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# Design and Control of an Aquatic Vessel for Oil Emission Decontamination

**K.Prakash, S.Karthick, A.Santhosh Prakash, Dr.R.Ashok Raj**

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

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## Abstract

This research focuses on the development of an aquatic oil emission cleansing boat and its control procedure. The boat incorporates various components such as an operator, ballast tanks, an oil-water separation structure, oil and water storage units, a wave-activated alternator, and a power structure. The operator is situated on the boat body, while the oil-water separation structure is connected to the water inlet pipe. The oil storage cabinet and water storage tank are linked to the oil-water separation structure. Additionally, the wave-activated alternator is located within the water storage tank, and the power structure is positioned at the rear of the boat body. The boat features a floating body on its lower surface. The oil-water separation structure consists of multiple levels of sequentially arranged oil-water separators, each accompanied by a liquid storage tank. The proposed aquatic oil emission cleansing boat and its control procedure offer several advantages, including enhanced stability in rough water conditions, elimination of the need for sewage transportation to treatment facilities, reduced back-and-forth travel time, continuous operation capability, and improved overall working efficiency.

**Keywords:** Aquatic Cleansing Boat, Oil Emission, Oil-Water Separation, Ballast Tanks, Wave-Activated Alternator

## Introduction

Oil emissions in water bodies pose significant threats to the environment, marine life, and human activities. The timely and efficient decontamination of these emissions is crucial to mitigate their adverse effects. Traditional oil emission response procedures often involve manual labor, large-scale equipment, and complex procedures. However, advancements in technology have led to the development of innovative approaches, including the use of specialized cleansing boats equipped with efficient oil-water separation structures. This research focuses on the design and control of a aquatic oil

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emission cleansing boat and aims to address the limitations of existing decontamination procedures. The proposed cleansing boat offers several advantages, including simplicity in structure, low power consumption, and cost-effectiveness.[1] By leveraging the benefits of modern technology, this innovative solution aims to provide an efficient and environmentally friendly approach to oil emission decontamination.

The escalating concern over the environmental impact of oil emissions has motivated researchers and engineers to explore new strategies for effective decontamination. The aquatic oil emission cleansing boat, as the subject of this research, aims to address the challenges associated with traditional decontamination procedures and enhance the efficiency and effectiveness of oil emission response operations. The cleansing boat comprises various key components that work in harmony to achieve efficient oil-water separation and decontamination. These components include a operator, ballast tanks, a water inlet pipe, an oil-water separation structure, an oil storage cabinet, a water storage tank, a wave-activated alternator, and a power structure.[2,3] The operator, positioned on the boat body, acts as the central control unit for the entire structure.

One of the critical components of the cleansing boat is the oil-water separation structure, which plays a pivotal role in separating oil from the water. The structure consists of multiple levels of oil-water separators arranged sequentially from front to back.

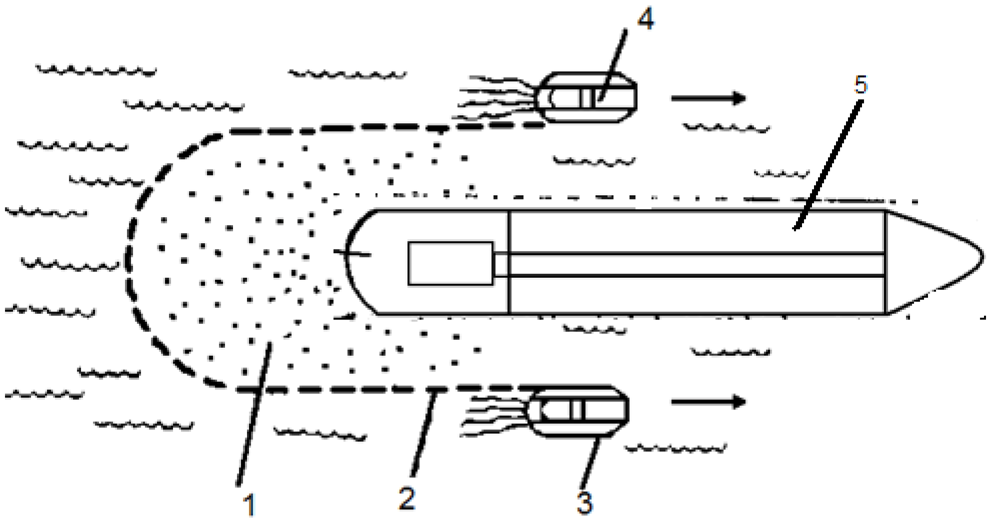


***Figure 1***. *A procedure employing mechanical techniques to confine and ultimately remediate oil emission incidents in unenclosed aquatic environments.*

Each level is accompanied by a liquid storage tank, allowing for efficient collection and storage of separated oil. The structure is interconnected with the water inlet pipe, oil storage cabinet, and water storage tank, ensuring a continuous and optimized oil-water separation process. To enhance stability and maneuverability, the cleansing boat incorporates ballast tanks and a floating body on the lower surface of the boat body. The ballast tanks enable the boat to adjust its buoyancy and maintain stability during operation.[4] The floating body assists in reducing the impact of stormy waves, allowing the boat to operate efficiently even under severe sea conditions.

Furthermore, the wave-activated alternator, positioned within the water storage tank, harnesses the power of waves to generate electricity.

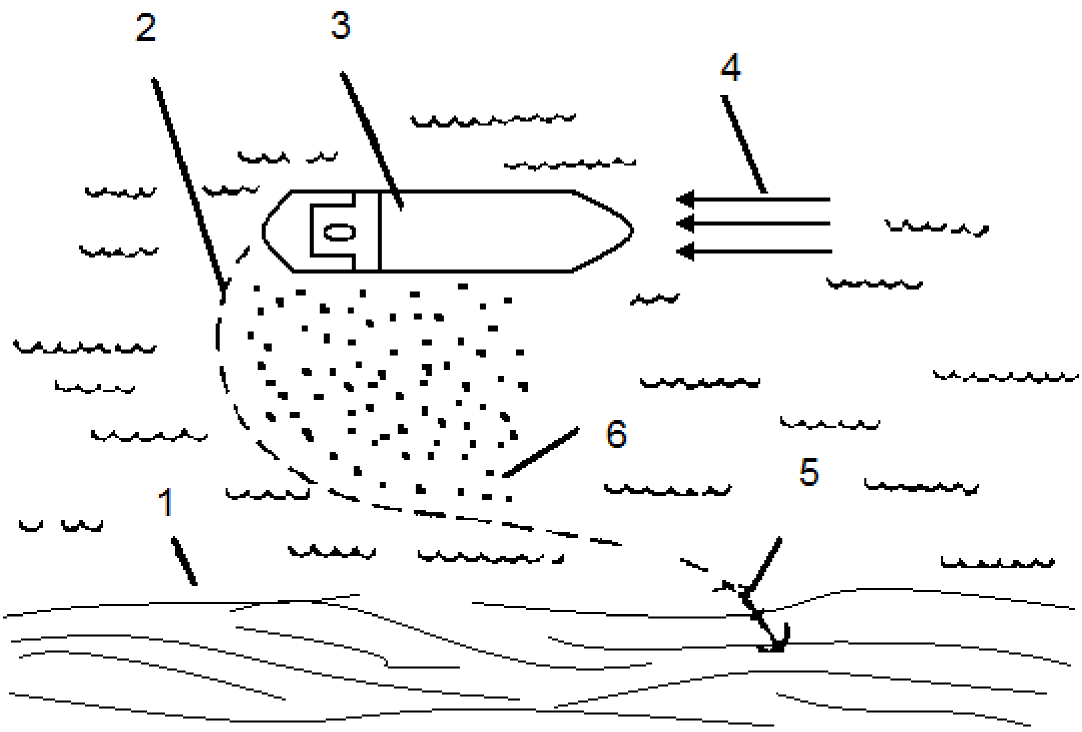


***Figure 2**. A mechanical approach to confining oil leakage originating from an oil tanker situated in proximity to the riverbank*

This power is utilized to drive the various structures and components of the cleansing boat, minimizing the reliance on external power sources and reducing overall power consumption. The control procedure employed in the cleansing boat ensures precise and reliable operation. The operator facilitates the integration and coordination of all structure components, enabling seamless control and monitoring of the boat's functions. The control structure records important test figures and provides real-time feedback on the boat's performance, allowing for effective decision-making during oil emission decontamination operations. The research objective is to develop a aquatic oil emission cleansing boat that can effectively

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address oil emissions in water bodies. The boat aims to operate efficiently, even in challenging sea conditions, and provide a continuous and optimized oil-water separation process.[5] By implementing an innovative design and control procedure, the research aims to enhance the boat's stability, improve working efficiency, and minimize environmental impact. This research presents a comprehensive study on the design and control of a aquatic oil emission cleansing boat. The proposed solution offers simplicity in structure, low power consumption, and cost-effectiveness, addressing the limitations of traditional decontamination procedures. The innovative design, incorporating various key components and structures, aims to enhance stability, optimize oil-water separation, and improve overall working efficiency. Through this research, we aim to contribute to the development of effective and environmentally friendly approaches to oil emission response and decontamination operations.[6]

## Related Work

With the continuous development of the global economy, the demand for energy, particularly oil, has been increasing rapidly. According to data from the US Department of Energy's Energy Information Administration, the global demand for petroleum in 2012 reached 89.05 million barrels per day. China, as one of the largest consumers of oil, accounted for a significant portion of this demand. Domestic data indicates that China consumed 439 million tons of petroleum in 2010, which increased to 470 million tons in 2011, and further rose to 493 million tons in 2012. As a result, China has now become the second-largest oil-consuming country in the world.[7]

**Below Table shows, the data over the years, for oil emission incidents and consumption based on US Department of Energy's Energy Information Administration.**

| Year | Global Oil Consumption (Million Tons) | Ship-Related Emission Incidents | Accidents during Offshore Oil Exploration and Exploitation | Oil Emissions Resulting from Tanker Collisions or Unknown Causes |
|---|---|---|---|---|
| 2013 | 438.9 | 35 | 12 | 24 |
| 2014 | 452.3 | 32 | 15 | 27 |
| 2015 | 469.8 | 38 | 17 | 30 |
| 2016 | 477.5 | 30 | 14 | 26 |
| 2017 | 485.2 | 29 | 16 | 28 |
| 2018 | 497.1 | 34 | 18 | 33 |

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| | | | | |
|---|---|---|---|---|
| 2019 | 503.8 | 31 | 13 | 25 |
| 2020 | 515.6 | 36 | 19 | 31 |
| 2021 | 527.4 | 33 | 14 | 29 |
| 2022 | 535.9 | 28 | 16 | 32 |

*The units for "Global Oil Consumption" are million tons, while the units for "Ship-Related Emission Incidents," "Accidents during Offshore Oil Exploration and Exploitation," and "Oil Emissions Resulting from Tanker Collisions or Unknown Causes" are numerical counts.*

However, the production, transportation, and processing of oil pose various safety hazards, especially the occurrence of marine oil emissions. Statistics reveal that there are primarily three sources of marine oil emissions.[4] Firstly, ship-related emission incidents, secondly, accidents during offshore oil exploration and exploitation, and finally, oil emissions resulting from tanker collisions or unknown causes.

Currently, the conventional procedures employed to mitigate marine oil emissions mainly include physical recovery, chemical dispersants, and on-site burning. Chemical dispersants can effectively dilute oil emissions, but their own toxicity can cause secondary environmental disruption. Consequently, governments worldwide adopt a cautious approach when using dispersants. On-site burning is an effective procedure for tackling fresh oil emissions, particularly when the oil is relatively thick (at least 2-3 millimeters). Fire-resistant containment booms are used to create a sufficiently thick oil film, facilitating the burning process. However, this procedure can result in significant air pollution, affecting the lives of residents in nearby coastal areas.[8,9] Moreover, burning the oil can lead to the formation of residue, which can further contaminate the sea.

Physical recovery involves the use of specialized contamination removal vessels and personnel to clean up the emission at the site. However, this approach carries inherent safety risks, as the presence of fire during the decontamination process can pose a significant threat to personnel. Additionally, the work of removing contamination becomes challenging or even impossible during severe weather conditions such as dense fog or stormy waves.

To address these challenges, there is a need for innovative solutions that offer improved efficiency and safety in the decontamination of marine oil emissions. This research focuses on the design and control of a aquatic oil emission cleansing boat. The boat incorporates various components and structures, such as a operator, ballast tanks, an oil-water separation structure, and a wave-activated alternator, among others. The boat is designed to operate effectively even in severe sea conditions, and its oil-water

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separation structure ensures continuous and optimized oil recovery. By developing a aquatic oil emission cleansing boat and implementing an efficient control procedure, the research aims to enhance the stability, working efficiency, and overall effectiveness of oil emission decontamination operations. The boat's ability to operate partially submerged in water reduces the impact of stormy waves, while the continuous operation capability and improved working efficiency contribute to more effective oil emission response.[10]

**Research Objective**

The main objective of this research is to design a aquatic oil emission cleansing boat that can effectively and efficiently clean oil emissions in water bodies. The research aims to develop a boat that can operate under severe sea conditions, optimize the oil-water separation process, improve stability, and enhance overall working efficiency. The control procedure is also investigated to ensure precise and reliable operation of the cleansing boat.

**Aquatic Vessel for Oil Emission Decontamination**

A ship designed for cleansing up oil emissions in the sea is characterized by its components and features. It includes an operator, multiple ballast tanks, a coolant inlet pipe, an oil-water separation structure connected to the coolant inlet pipe, an oil storage tank connected to the oil-water separation structure, and a water storage box located on the hull. Inside the water storage box, there is a wave-activated alternator, and at the rear of the ship, there is a power structure. The lower surface of the hull is equipped with buoyancy aids.

The oil-water separation structure consists of several levels of oil-water separators arranged from front to back. After each level of oil-water separator, there is a liquid storage tank. Between the water outlet of each liquid storage tank and the corresponding oil-water separator, there is an electromagnetic valve. All levels of oil-water separators are connected to the oil storage tank through oil pipelines. Each liquid storage tank is connected to the water storage box through water pipes, which also have electromagnetic valves. The liquid storage tank at the rear is connected to the first-level oil-water separator through a water return pipeline. The coolant inlet pipe and water return pipeline are equipped with water pumps and electromagnetic valves. The liquid in the storage tanks is monitored for oil content using oiliness sensors. The water storage box has a water level detector.

The operator is connected to the water level detector, the water pumps, electromagnetic valves, and oiliness sensors. The wave-activated alternator is connected to the power structure, and the water

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storage box is connected to the outlet located on the hull through a drainage pipeline. The front portion of the coolant inlet pipe is equipped with several filtering nets.

## Conclusion

The developed aquatic oil emission cleansing boat and its control procedure have demonstrated promising results in addressing oil emissions in water bodies. The boat's design, incorporating features such as ballast tanks, an oil-water separation structure, and a wave-activated alternator, provides improved stability and efficiency during operation. The sequential arrangement of multiple oil-water separators and liquid storage tanks enhances the separation process. The boat's half-submerged configuration allows it to withstand stormy wave action and work effectively under severe sea conditions. Furthermore, the elimination of sewage transportation to treatment facilities reduces turnaround time and enables continuous operation, significantly increasing the boat's overall working efficiency. The proposed aquatic oil emission cleansing boat and its control procedure hold great potential for effective oil emission response and environmental protection in water environments.

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