Research on the multifunctional oil spill recovery rescue ship

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Abstract: In order to deal with sudden oil spills at sea in a timely and effective manner, the ship mainly uses bubble-type anti-fouling curtains to isolate the pollution, combined with the oil spill recovery device of the bionic jellyfish for oil spill recovery. Traditional oil spill accident handling requires coordination and arrangement of various functional ships to operate separately. The integrated scheme designed in this paper integrates the improved pipe laying device and oil spill recovery device into a unified whole. As the development of marine oil and gas continues to heat up, and the requirements for marine environmental protection in the world continue to increase, there are also higher and higher requirements for oil spill recovery vessels and oil booms. Therefore, a rescue ship that can respond quickly in the event of an oil spill has great prospects.

1. Introduction

From 2008 to 2017, the accident rate of light-duty and above tankers (with or without spills) almost tripled: the frequency of accidents increased from 0.025 to 0.066. In 2017, China surpassed the United States as the world's largest crude oil importer for the first time. According to data from the General Administration of Customs of China, China imported 420 million tons of crude oil in 2017, a year-on-year increase of 10.1%. A large part of China's crude oil imports are transported by sea ships, and large oil tankers are busy shuttling through major ports. Therefore, the oil spill risk brought by shipping to China is destined to gradually increase.

However, due to the rapid spread of marine oil spill accidents, when the oil spill is effectively controlled, there are already large areas of pollution in the relevant sea area, and the task of cleaning up the oil spill is difficult and the efficiency is low. Aiming at the problems of rapid spread of marine oil spills, heavy pollution and difficulty in cleaning up, a class of engineering ships can be designed to quickly respond to sudden oil spills at sea, to block when the pollution has not spread to a large extent, and to efficiently handle the barrier area. The pollution will greatly reduce the environmental pollution caused by oil spill accidents and save treatment costs.

At present, the anti-proliferation control of marine oil spill pollution mostly uses tugboats to arrange solid oil booms, and then dispatch oil spill recovery vessels for recovery operations. However, the response time to accidents is long, and the functions of each engineering equipment are single, and the cooperation efficiency is low. The diffusion of pollutants cannot be treated quickly and effectively. In addition, the solid oil boom will not only hinder the passage of ships, but also interfere with the normal life of marine life, and the layout range is limited. Therefore, an oil spill recovery rescue ship based on bubble curtain barrier technology came into being.
2. Multifunctional oil spill recovery rescue ship

2.1. Hull design
The hull design mainly includes winches, pipe laying frames, air compressors, oil storage tanks, bionic jellyfish, etc., as shown in Figure 1.

![Figure 1: Schematic diagram of the hull](image)

2.2. Efficient and automated pipe laying device design
Because the pipe that releases bubbles needs to be suspended in the water, the depth of the pipe in the water is changed by the counterweight, and the pipe is a plastic hose, so the tensioner, winch and stinger do not need to be too heavy.

The pipelaying equipment effectively solves the pipeline transportation and docking problems through the new device, and realizes the pipeline transportation automation. It has the advantages of high efficiency, simple operation, high safety and stable pipe transportation.

The tube reel system consists of two parts: a motor and a tube drum. The drum is used to store pipelines and the motor is used to provide rotational power. The entire system cooperates to complete the two actions of the pipeline winding up and down the drum. The function of the positioning system is to change the direction of the pipe, reduce the bending stress of the pipe laying, and position the pipe. The positioning wheel structure is also used in the test system, and the outer ring of the round wheel has a groove for placing pipelines, as shown in Figure 2.

![Figure 2: Structure diagram of simulation test system](image)
The pipeline paving process is roughly as follows:
a) The oil spill recovery rescue ship is in place at the location where the oil spill occurred.
b) The pipeline is lowered, and the pipeline is transferred to the jacket or cantilever structure on the ship through the tensioner and then lowered into the water. During the lowering process, the pipeline is in a vertical bend, and the pipeline is bent from the bottom to the oil spill recovery ship. During the laying process, the bending degree of the pipeline should be controlled within the allowable range of the pipeline to ensure the structural integrity of the pipeline.
c) Adjust the water inlet angle of the pipeline. According to the laying depth, calculate the appropriate water inlet angle. During the laying process, the tensioning force is applied by the tensioner, and the power of the ship is used to control the speed of the pipeline down and the shape of the pipeline under water, and reduce the bending stress and deformation of the underwater pipeline to prevent instability or damage occurs.
d) Under the guidance of the rope, the pipeline extends into the water and is connected and fixed with the suction anchor at the bottom.
e) Laying pipelines along the set route. In the whole pipe laying process, the positioning and stability of the ship are very important, which affects the pipe laying process and the safety of the pipe laying. It is necessary to monitor the condition of the pipeline in real time, control the bending and force of the pipeline, and ensure the integrity of the pipeline.

3. Bionic jellyfish receiving and sending device and oil return system

3.1. Device design
According to the jellyfish sending water and food into the stomach through the tube of the body, the bionic jellyfish oil recovery device sucks the oil-water mixture into the device through the liquid inlet pipe. The liquid inlet pipe is connected to the casing of the device in a tangential direction. The elbow in the form of a Kimide spiral reduces the interference of the liquid inlet on the center vortex field of the device. According to the swing of the cilia in the pipe of the jellyfish, the water flows in one direction. A drainage impeller is installed on the rotating shaft of the center of the device.

The drainage impeller can not only discharge the liquid in the device, but also make the liquid outside the device flow in continuously. In the device. According to the external shape of the jellyfish, the oil storage tank of the device is flexible and has a bell-shaped shape. In addition, according to the balance bag of the jellyfish, a circular floating body is installed around the device to make the device have a certain buoyancy during operation. At the same time, the concept of vortex is introduced, which is similar to the principle of oil separation of oil separators. The shaft with impeller installed in the center of the artificial jellyfish device is rotated by the motor to form a vortex, which makes the oil-water mixture with density difference natural under the action of centrifugal force.

The stratification of the oil is sucked into the oil storage sac through the oil pump, so as to achieve the purpose of collecting the spilled oil. The artificial jellyfish oil spill recovery device is shown in Figure 4. When the artificial jellyfish device is working normally, the oil-water mixture flows into the device along the pipeline 4, and the motor 2 is turned on at the same time to rotate the rotating shaft to form a vortex.

Due to the difference in oil and water density, in the vortex field, the oil layer will gradually slide down the bottom of the formed vortex center, and the oil layer near the central axis will become thicker and thicker. The oil pump 3 will automatically turn on to suck away the oil accumulated in the center. Collected in the flexible oil storage bag 1 or other large-scale equipment that can store oil. At the same time, the central rotating shaft drives the drainage impeller 5 to discharge water, causing a certain pressure difference in the device, so that the mixture of seawater and petroleum continuously enters the artificial jellyfish shell from the inlet of the pipeline 2.
3.2. Research and Design of Bionic Jellyfish Control System
In order to better realize the flexible movement of the bionic jellyfish in the water and oil spill recovery, the bionic jellyfish is equipped with a sensitive remote control system. Use remote control system to meet the movement, floating and sinking of jellyfish in water and recovery of spilled oil. Imitating a remote control robot, using a single-chip wireless remote control to control the movement and oil absorption of the bionic jellyfish in the water.

4. Conclusion
For timely and effective treatment of sudden oil spills at sea, the ship mainly uses bubble-type anti-fouling curtains to isolate the pollution, and combines the oil spill recovery device of the bionic jellyfish for oil spill recovery. The organic combination of rapid pipe laying device, bubble curtain oil containment device, and oil spill recovery device will effectively solve the traditional solid oil boom's low flexibility, oil spill and seawater corrosion, which lead to reduced oil containment efficiency and single function of each vessel And coordination response time is too long.

When laying pipes and implementing oil spill recovery, not only safety and efficiency must be considered, but also the impact on the environment and the impact on underwater organisms must be considered. The pipes laid in the water continuously pass air into the water through the air compressor on the ship, which can alleviate the lack of oxygen in the seawater and improve the ecological environment in the water while forming an air curtain oil boom.

Compared with the traditional pipelaying ship or dragging construction method, it has the advantages of short construction period, low cost and high efficiency. As the development of marine oil and gas continues to heat up, and the requirements for marine environmental protection in the world continue to increase, there are also higher and higher requirements for oil spill recovery vessels and oil booms. Therefore, a rescue ship that can respond quickly in the event of an oil spill has great prospects.

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