SEARCHING OF BURIED OBJECTS IN VERY SHALLOW WATER BY MEANS OF ACOUSTIC METHODS

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ABSTRACT

The subject of the paper is the description of usage of the connected system for searching the objects that are on the surface of the seabed or under it by means of the parametric sonar or side sonar. The results of the preliminary experimental studies that will depend on detection of the objects of the known geometrical shape and the structure will be presented in this paper.

The usage of the side sonar that works at the two frequencies above 600 kHz and 900 kHz enables detection of the objects which dimensions are small from the relatively small distance.

It is a premise that this system can be used in the conditions of the shallow sea or in normal conditions while using underwater vehicles. The second element of the searching system is the parametric sonar that after preliminary tracking the object enables to define the direction as well the shape of the searched object.

INTRODUCTION

Searching of underwater objects, especially these ones buried in the seabed has a very practical meaning. Presently more often mass destruction weapon is placed in the very difficult way to find it. Moreover searching of the objects of the archaeological character at sea requires usage of devices that have possibility of penetration of sediment which covers the searched object.

In this case the most useful of acoustic means are parametric sonars that due to their specific features are good tools for underwater searching. The principle of detection of buried objects is similar to the detection in the case of usage of the classical sonars. The dispersion of the sound field on the object is different from the dispersion on the surrounding medium. The dispersion of the sound field enables to track the object and sometimes enables to define the shape of the searched object. The measurement equipment was connected to the Global Positioning System (GPS).
OPERATING PRINCIPLES OF THE PARAMETRIC SONAR

In the 1960s, it was theoretically described and then a bit later the system that used the methods of parametric creation of the sound field was built. In general, it is the creation of the additional waves in the common area of the dispersion of the two acoustic bundles which wave vectors are parallel, their frequencies slightly differ from each other and maintain the constant difference of the phases. The most interesting wave that originates as a result of these influences is the wave of difference frequency. It is the wave created in the same area of the volume that for low frequency has the narrow directional pattern without the side lobes. Dependence that describes the pressure of the wave of difference frequency is presented as:

\[ p_2(R, \Theta) = \frac{\varepsilon (\omega_1 - \omega_2) W_1 W_2}{4\pi c_0^3 R \alpha_T} \left( k_1 a^2 \gamma \right) \left( 2J_1(k_1 a \gamma) \right)^2 \left( \frac{2J_1(k_1 a \gamma)}{k_1 a \gamma} \right)^2 \left( 1 + \frac{\gamma}{\Theta_{0.5}} \right)^2 \]  

(1)

where:
- \( \varepsilon \) - the coefficient of nonlinearity of water medium - about 3.5
- \( \omega_1 \) and \( \omega_2 \) - respectively angular frequencies of the primary waves
- \( R \) - the distance between the source and the point of observation
- \( W_1 \) and \( W_2 \) - the power of transducers 1 and 2
- \( k_1 \) - the wave number of the primary source
- \( a \) - the radius of the source
- \( \alpha \) - the attenuation coefficient
- \( J_1 \) - the Bessel’s function
- \( c_0 \) - the speed of sound of the low amplitude
- \( \Theta, \gamma \) - The angles in spherical coordinate system

The schematic operating principles of parametric sonar is shown in Figure 1.

![Figure 1. The operating principles of parametric sonar](image-url)
EXPERIMENTAL STUDIES (PRELIMINARY STAGE)

It was established that contribution for partly or entirely slimed objects will consist of side sonar working at two basic frequencies $f_1 = 675$ kHz and $f_2 = 935$ kHz and parametric sonar of primary frequency of $f = 100$ kHz. The system was mounted on the catamaran as showed in Figure 2.

![Figure 2. The view at the measuring equipment](image)

The exemplary elements that will be searched are showed in Figure 3.

![Figure 3. The models of targets that will be searched](image)
THE RESULTS OF THE PRELIMINARY STUDIES

Using the measuring equipment described earlier, the preliminary studies were carried out in the natural environment. They were carried out in two stages. In the first case the catamaran was a carrier on which were mounted the two harmonic side sonar as well as the parametric sonar. The second stage was searching the objects by underwater vehicle. In Figure 4 there is the image received from the parametric sonar of two small balls lifted up to the surface.

![Figure 4 The image of the two balls lifted up by parametric sonar](image)

In Figure 5 there is sonar’s image of the object made of plastic that was detected by the side sonar mounted on the underwater vehicle.

![Figure 5. The sonar’s image of plastic object detected by side sonar mounted on the underwater vehicle. The right side – the image taken from antenna f=935 kHz. The left side – the image taken from antenna f=675 kHz.](image)
In the images that are shown above could be noticed clear characteristics of sonar’s images that can indicate the target. The research studies were carried out in the circumstances of slimed seabed. This paper presents only the results of the preliminary studies which the main purpose was testing and calibration of the measurement equipment.

CONCLUSION

In the conclusion of the results of the preliminary studies it is possible to claim that the usage of the surface measurement platform in the shallow water can be treated as the preparation for the studies that can be carried out from the underwater vehicle by keeping the same distance from the seabed. The connected measurement equipment that consists of the side sonar and the parametric sonar can enable to track the objects that are located under the seabed.

REFERENCES

