A New Design Of Navigation Light Using Wave Energy

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Abstract—Numerous floating beacon lights are distributed along the coast and inland waterways. Beacon light is a kind of traffic light that is installed on some beacon to provide safety for ships traveling at night. Beacon lights mostly use batteries as power sources, and some use wind and mechanical energy to convert into electrical energy. Large lighthouses mostly use diesel engines. As a renewable and clean energy, wave energy provides a new solution to the continuous power supply needs of floating beacon lights. We have designed a new beacon light device using wave energy. The device uses low-frequency irregular wave energy to convert to high-frequency stable mechanical vibration required for power generation, and then uses piezoelectric power generation technology to convert mechanical energy into electrical energy and store it to power the floating navigation light.

1. INTRODUCTION
Beacon light is a kind of traffic light installed on some navigation aids, which provide safety guarantee for ships sailing at night. Beacon lights mostly use batteries as power sources, and some use wind energy and mechanical energy to convert into electrical energy. Large lighthouses mostly use diesel engines. The battery power supply has many problems such as limited capacity, short power supply time, long power supply replenishment time, difficulty in replenishment and high replenishment cost [1-2]. With the development of new energy technologies, solar energy emerged as an inexhaustible environment-friendly energy source, which greatly solved the energy problem and greatly reduced the cost of use. Foreign countries are engaged in research on solar integrated navigation lights much earlier than domestic ones. The United States, Japan, New Zealand and other countries started the research as early as the end of the 1990s, and achieved great results. However, due to the strong directivity of solar panels, it is not easy to absorb the sun, and the volume is large. This is only suitable for use in lighthouses, shore signs and sea signs. At the same time, it is expensive and difficult to be widely promoted in my country's inland waterways [3].

Wave energy is a kind of renewable and clean energy, with abundant reserves, it is a new energy with great potential [4-8]. The maturity of wind power generation technology provides support for solving the unstable power generation of wave energy. From the perspective of energy density, wave energy is 4 to 30 times that of wind energy. If the wave energy in the ocean can be effectively developed, the benefits it brings will be much higher than wind energy and solar energy. The main obstacle to commercialization of wave power is cost [9-12]. The key to reducing the cost of wave power generation is to improve the efficiency and reliability of the device. According to foreign wave
energy research experience, the development of large-scale devices is currently not easy to achieve due
to high investment costs, but wave energy can satisfy remote islands and special uses on the sea. If the
wave energy power generation technology is applied scientifically and conveniently to the floating
beacon light, the cost of the beacon light will be reduced, which will bring great convenience to its
maintenance and maintenance [13].

Our design is based on this goal and is committed to solving this problem. First of all, it does not
need to replace the power source of the navigation mark, it can use the wave energy to provide
continuous power supply, and it will not be restricted by sunshine, which greatly improves the current
power supply problem of ordinary floating navigation lights. Through improvement, this work also has
a good value for promotion and application [14-17]. By changing the part size and device size, it can be
further improved, and a wave power generator with a larger output power can be manufactured to
supply power to components with larger power consumption [18-20]. In addition, the current marine
buoy power supply is not only carried out by regularly replacing the internal battery or submarine cable
from the nearby integrated platform, but also the power supply of some island-based water sound
network central stations, offshore radar stations, observation and measurement platforms, etc. The
traditional diesel engine power generation method has many problems such as high noise, polluted
environment, difficulty in replenishing fuel, long replenishment time, and high replenishment cost. This
design can also solve the above problems after modification. Therefore, after further experiments and
commissioning, the designed ocean wave energy power generation device will have considerable
economic and social benefits, and has a very good promotion prospect and utilization value [21].

2. DESIGN
The wave energy can be converted into electrical energy for navigation light through four links: one is
the wave flow to make the navigation buoy up and down; the second is the mechanical energy
conversion between the metal paddle and the piezoelectric vibrator[22], and the third is the
piezoelectric vibrator will The kinetic energy of the floating body is converted into electrical energy;
fourth, the piezoelectric vibrator is stored and used under the external circuit. Working principle
diagram is shown in Figure 1.

2.1 Working principle of floating body power generation device.
The floating body power generating device is composed of piezoelectric vibrator, guide rod, flexible
spring and bushing. The top of the floating body is connected with an energy storage circuit and a
navigation light. The piezoelectric vibrator is fixed on the inner wall of the floating body, the guide rod
passes through the center line of the floating body cylinder, and is fixed on the floating body. The
bushing passes through the guide rod and is fixed on the upper and lower bottom surfaces of the
floating body with flexible springs above and below. A metal pick is installed on the bushing at a
position corresponding to the piezoelectric vibrator. The piezoelectric vibrator and the end of the metal
pick have a short distance Horizontal projections overlap. The overall device is similar to a piston with
a hydraulic cylinder on the top and a guide rod on the bottom[23]. When the floating body is under
the action of wave energy, the bushing oscillates up and down along the guide rod through the flexible
spring, and the metal paddle fixed on the upper end of the floating body comes into contact with the
piezoelectric vibrator and drives the latter to buckle. During the buckling process of the piezoelectric
vibrator, the lateral displacement of the tip occurs, and as the deflection increases, the lateral
displacement increases. When the lateral displacement of the end of the piezoelectric vibrator exceeds
its original overlapping length with the metal paddle, the piezoelectric vibrator comes out of contact
with the metal paddle and freely attenuates vibration until the two come into contact again with the
movement of the floating body. The piezoelectric vibrator is composed of a piezoelectric film stuck on
the upper and lower surfaces of the cantilever beam substrate. During the deformation of the
piezoelectric film, charges accumulate on the surface and output current for the resistance of the
external circuit.
2.2 Derive the circuit balance equation.
Through calculation, we obtained analytical expressions for the displacement, output voltage, and conversion efficiency of the piezoelectric vibrator under the excitation of a simple harmonic support near the natural frequency. Carry out a vibration test to verify the model. The validated model is used to analyze the influence of changes in material and structure parameters on the electromechanical conversion characteristics of piezoelectric vibrators.

2.3 Establish mathematical model of wave energy load coupling.
At this stage, we established a mathematical model of wave energy coupling and conducted hydrodynamic tests in the laboratory to verify the accuracy of our model. Then we carried out simulation experiments based on the model, and discussed the interaction between the floating body, the piezoelectric vibrator and the load under the action of the wave energy, and the transmission characteristics of this wave energy piezoelectric generator.

2.4 Device simulation experiment and test.
Next, we carried out the mechatronics test of the device in the laboratory, and recorded the relationship between the floating body response and the output voltage with time under different wave cycle conditions. We use the experimental data to verify the theoretical model and carry out simulation experiments [24]. We use simulation experiments to study the effect of system parameter changes and wave element changes on wave piezoelectric output power.

2.5 Piezoelectric energy storage.
Because the charge generated by the piezoelectric element is instantaneous and alternating, it provides energy in the form of irregular random bursts, and it has a damping effect during the extraction of electric energy. The generated electric energy is not digested and will be converted into vibration energy again. Repeating this process, the vibration attenuation will continue for a period of time. The accumulated charge hinders the further generation of charge. Therefore, it is necessary to accumulate enough energy in a supercapacitor, and then store the energy in the battery through the conversion circuit. In this work, the positive and negative poles of the piezoelectric vibrator are connected to the rectifier circuit, then the supercapacitor, then the switch circuit is connected to the charging chip, and finally the rechargeable lithium ion battery is connected. This completes the collection of electrical energy generated by the piezoelectric vibrator.

3. DISCUSSION
Our design uses wave energy to drive piezoelectric vibrators to vibrate to achieve electrical energy conversion through intermittent collisions and releases with piezoelectric vibrators. Due to the simple structure and small size of the device, the cost of the navigation light can be reduced, and at the same time it brings great convenience to its maintenance and repair. During the design, we established a nonlinear mathematical model of the coupling between the time-domain wave flow, navigation aids, piezoelectric vibrator, and working load, and verified it through physical model tests. Provide a theoretical basis. In addition, our design improves the piezoelectric energy storage collection circuit, and stores the electrical energy generated by the piezoelectric sheet in the super capacitor first. Then, the switching system is used to control the super capacitor to supply power to the subsequent circuits, which realizes intermittent charging and greatly improves the charging efficiency.

Our design is composed of power generation device and power storage device. The floating body power generation device is composed of a cylindrical floating body, several tubular vibrators and metal paddles. The floating body and the piezoelectric vibrator are connected together, and a movable guide rod is erected through the center of the floating body. The guide rod is fixed with some metal paddles around the shaft sleeve. The paddles correspond to the piezoelectric vibrator one by one, and there are short distances at both ends. The horizontal projections overlap, and the shaft sleeve is connected to the floating body through a flexible spring. When the floating body is under the action of waves, the
bushing compresses the spring, and the guide bar and the floating body move up and down relative to each other, so that the metal paddle comes into contact with the piezoelectric vibrator and drives buckling. During the buckling of the vibrator, the end of the vibrator is displaced laterally, and its deflection is increased. When the lateral displacement of the vibrator end exceeds its original overlap length with the metal paddle, the vibrator and the metal paddle are in separate contact and freely attenuated vibration occurs until the floating body moves alternately, and contact occurs again many times. During the deformation of the piezoelectric film, charge accumulation occurs on the surface, and the output current is placed in a super capacitor. When enough energy is accumulated, the energy is then stored in the battery through the conversion circuit. Connect the positive and negative pole leads of the piezoelectric vibrator to the rectifier circuit, then connect the super capacitor, connect the switch circuit to the charging chip, and finally connect the rechargeable lithium ion battery to complete this energy collection work.

4. CONCLUSION
At present, the use of wave energy mainly uses traditional rotary electromagnetic power generation, which generally has the disadvantages of complex structure, heavy equipment, bulky, easy to corrode and difficult to maintain. The wave piezoelectric we designed is different from the traditional mechanical and hydraulic transmission. It has electromechanical conversion characteristics that can directly convert the obtained strain energy into electrical energy. This design greatly simplifies the device structure and reduces the energy loss caused by the intermediate transmission. In addition, piezoelectric materials have excellent characteristics such as corrosion resistance, high strength, low cost, and stable performance, which is beneficial to the device for long-term use in harsh marine environments. Compared with the electromagnetic conversion method, it can achieve higher conversion efficiency. Wave piezoelectric power generation is an ideal way to realize the power supply of small and micro electrical equipment at sea, and is more suitable for use in navigation lights. This design uses a super capacitor to accumulate the energy generated by the piezoelectric element in time, and then stores the energy in the battery through the conversion circuit, which ensures the continuous storage of the device and further improves the conversion efficiency of the device.

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