Stability Calculation of Green Energy Unmanned Small Ship

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Abstract: Global warming is very serious, and human beings should study green energy ships to prevent pollution. First, people should do research about small ships with green energy power, such as battery and solar panels and wind power. This paper will carry out science research under limit fund, and design a small unmanned green energy ship with battery and solar panels and wind power, and calculate the stability of the ship. The ship will be designed as a tumbler, and be ensured to be safe. After calculation, the center of gravity of the ship is always under the metacenter. When the ship rolls horizontally, it will return to a positive floating state and maintain normal stability.

Keywords: Green Energy; Ship; Wind Turbine; Solar Panels; Storage Battery

1. Introduction

Global warming poses numerous disasters. Human rapid development consumes too much fossil fuels in a short period of time, producing excessive greenhouse gases, leading to global warming. Global warming has led to some forest fires; Forest fires are exacerbating global warming. This vicious cycle has terrifying consequences. Some species have become extinct; Many species are still on the brink of extinction. Humans should sound the alarm.

In order to slow down global warming, the World Climate Conference has been held many times. However, there were not many effects. In order to enhance people's environmental awareness and promote people around the world to take more actions as soon as possible, many people have studied and designed green energy ship. The world shipping administration has prioritized emissions reduction and invested in green technologies on ships [1]. Hybrid renewable energy systems on low emissions ships become important resources of demand side management, when ships have the grid connection during in port [2]. The nowaday shipping field has achieved a higher level of maturity in terms of its knowledge and awareness of decarbonization challenges. The deterioration of the environment has also made people pay more attention to carbon-free or carbon-neutralized green fuel, such as green hydrogen, green ammonia, and green methanol [3]. Some people follow with interest on the photovoltaic system, but it is not widely used on ocean-going ships with the abundant solar resources on the ocean, and it is hard to reduce the ship's fuel consumption and shipping pollution because of low efficiency [4]. Nowadays, human beings can use a hybrid power system, and it comprised of various types of energy, such as conventional fossil fuels, renewables, hydrogens, fuel cells and batteries. This can ensure that the ship has sufficient power to continue sailing [5]. Therefore, people must try to find a best power system configuration in designing, constructing, and applying low-carbon and zero-carbon fuel-powered ships regardless of any resistance by waters, routes, ship types, demand, power, alternative fuels, carbon emission reduction policies, and other dimensions. Based on this situation, to fill in the top-level architecture of the ship green power system and form a preliminary ship green power system configuration, this paper constructs a "demand-configuration-integration-system evaluation" architecture of ship green power system based on zerocarbon fuels from two kinds of zero-carbon fuels, i.e., hydrogen and ammonia [6]. Also someone do research on Environmental impact assessment of green ammonia-powered very large tanker ship for decarbonized future shipping operations [7]. Human beings should work hard to get a better circumstance on the earth.

Large ships require enormous power consumption, making it difficult to use solar energy and batteries as their main power sources. The power of solar panels and batteries is relatively small. If used on large ships, a large number of solar panels and batteries are required, which will consume space and load capacity. Batteries are usually used in small cars, such as modern new energy electric vehicles [8-9]. Due to limited funds, a green energy boat is in process. First, stability of ship should be calculated. According to the stability theory of ship, a ship is regarded as a floating object whose stability is indicated by its gravity, buoyancy and meta centers. Based on these theory, the small ship with batteries and solar panels can be start as following [10-12].

The ship design is shown in Figure 1, with a bottom length of 2.4 meters, a deck length of 4.8 meters, a deck height of 1.2 meters, and a width of 1.2 meters. The ship is symmetrical in the middle, with the bow extending 1.2 meters relative to the bottom of the ship and the stern also extending 1.2 meters. Installing a 2 kW wind turbine in the center of the ship; Installing two 550 watt solar panels on the deck. The vertical column of the wind turbine is 4 meters high, standing on the bottom plate and 2.8 meters above the deck. Green energy ship uses stainless steel plates with a density of 7930 kilograms per cubic meter. With these data, the buoyancy of the ship can be calculated.

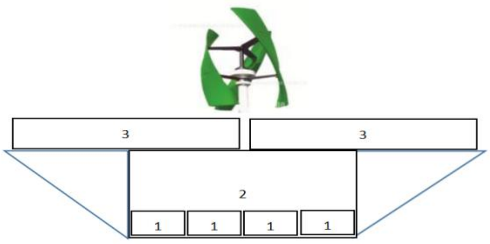

Figure 1. Green Energy Small Ship
1. Storage Battery; 2. Ship; 3. Solar Panels

2. Draft Calculation in a Positive Floating State

The length of the ship's bottom plate is 2.4 meters, the width is 1.2 meters, the thickness is 3 millimeters, and the weight is 68.5 kilograms. The trapezoidal stainless steel plates on both sides of the ship have a length of 4.8 meters on the top and 2.4 meters on the bottom, a height of 1.2 meters, a thickness of 3 millimeters, and a total weight of 205.6 kilograms. The ship has two inclined plates at the front and rear, with a length of 1.4 times that of 1.2, a width of 1.2 meters, a thickness of 3 millimeters, and a weight of 95.9 kilograms. The length of the ship's cabin cover is 4.8 meters, the width is 1.2 meters, and the thickness is 1 millimeter. The weight of the cover is approximately 45.7 kilograms. Five transverse frame partitions are installed in the middle of the ship, with a width of 1.2 meters, a height of 1.2 meters, a thickness of 3 millimeters, and a total weight of 171.3 kilograms. Two longitudinal reinforcement plates are installed at the front and rear of the middle column of the ship, with a height of 1.2 meters, a width of 0.44 meters, a thickness of 3 millimeters, and a weight of 25.1 kilograms. The diameter of the column is 160 millimeters, and the middle transverse partition needs to subtract the diameter size of the column, with a weight of 4.6 kilograms. After calculation, the weight of the ship's structural plate is:

$$68.5+205.6+95.9+45.7+171.3+25.1-4.6=607.5 \quad (1)$$

The ship is installed with 16 batteries at the bottom of the cabin, totaling 864 kilograms. Each battery has a length of 0.52 meters, a width of 0.26 meters, a height of 0.23 meters. The total weight of the 2 kW wind turbine and its accessories is 72 kilograms; The total weight of two solar panels and accessories is 76 kilograms. Two 1000 watt drive motors weigh a total of 36 kilograms, with a base length of 1.2 meters, a width of 0.6 meters, a thickness of 3 millimeters, and a weight of 17.13 kilograms. The column is made of Q355 reinforced steel pipe, with a length of 4 meters, a diameter of 160 millimeters, a wall thickness of 4 millimeters, and a weight of 61.2 kilograms. The weight of two propellers is 38 kilograms, and the weight of two propeller shafts is 10 kilograms. After calculation, the weight of the ship's accessories is following,

$$864+72+76+36+17.13+61.2+38+10=1174.33 \quad (2)$$

According to equations (1) and (2), the total weight of the ship can be obtained as following,

$$607.5+1174.33=1781.83\approx 1782 \quad (3)$$

Based on the total weight of the ship of 1782 kilograms and the seawater density of 1025 kilograms/cubic meter, assuming the ship's draft is h, the draft size can be calculated as following,

$$(2.4+2.4+2h)*2\times h\times 1.2\times 1025=1782 \quad (4)$$

After calculation, it can be obtained that the draft of the green energy small ship in the positive floating state is about h≈0.5 meters.

3. Stability Calculation of Ships

Assuming that the ship encounters strong winds and waves at sea, causing the green energy ship to roll horizontally, as shown in Figure 2. At this point, we need to calculate the stability of the ship and see if it will return to a positive floating state, as shown in Figure 2. The length of the ship's deck is 4.8 meters, the length of the ship's bottom plate is 2.4 meters, and the height of the deck is 1.2 meters. After calculation, the side area of the ship is 4.32 square meters. Assuming that the draft of the ship's horizontal overturning is H, according to equation (3), the draft H can be calculated,

$$4.32 \times 1025 \times H = 1782 \quad (5)$$

$$H \approx 0.402\,(m) \quad (6)$$

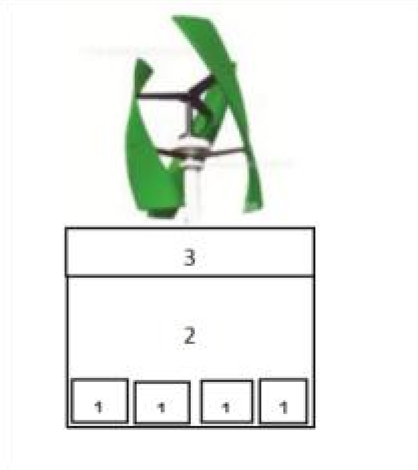

Figure 2. Positive State

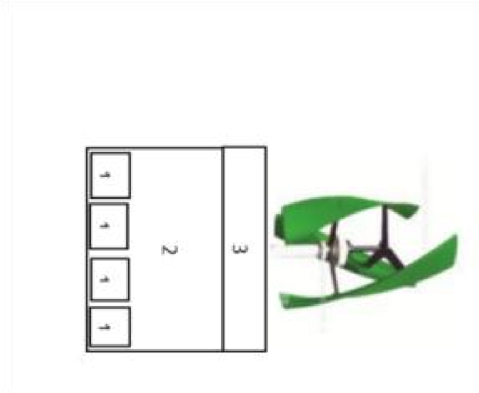

Figure 3. Horizontal Overturning State

1. Storage Battery; 2. Ship; 3. Solar Panels

So, the draft for a ship to roll horizontally is 402 millimeters. In this way, the center of buoyancy action for the ship's horizontal roll state can be calculated. Assuming that the distance between the center of buoyancy action of the ship in a horizontal overturning state and the ship's bottom plate is L, then according to equations (3) and (6), the formula can be obtained as following:

$$(2.4+2.4+2L) * 2 \times H \times L \times 1025 = 1782 * 2 = 891 \quad (7)$$

$$L \approx 0.698 \approx 0.7\,(m) \quad (8)$$

After calculation, the distance between the center of buoyancy action and the bottom plate of the ship in a horizontal rollover state is 0.7 meters.

With the center of buoyancy action in the horizontal overturning state of the ship, the torque generated by each component towards the center of buoyancy action can be calculated. As shown in Figure 3, the objects on the left side of the center of buoyancy action in the horizontal overturning state of the ship include batteries, ship bottom plates and partitions, as well as driving electric motors and propellers, as well as the shaft of the wind turbine section. The objects on the right side of the center of buoyancy action in the horizontal overturning state of the ship include solar panels, wind turbines, and shafts, as well as the ship deck and partitions.

The height of the batteries is 0.23 meters, with a total weight of 864 kilograms. The distance between the center of buoyancy action in the horizontal overturning state of the ship and the meters, and the torque generated is following,

$$864 \times (0.7 - 0.23 * 2) = 505.44 \quad (9)$$

The weight of the ship's bottom plate is 68.5 kilograms, and the distance between the center of buoyancy action in the horizontal overturning state of the ship and the bottom plate is 0.7, resulting in a torque of following:

$$68.5 \times 0.7 = 47.95 \quad (10)$$

The column of the wind turbine is 0.7 meters to the left of the center of buoyancy in the horizontal overturning state of the ship, with a weight of 15.3 kilograms per meter. The torque generated is following:

$$15.3 \times 0.7 \times 0.7 * 2 = 3.7485 \quad (11)$$

The column of the wind turbine section is 3.3 meters to the right of the center of buoyancy action when the horizontal ship is overturned, and the torque generated is following:

$$15.3 \times 3.3 \times 3.3 * 2 = 83.3085 \quad (12)$$

The weight of a 2-kilowatt wind turbine is 72 kilograms, and the distance from the center of buoyancy action in the horizontal overturning state of the ship is 3.3 meters, resulting in a torque of following,

$$72\times3.3=237.6 \quad (13)$$

The 550 watt solar panels, with a thickness of 35 millimeters, has a distance of approximately 0.52 meters from the center of buoyancy in the horizontal overturning state of the ship. It weighs 76 kilograms and generates a torque of following:

$$76\times0.52=39.52 \quad (14)$$

The weight of the ship's hatch cover is about 45.7 kilograms, and the distance from the center of buoyancy action in the horizontal overturning state of the ship is about 0.5 meters, resulting in a torque of following:

$$45.7\times0.5=22.65 \quad (15)$$

According to equations (9), (10), and (11), the total moment on the left side of the center of buoyancy action in the horizontal overturning state of the ship is following:

$$505.44+47.95+3.7485=557.1386 \quad (16)$$

According to equations (12), (13), (14), and (15), the total moment on the right side of the center of buoyancy action for the ship's horizontal roll state is following:

$$83.3085+237.6+39.52+22.65=383.0785 \quad (17)$$

From formulas (16) and (17), it can be seen that the total moment on the left side of the buoyancy action center in the horizontal overturning state of the ship is greater than the total moment on the right side of the buoyancy action center in the horizontal overturning state of the ship, and the stability of the ship is ok.

$$(557.1386-383.0785)*1782=174.0601*1782=0.0976 \quad (18)$$

$$0.7-0.0976=0.6024 \quad (19)$$

4. Conclusion

After calculation, the center of gravity of the ship is below the buoyant centre. When the ship rolls horizontally, it will return to a positive floating state and maintain normal stability.

Due to the fact that the center of gravity of the driving motor, propeller, and partition is located near the left side of the center of buoyancy in the horizontal overturning state of the ship, it can be temporarily ignored. So, when this green energy ship rolls over horizontally, the torque at the bottom of the ship will restore the ship to a positive floating state. That is to say, the center of gravity of the ship is below the ship's stability center, and the ship's stability is normal.

The metacenter is the intersection of the buoyancy action lines of various states of a ship floating on the water surface. According to these calculation, the metacenter of our green energy ship is approximately 0.7 meters from the bottom of the ship. When the total moment on the left side of the center of buoyancy action in the horizontal overturning state of the ship is greater than the total moment on the right side of the center of buoyancy action in the horizontal overturning state of the ship, it indicates that the center of gravity is lower than the center of stability and the ship is safe. Of course, the paper can calculate the position of the center of gravity. According to equations (16) and (17), this paper can obtain the position of the ship's center of gravity according to (18) and (19).

So, from equation (19), it can be seen that the center of gravity of the green energy ship is 0.6024 meters above the bottom of the ship, which is a bit high. In this situation, the stability of the ship is not very good and should be changed. People can increase the weight at the bottom of the ship, which can lower the center of gravity. People can increase the thickness of the ship's bottom plate or install anti roll fins at the bottom of the ship. On the other hand, people can reduce the height of the driving motor and propeller, and also lower the center of gravity to improve stability. In order to ensure the safety of the ship, people must ensure sufficient stability.

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