Comprehensive System of Preventing Marine Pollution in Ocean-going Ships

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Abstract. In order to prevent and control marine pollution, the paper uses WinCE operating system and Advantech embedded industrial computer to design a ship oil discharge monitoring system. The system uses various sensors to detect and collect relevant data to calculate the instantaneous discharge rate of oil and the total amount of oil discharged. It realizes automatic control of the discharge of oily sewage from oil tankers, and can realize real-time display, printing, sound and light alarms and other functions. The simulation results show that the new oil discharge monitoring system can meet the requirements of operators to monitor the ship's oil discharge process in real time, query historical data and alarm data at any time, and the analysis results meet the expected assumptions.

Key words. Ocean, pollution, monitoring system, oil discharge monitoring.

1. Introduction
With the increase in the volume of oil shipments and the huge size of oil tankers, coupled with technical and human factors, the possibility of marine oil pollution is also increasing. Oil pollution from ships not only has a significant impact on the marine environment, but also causes a serious waste of petroleum energy. The oily sewage discharged from ships into the ocean includes: 1. Engine room bilge sewage. In order to ensure the normal operation of the ship's power plant, water is required as a cooling medium. Due to the imperfection of the system, part of the cooling water will lead to the bilge of the engine room and mix with various pollutants there or other contaminated water to form the bilge sewage of the engine room. 2. Cargo tank washing water. Especially liquid cargo ships (tankers, bulk liquid chemical tankers, etc.), in order to achieve the required cleanliness of cargo transportation conditions, or due to the maintenance of cargo tanks, they often need to be cleaned with water or detergent [1]. The washing water contains petroleum, chemicals, toxic substances, or detergents, etc. 3. Ship's ballast water. Especially when the tanker sails with no load, it needs ballast to ensure its necessary stability. After the overboard water as ballast water is loaded into the cargo tank, it is mixed with the residual cargo oil or other harmful liquids in the tank. If the dirty ballast water is not treated, it will cause serious pollution if it is directly discharged into the sea.

In response to the above problems, this paper proposes an optimized design method for the Beau Gulf marine ship pollution real-time monitoring system based on dual 16-bit fixed-point DSP control. First, the visual and chemical detection design of the pollution source is carried out, then the hardware
modular design of the system is carried out, and the experiment is finally carried out. Test and draw conclusions about effectiveness.

2. Overall system design

According to the requirements of the Convention, the system should be able to monitor the amount of oil pollution discharged into the sea and realize emission control management. At the same time, it can complete the indication and record of speed, position, flow rate, instantaneous fuel content, and cumulative emissions. According to this requirement, the system consists of monitoring main engine fuel meter, flow meter, control valve, GPS positioning system and speed measuring device. The system block diagram is shown in Figure 1. The GPS module receives the information from the satellite positioning system and sends it to the monitoring host by RS485 communication to complete the positioning function. The positioning function is mainly used to judge the sea area where the ship is in the current period. Different sea areas have different oil pollution discharge standards. The ship's speed measurement module comes with it and transmits it to the monitoring host with a standard 4-20mA signal. The sampling probe is installed on the sewage pipeline, and the monitoring host periodically starts the sampling pump and vacuums, so that the sampling probe takes the sewage sample from the pipeline into the oil content meter, measures the oil content, and sends the 4-20mA standard signal to the monitoring host [2]. The flow meter is installed on the sewage pipeline to measure the current flow rate to calculate the cumulative oil discharge together with the oil content meter. The control valve implements emission control management, and can prohibit emission when the oil pollution does not meet the standard or the total discharge exceeds the standard.

![Figure 1. Structural block diagram of the monitoring system for oil pollution emissions from ships](image)

The main functional modules of the system include ocean image acquisition and seawater sampling acquisition module, image video encoding module, external clock module, image information conversion module, pollutant feature extraction module, local bus module, data output module, human-computer interaction module and visualization Remote control module, etc. According to the overall design architecture of the system in Figure 1, the functional composition and structure of the ship pollution real-time monitoring system are analysed. First, the sampled marine ship pollution laser three-dimensional scan image is imaged and extracted. Through the video collection of the ship pollution area, combined Video frame encoding is used for external bus triggering, combined with chemical spectroscopy analysis methods, and chemical characteristics analysis of ship pollutants. DSP and logic programmable PLC are used to transform the video information of visual sampling of ship pollution, and establish a video acquisition module, core control module and human-computer interaction module for real-time monitoring of marine ship pollution in the Beau Gulf [3]. The real-time video image collection method is used to collect and analyse the visual characteristics of the ship's pollution area, realize the I/O data output and the spectrum analysis of the pollution source, thereby realizing the real-time monitoring of marine ship pollution.
3. System hardware design

The hardware design includes two parts: shipborne terminal hardware system and shore-based hardware system, as shown in Figure 2. The onboard terminal hardware system includes onboard data processor, onboard data storage and flame detector, oil concentration sensor, liquid level sensor, flow sensor, time counter and other data acquisition modules [4]. Among them, considering the large amount of information and high real-time requirements of the data set to be processed by this system, the STC89C52RC microcontroller of Hanging Company is selected as the processor, which has the advantages of high performance, low power consumption and real-time signal processing.

The flame detector is installed in the furnace of the incinerator to detect whether the incinerator is in a burning state, and transmit the collected data to the on-board data storage through the field bus; the quality sensor is used to detect the quality of solid waste processed by the incinerator on the ship; the liquid level sensor is installed in the slop water tank to calculate the amount of sewage and slop oil produced by the ship; the oil concentration sensor and flow sensor are mainly installed in the slop water pipeline to measure the oil concentration and The discharge amount of dirty oil and water; the man-machine exchange module adopts a screen display interface, and the data in the memory can be accessed by logging in. In addition, the sulphur content of exhaust emissions can also be recorded by corresponding sensors and stored in the shipboard data storage.

4. Software Design

The operating system selects the embedded operating system WinCE. WinCE is an embedded operating system launched by Microsoft. It extends the external features of the Windows operating system. The kernel is a simple and efficient fully pre-emptive multitasking operation mode, and has strong versatility and portability [5]. According to the actual situation of the PCM-9575 motherboard, we use Plat Form Builder to do the corresponding tailoring and customization, and only retain the necessary kernel and drivers to reduce the storage capacity and speed up the start-up. During the cutting and customization process, some of the native devices on the PCM-9575 motherboard can be directly loaded into your own operating system, such as display, serial port, and parallel port. Not in some Plat Form Builder, you need to do some modification manually, and then copy the DLL file of the driver to NK. Under the bin generation path, just recompile and link. Application programming adopts Embedded VC.

After completing all preparations, start the ship oil discharge monitoring system to control the ship's oil pollution discharge. Various monitoring functions can be realized through the host computer to simulate the actual situation, and the monitoring and management can also be performed by the host computer. The new oil discharge monitoring system uses the configuration software MCGS for...
simulation and analysis. Use this software to develop a real-time monitoring flow chart of the improved ship oil discharge monitoring system (Figure 3).

![Real-time monitoring flow chart](image)

**Figure 3.** Real-time monitoring flow chart

The detection sensor measures the oil concentration signal, the flow meter measures the oil flow signal, and the log meter measures the speed signal. These three signals are processed by the measurement and control unit, and the pressure switch signal is directly collected by the measurement and control unit [6]. The discharge valve, solenoid valve, sampling motor and other execution parts are all controlled by the control execution box.

5. **Working principle and data collection of oil discharge monitoring system**

5.1. **Working principle**

This system is mainly based on the ship’s speed (provided by the ship’s GPS or log, through the measurement of the discharge pipe flow and the oil content of the oily sewage, when the conditions of equations (1) and (2) are met and there is no system Oily sewage is allowed to be discharged in the event of operational failure (power failure, sample loss, major error in the measurement or recording system, when any sensor input exceeds the effective capacity of the system) to reduce the pollution of the ship to the ocean. When the equation (1) or equation is not satisfied (2) Discharge must be terminated when there is any system operation failure.

\[
\frac{QC}{1000V} < 30L/nmile \quad (1)
\]

In formula (1), Q is displacement, m³/h; C is oil concentration; V is speed, mile/h.

\[
\frac{I_1}{30000} > I_2 \quad (2)
\]

In formula (2), \( I_1 \) is the last load; \( I_2 \) is the total discharge.
5.2. Data collection and calculation
During the data collection process, it is necessary to transmit the collected sewage and slop oil volume of the ship to the maritime supervision department and ship management company on the land side through the Baidoo short message communication function in real time [7]. Therefore, the corresponding data transmission capacity needs to be calculated and collected, processed, and stored in a unified manner. Data information is calculated in bytes. Each character corresponds to 1 byte, and each Chinese character corresponds to 2 bytes. The collected data is converted into a binary number that can be stored. The data collection of the ship-shore integrated simulation system is shown in Table 1. Shown.

| Data collection project         | Bytes | Data attributes | Remarks         |
|--------------------------------|-------|----------------|-----------------|
| Ship identification code       | 8     | Data attributes |                 |
| Date and time                  | 14    | Switch         | 0/1 on/off      |
| Incinerator fan status         | 1     | Switch         | 0/1 on/off      |
| Incinerator burner status      | 1     | Switch         | 0/1 on/off      |
| Oil-water separator status     | 1     | Switch         | 0/1 on/off      |
| Spare switch 1                 | 1     | Switch         | 0/1 on/off      |
| Spare switch 2                 | 1     | Switch         | 0/1 on/off      |
| Dirty oil level                | 2     | Analog         |                 |
| Sewage level                   | 2     | Analog         |                 |
| Analog spare 1                 | 2     | Analog         |                 |
| Analog spare 2                 | 2     | Analog         |                 |
| Exhaust sulphur content        | 2     | Analog         |                 |
| Extend part of exhaust emission analysis | 2 | Analog | Extended part |
| total                          | 43    | Data attributes |                 |

6. Experimental test analysis
In order to test the application performance of the method in the implementation of real-time monitoring of marine ship pollution in the Beau Gulf, experimental testing and analysis were carried out, the hardware circuit of the system was debugged, and the real-time monitoring and identification of ship pollution was realized through software development, and the SCSI ship pollution of HPE1562E was cyclically read. Regional ocean image satellite data and seawater sampling data, and information fusion and monitoring and identification to obtain data analysis results are shown in Figure 4.

![Figure 4. Data analysis of real-time monitoring of ship pollution](image_url)
7. Conclusion
In view of the actual development situation, this paper introduces the composition of the ship oil discharge monitoring system and the application of Advantech's embedded system in the ship oil discharge monitoring system, including hardware design and software design. When the oil pollution does not meet the standard or the total discharge exceeds the standard, the system can effectively achieve emission control and management, and it is currently operating well in practical applications.

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