine room of the cutter.

carried out measurements of hydro-acoustic pressure for:

- rotational speed of the main engine n = 1000 rpm;
- rotational speed of the main engine n = 1950 rpm;

did not show zones of increased zones of noise for these frequency bands.

On the basis of carried out measurements and analyses one may say that the source of searched noise is the marine propeller screw. in order to reduce underwater noise levels, noise and vibrations is necessary to check:

- external state of the marine propeller screw;
- connection of the screw and the shaft;
- marine propeller screw balance.

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