Oil spill collection boom of ship based on negative pressure principle

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Abstract: The oil boom has played an important role in the control of ship oil spills, but the oil spill often spreads fast and the control ability of the oil boom is limited. If the oil spill cannot be absorbed and processed in time, the traditional oil boom is difficult to grow. This work designs a new type of oil spill collection fence based on the principle of negative pressure. The main function of this device is to control the area of oil spill area and recover oil spill in time. The device is a unit system and can be folded, which is convenient for the ship to store the device. The device is mainly composed of a water surface oil spill collector, a new type oil boom, a pressure pump and a ship’s fast oil-water separation device. The oil control part relies on the function design of the traditional oil boom to enable timely control of oil spill on the water surface. The oil spill recovery function is realized by the cooperation of a surface oil spill collector based on the principle of negative pressure and a new type of oil fence. Compared with the traditional ship oil spill treatment, the device studied in this project has the characteristics of timely, fast and recoverable oil spill. It can make a significant contribution to maintaining the balance of the marine ecosystem.

1. Introduction
With the rapid development of the shipping industry, the risk of pollution from marine activities to the marine environment has also increased. According to statistics, the most serious pollution produced by ships during marine transportation is oil spill pollution, which accounts for about half of the total marine pollution. Once a ship oil spill accident occurs, its impact is huge, and usually the ecological environment of the sea area around the oil spill accident is severely damaged. In the past few decades, oil pollution accidents of ships have occurred frequently in China in the past decades. From 1973 to 2014, there were a total of 3,035 oil spill accidents on ships along the coast of China, with an average of 76 cases per year, posing a serious threat to the environment. The damage caused by ship oil pollution has attracted great attention both at the international level and the domestic level.

At present, the treatment of oil spills on water usually involves the containment and interception of oil pollution according to professional operations by means of oil fences, thereby preventing the continued spread of oil spills. Through the control of the oil boom, the spilled oil is processed centrally, so that it gradually becomes thicker. Finally, wicking felt, oil spill recovery ship equipment or oil skimmer equipment are used for vigorous recovery, and finally the oil spill is transferred to the corresponding storage device. However, in the existing oil spill treatment method, after the oil spill is controlled, the treatment rate is not high, and timely treatment of the oil spill cannot be achieved, which further increases the uncertainty factor for the further expansion of the oil spill area.
Based on the above background, the project team combines the oil control function of the oil boom with the oil collection function of the oil skimmer, and plans to design a device for oil spill collection boom based on the principle of negative pressure. The device uses the negative pressure generated by the ship's own pressure pump to collect the oil spilled on the water surface through the oil spill collection device to the ship. The ship uses the principle of different oil-water density to separate oil spills and water through the oil-water separation device, and at the same time, drains the collected water back to the water area.

Figure 1: Spilled oil spill caused by improper oil spill processing

2. Design of New Type Oil Spill Collection Fence Based on Negative Pressure Principle
A new type of oil spill collection boom based on the principle of negative pressure is designed. The device is mainly composed of a water spill collector, a new oil boom, a pressure pump and a fast oil-water separation device for ships. Compared with the traditional ship oil spill treatment, the device provided by this project has the characteristics of timely, fast and recoverable oil spill. The combination of a separate oil boom and a negative pressure water surface floating object collector in the traditional mode simplifies the processing method of oil spill recovery and improves the processing efficiency of oil spill recovery. The main design of this project:

(1) Analyze the stability of the boom in different water environments
The simulation software is used to simulate whether the stability of the oil boom meets the requirements in different wind speeds, wind directions, and water bodies with different densities, and to improve the structural design of the oil boom according to the deficiencies.

(2) Design the overall structure
The device is mainly composed of a water surface oil spill collector, a new type oil boom, a pressure pump and a ship's fast oil-water separation device. Through the design, the various components are organically combined so that the various devices cooperate with each other, so that the collection of oil spills has the characteristics of instant and rapid.

(3) The optimal solution for the height of the collector under different thickness oil spills is obtained
The simulation software is used to simulate the oil spill environments with different thicknesses, and the oil spill collection efficiency of different heights of oil spill collectors under different oil spill thickness environments is analyzed, so that the height of the oil spill collectors under different oil spill thickness environments is obtained. best plan.

Analyze the oil-water separation efficiency of the lipophilic membrane and the hydrophilic membrane: perform an experimental analysis on the performance and efficiency of the lipophilic membrane and the hydrophilic membrane, and use the experimental data supplemented by the application of simulation software to analyze the separation efficiency of the membrane for the
As a result of the separation efficiency, the design of the ship oil-water separator is designed accordingly.

3. Research implementation plan and proposed research methods and technical routes

(1) Oil Spill Collector Design

The oil spill collector consists of an oil inlet, a barrel, a filter, a water flow floating stabilizer and a pipe. The top of the barrel is an oil inlet. The oil spilled on the water flows into the barrel through the negative pressure generated by the barrel. A circular hole is provided at the bottom of the circular barrel body, and the barrel body is connected to one end of the rigid oil suction pipe through the circular hole, and the other end of the rigid pipeline is connected to the oil fence. The oil spilled on the water surface is sucked into the pipeline of the oil boom through the round hole and the rigid pipeline. In this process, the filter screen inside the barrel can effectively prevent the solid surface floating objects from entering the pipeline from being blocked. A height adjuster is installed on the barrel body. The height adjuster can adjust the height of the barrel wall to keep the mouth of the device at the same level as the water surface. The height adjuster plays a role. The barrel is fixed to the floating body, and with the stability of the floating body, the influence of water flow on the barrel is reduced to a certain extent, so that the barrel is always kept vertical.

(2) New oil boom design

Spilled oil is sucked into the pipeline inside the new boom by the barrel. The new boom includes a floating boom, skirt, tension belt, weights, joints, and built-in pipes. The floating body is placed outside the surface of the oil boom to provide buoyancy for the entire processing device, so that the device can float on the water. The skirt is a continuous part of the oil boom below the floating body, which can effectively prevent the oil spill from escaping from below the oil boom. The tension band can withstand the pressure caused by the tide and wave. The counterweight can droop the boom. The oil boom is designed with a hook to facilitate the hanging of the oil spill collection barrel. The internal pipes are designed with joints to connect each section of the boom.

4. Key problems to be solved and research methods to be adopted

(1) How to design the oil boom with good stability:

The stability of the oil boom directly affects the recovery efficiency of the oil spill collector. After the oil spill collector pendant is installed on the oil boom, whether the traditional oil boom structure can guarantee the stability of the oil boom, and how the device needs to be improved so that the stability of the device can ensure the normal operation of the collector.

(2) Connection problems between the oil booms of the unit:

The weak connection of the oil booms is easy to make the internal pipeline connection of the oil boom not smooth, and there is a risk of breakage between the oil booms of the unit. The new oil boom is intended to adopt a snap design. Can this design ensure that the connection between the oil booms of the unit is secure under the harsh wind and wave environment.

(3) Research on ship's rapid oil-water separation technology:

In the process of oil spill collection, a large amount of water mixing will inevitably occur. How to quickly separate the oil-water mixture and discharge the water back into the water for oil storage Providing enough space is an important issue.

Based on the finite difference method, a three-dimensional numerical wave flume was constructed using Flow3D software, the geometry was displayed using FAVOR technology, and a finite element model of the boom was established using ANSYS to analyze the mechanical properties of the boom. Design a device that meets the expectations. At the same time, the efficiency analysis of the lipophilic and hydrophilic membranes in the oil-water separation technology is carried out through experiments and simulations. According to the modeling and analysis results, analyze and improve the details of the device until the best results are achieved.
Research method: The device is based on the design of the existing negative pressure water surface garbage recovery device and the traditional oil fence. The combination of the two and optimized design has strong operability.

Technical route: The technical route of theoretical derivation-simulation-experiment is adopted. In the process, the project is continuously innovated and improved, which is of good science.

Experimental method: Based on the finite difference method, Flow3D, ANSYS, and other software that are very mature in the field are used to construct the wave tank and oil boom model, and the simulation data is used to design the expected device shape.

5. Project innovation
(1) The device integrates the oil control function and the oil absorption function, so that the oil spill on the water surface can be treated in a timely manner:
It breaks the limitation of the traditional oil boom that can only control oil spills, so that when a ship oil spill occurs, it can be timely The treatment of oil spills is expected to prevent the uncontrolled spread of oil spills due to uncertain factors such as the environment.
(2) Multi-stage dewatering design makes the recovered oil spill more purified:
The device has been designed with oil and water separation devices on the pipeline and the ship. The pipeline uses a hydrophilic membrane and a lipophilic membrane to perform preliminary and efficient separation of oil and water. On the ship, the characteristics of different oil-water density are used to separate the oil-water mixture twice, and the separated water is discharged into the water area again.
(3) The oil spill is recovered based on the principle of negative pressure to make oil recovery more efficient:
The oil spill on the water surface is collected using the principle of negative pressure. The collection speed is fast and the energy consumption is low. Compared with the traditional manual recovery method, it reduces Costs and risks of oil spill recovery.
(4) The foldable design of the device is adopted to maintain the convenience of storage of the oil boom:
On the base material of the foldable oil boom, a hose made of polyurethane polymer material is used as the internal pipe material to ensure the oil boom At the same time, it will minimize the impact on the space occupied by the ship.

6. Conclusion
This project studies the design of hybrid ships based on fuzzy logic and intelligent energy management control strategies. It has strong generalization, wide adaptability, and high feasibility. It has stable and reliable characteristics and can be widely applied to inland river cruise ships, ferries, and small freight ships. The benefits of fuzzy logic control algorithms are not only in expressing rules that are difficult to accurately quantify, but also in saving power. Compared with traditional algorithms, it can make full use of the dynamic characteristics of each power source to optimize the power output of each power source, thereby reducing the waste of electrical energy and improving the stability of the power system. This design belongs to a pure green hybrid ship. If it can be applied to actual production and life, it will have a strong social effect on protecting the environment, saving energy and reducing emissions.

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