Research on Acoustic Recognition of Underwater Targets based on the Principle of Sound Absorption

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Abstract. Due to the concealment of underwater engineering, the detection and monitoring of hydraulic structure construction is often more complicated and difficult than surface engineering. Cofferdam construction inspection and settlement construction quality inspection, especially to ensure the accuracy and efficiency of inspection in complex environments, have become an urgent problem to be solved in underwater engineering quality inspection and monitoring. This project designs an offshore fixed-point monitoring device based on wave energy and piezoelectric effect energy. The invention provides a wave power generation system. The system include simple structure, reliability and stability The fixed-point monitoring device combines the cantilever float device, the gas storage tank device and the piezoelectric ceramic energy supply device to provide the marine monitoring device with energy for automatic water surface monitoring, fixed-point and data collection. Finally, the comprehensive utilization of sea surface wave, compressed gas energy storage and piezoelectric effect energy is realized.

Keywords: Underwater Engineering Quality Inspection; Wave Energy and Piezoelectric Effect; Offshore Fixed-Point Monitoring Device; Wave Energy Power Generation System.

1. Research Background and Significance

1.1 Research Background

The waterway resources represented by the Yangtze River play an increasingly important role in promoting the development of inland transportation, logistics, shipbuilding, tourism, environmental protection and other industries. Infrastructure construction, construction and maintenance represented by waterway renovation projects and bridge. Tunnel projects are important factors to ensure the development of my country's transportation industry. Reasonable and effective inspection and monitoring of the construction quality of related projects are carried out to ensure construction accuracy. It improves construction efficiency and Guaranteeing the structural safety during the service period is a safe, efficient and green modernization project[1].

In the underwater engineering, bridge pile foundation and cofferdam construction inspection of the Yangtze River waterway renovation project. Whether it is the quality inspection of sinking and overlapping. The bridge pile foundation and cofferdam construction inspection, traditional divers are usually used for detection or carrying cameras. For example, for the detection of underwater pavement, the existing detection construction technology is to set color reinforcement strips at a certain position away from the edge of the layout. Ranging, return data, and judge whether the quality of the lap is qualified. For the inspection of hydraulic structures, the current inspection and construction process is that divers carry underwater cameras. And it conduct visual inspections of underwater structures through visual inspections and cameras to identify damaged areas and locations. The innovative method of sonar scanning surveying and mapping proposed by Wuhan Yangtze River Channel Rescue and Salvage Bureau Inspection Center can realize real-time monitoring of underwater engineering construction conditions and effectively improve the quality of underwater construction[2]. However, due to the limitation and influence of factors such as the detection environment conditions, the distance between the sonar equipment and the detection target. The acoustic characteristics of the detection target. It often occurs that an ideal sonar image or a specific

sonar image cannot be obtained. The position (coordinates) of the detection target corresponding to the feature points of the sonar image cannot be determined[3].

1.2 Project Research Significance

By studying the acoustic and sound field characteristics of the object, researching and developing the corresponding acoustic markers, analyzing the acoustic image characteristics of the acoustic markers in the target body field. it can be widely used establishing the relationship and connection between the acoustic image and the actual positioning markers. It is used in underwater engineering and underwater rescue work. It can effectively solve the problem that the ideal sonar image cannot be obtained or the specific location (coordinates) of the detection target corresponding to the feature points of the sonar image cannot be determined due to the limitation and influence of factors such as the detection environment conditions, the distance of the sonar equipment and the detection target, and the acoustic characteristics of the detection target. problem[4].

This project intends to take a combination of theoretical analysis and experimental research to solve problems such as insufficient accuracy in monitoring and measurement of some underwater projects and underwater rescue work, and independently research and propose underwater detection targets based on acoustic markers. Accurate measurement technology provides an effective basis for accurately judging the results of underwater quality inspections, and also effectively solves the inability to obtain ideal sonar images due to the limitations and influences of factors such as detection environmental conditions, sonar equipment and detection target distance, and detection target acoustic characteristics. The problem that the specific position (coordinate) of the detection target corresponding to the feature point of the sonar image cannot be judged. According to different underwater detection objects, rational use of acoustic markers and design of targeted underwater detection schemes can greatly improve the recognition of acoustic detection targets in underwater detection engineering, and effectively improve underwater detection efficiency and monitoring capabilities[5].

2. Research Status at Home and Abroad

2.1 Current Status of Foreign Research

The acoustic covering layer is mostly a periodic array structure, which is composed of a number of identical units arranged regularly. This may not only produce effective absorption of incoming sound waves in certain frequency bands, but also effective reflection. Therefore, in addition to sound absorption. Periodic structures are also widely used as sound insulation and sound-transmitting structures in underwater acoustics: for example, to improve the directivity of low-frequency sound sources, and to shield and receive interference from noise sources near the hydrophone. Hydroacoustic periodic structures can be divided into two types: single-period and double-period structures. Single-period structures such as flexible pipe grid systems used as acoustic reflection baffles in the resonance frequency band, and double-period structures such as Alberich-type sound-absorbing cover layers[6].

In order to understand the physical mechanisms inside acoustic cladding to help guide the design of such structures, a variety of efficient mathematical models have been developed for periodic structures. For the study of the tube grid system, Burke, Brigham, Dumery and others used multiple scattering theory to consider the case of cylindrical tube grid and elliptical column tube grid. Vovk, Radlinski analyzed using waveguide theory[7]. Lakhtakia's method utilizes Fourier-Bessel expansion combined with transfer matrix theory. The above researches are all carried out on the basis of the two-dimensional model, that is, the scatterer is a parallel cylinder, and the incident wave vector is in a plane perpendicular to the cylinder axis. Using a three-dimensional model, Achenbach considered the case of an arbitrary incident direction of acoustic waves [6-8], and studied the dispersion relation of two-dimensional and three-dimensional spherical cavity arrays in elastic media [8].

2.2 Research State in China

Since the mid-1970s, my country has carried out research on various types of acoustic overlays. In order to effectively evaluate the acoustic performance of the acoustic cover. Some scholars use the transfer matrix theory of sound propagation in a layered elastic medium system. It approximates the viscoelastic material as a highly viscous liquid, considers the damping of the material. And the system uses a complex modulus value to represent it. The loss of material, this method is simple and fast. But it ignores the shear effect.it can only analyze the case of the normal incidence of sound waves. He Zuoyong studied the sound absorption problem of underwater non-uniform composite layer structure according to the theory of non-uniform waveguide. The sound wave is incident vertically, the material is regarded as multiple thin layers, and the effect of cavity is regarded as the change of area. In the thin layer, the area change law is approximated as a linear law, an exponential law or a hyperbolic law, etc. According to the boundary conditions between the layers with continuous pressure on the section and continuous particle vibration velocity, the transfer matrix is obtained, and the sound absorption coefficient is finally obtained . Zhu Beili studied the sound characteristics of the rubber body with cylindrical channel, and believed that the rubber material mainly achieved sound absorption through waveform transformation, and studied the sound absorption mechanism of composite transition rubber by using the transfer function method to find the total reflection coefficient[9].

The sound-absorbing effect of the sound-absorbing cover not only depends on its own performance, but also is closely related to the structure on which it is laid. Therefore, independent research on the sound-absorbing cover cannot fully and objectively reflect the sound absorption characteristics in the actual application state. Therefore, In order to reasonably evaluate the sound transfer characteristics of the acoustic covering, it is necessary to consider the acoustic impedance parameters of the acoustic covering and the acoustic-vibration coupling performance of the hull structure as a whole. It is particularly necessary to study the transmission characteristics of sound waves in typical hull structures covered with acoustic coverings, such as plate-girder structures, cylindrical shells, etc. At the same time, the acoustic reflection and radiation characteristics of shell structures covered with various acoustic coverings It has also become a research hotspot[10].

3. Project Research Content and Research Objectives

3.1 Project Research Content

The underwater acoustic identification structure takes the underwater construction structure as the carrier, and forms a mark area that can be clearly distinguished from the construction structure during the two-dimensional image sonar or three-dimensional sonar scanning by means of attachment. According to the sonar imaging results, the underwater construction can be judged in real time. Therefore, it is necessary to study and demonstrate the materials, structural forms, manufacturing and attachment processes of underwater acoustic marking structures[11].

The specific research contents include: structural design and applicability analysis of underwater acoustic markers based on sound absorption principle; structural design and applicability analysis of underwater acoustic markers based on anti-sound principle. underwater sonar scanning imaging effect of acoustic markers and its attachment process research.

3.2 Project Research Goals

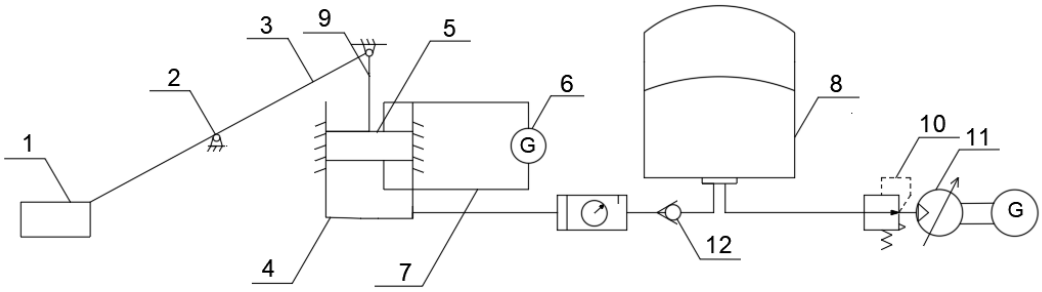
Establishing acoustic marker design methods that can target different underwater detection objects and purposes; Using a combination of theoretical analysis, numerical calculation, model test and engineering verification, research and form a set of underwater detection target measurement methods based on acoustic markers. Relying on engineering practice to continuously optimize the underwater detection technology scheme to achieve the goal of "seeing, clearly seeing, and accurately evaluating" the underwater detection object[12].

4. Content Design Scheme

4.1 Device Design

The device is hinged with the main platform through the hinge point and the cantilever float connected to the outer end of the cantilever. The energy conversion device is connected with the inner end of the cantilever and converts the kinetic energy of the inner end of the cantilever into electrical energy and compressed gas energy storage. The generator generates electricity and directly supplies power to each detection system without the need for a power storage device, which not only saves energy, but also reduces the conversion process of wave energy. The air storage tank connected to the main platform uses the wave energy for compressed air energy storage. When the energy provided by the wave energy is not enough to make the detection devices work normally, the high-pressure air in the air storage tank drives the air pressure motor to make the generator generate electricity. The device is also equipped with piezoelectric ceramics to generate electricity, and finally realizes the integrated utilization of wave energy, compressed gas energy storage and piezoelectric effect energy [13].

The device is composed of a wave energy collection device and an energy conversion device. The wave energy collection device collects the wave energy and finally converts it into electrical energy through the energy conversion device. The schematic diagram of the device is as follows:



(1-oscillating float 2-fixed hinge 3-oscillating force arm 4-air cylinder 5-direct generator float 6-generator 7-transmission belt 8-air storage tank 9-direct generator float link rod 10-reducing valve 11-air motor 12-check valve)

Figure 1. Schematic diagram of the device

4.2 Research Proposal Design

4.2.1 Power System

The power system is the basis for the operation of the entire device. The electrical energy required for the operation of the device and the operation of the measuring equipment comes from this system, which consists of oscillating floats, fixed hinges, oscillating force arms, belt transmission devices, pneumatic cylinder devices, generators, It is composed of air storage tank, air motor, direct generator float and piezoelectric ceramic sheet[14].

4.2.2 Wave Energy Utilization Module

The wave energy utilization module mainly adopts the conversion method of wave energy, mechanical energy and electric energy to realize power generation.

The specific conversion process is as follows: First, the oscillating float at the outer end of the cantilever in contact with the seawater moves up and down with the waves, driving the oscillating force arm to move up and down, converting the wave energy into mechanical energy. Then, the oscillating force arm acts as a lever up and down to push the piston of the pneumatic cylinder, the corresponding link and the direct generator float under the piston of the pneumatic cylinder drive the circulating belt to reciprocate, and the circulating belt drives the pulley on the input shaft end of the generator to make a one-way rotational motion And the gas storage tank is inflated. During this

process, the mechanical transmission device not only plays the role of speeding up and transmitting energy, but also converts the reciprocating motion of the oscillating float into the unidirectional rotating motion of the belt. Finally, the recirculating belt drives the pulley on the input shaft end of the generator to reciprocate, which in turn drives the generator to rotate, converts mechanical energy into electrical energy, and generates electricity[15].

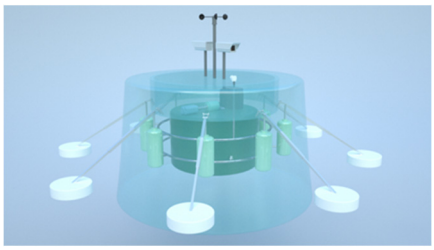


Figure 2. Appearance of fixed-point monitoring device at sea

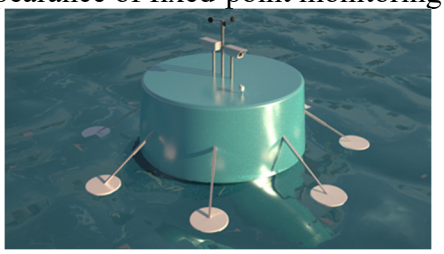


Figure 3. Internal structure of monitoring device

4.2.3 Piezoelectric Energy Storage and Piezoelectric Effect Energy Collection Module

A piezoelectric ceramic chip is installed under the force arm of the oscillatory float link. When the oscillatory float is subjected to the fluctuation of the wave, the force arm will be combined and deformed by the external force, and the piezoelectric ceramic piece attached to the bottom will be deformed accordingly, and both ends will be deformed. Charges with opposite polarities are generated, and a current flow through the loop.

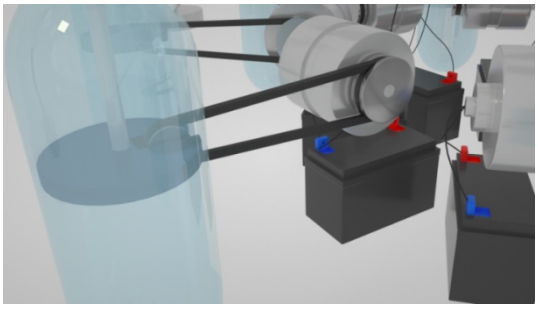


Figure 4. Energy storage and power generation module

4.3 Ocean Monitoring System

The fixed-point detection device performs ocean detection by fusing sensor information such as image, wind speed, underwater detection, and water temperature.

4.3.1 Image Acquisition System

The image is sampled, quantized and then converted into a digital image and input and stored in the frame memory. Image processing refers to the process of analyzing images with a computer to achieve the desired results, also known as image processing, generally refers to digital image processing. The main functions of the image acquisition and processing system include single-chip microcomputer controlling ISP-PLD device, realizing high-speed image acquisition and storage of camera, image compression of single-chip computer and serial communication with PC to realize image data transmission, and image processing and display on the PC side.

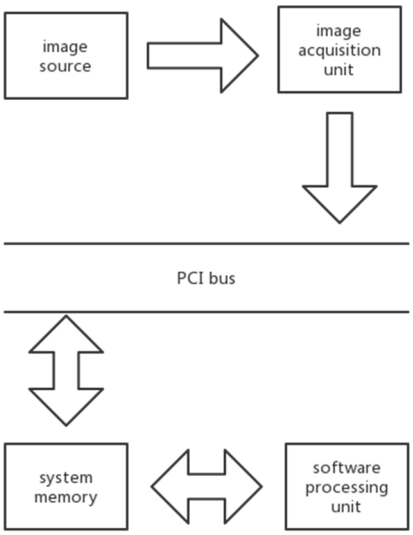


Figure 5. Schematic diagram of the image acquisition system

4.3.2 Wind Speed Acquisition System

This system is assembled with a small DC brush motor and a three-cup type rotating wind cup. Its working principle is that when there is horizontal flow of wind in the environment, the rotating wind cup can generate rotation, and drive the small motor to generate voltage. The speed is basically proportional. Using this signal voltage, the ambient wind speed can be measured.

4.3.3 Underwater Detection System

The system conducts real-time monitoring of marine creatures in the near range through the underwater high-definition camera. The camera is located at the lower part of the float and firstly connected to the main platform.

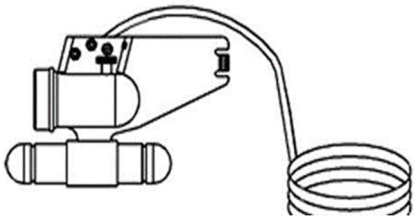


Figure 6. Installation diagram of underwater detection system

5. Summary and Outlook

The main innovations of this work are as follows: the anti-rollover telescopic floating body of the fixed-point device is combined with the piezoelectric energy storage device, which realizes the stable collection of wave energy; the mass of the main platform is large, and the 8 swinging buoys are evenly distributed, which improves the offshore performance of the device. Stability; the complementary utilization of wave energy power generation and compressed air energy storage improves energy utilization efficiency; equipped with automatic fixed-point ocean monitoring equipment powered by renewable energy to ensure long-term stable operation of the device in offshore waters.

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