The design of marine hydraulic oil detection and purification system

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Abstract. In this text, hydraulic oil is the research object. Aimed at improving the problems and shortcomings of present hydraulic oil detection and purification. By looking up for relevant information, and used Auto CAD to design working principle and main components. Finally, arguments the feasibility of the hydraulic oil detection and purification system from the aspects of technology, structure, operation and economy. The results show the system realizes the integration of hydraulic oil detection and purification, simplifies the operating steps, saves manpower and materials, and avoids the secondary pollution of hydraulic oil.

Keywords: Hydraulic oil, detection, purification.

1. Introduction
The safety of vessels depends on the normal operation of the hydraulic system.[1] Hydraulic oil is an important working quality of the hydraulic system and the quality of oil directly affects the working state of the hydraulic system. Therefore, the detection and purification of hydraulic oil has great significance.

The existing hydraulic oil detection technology mainly includes microscopic counting method, microscopic comparison method, filter plugging method, quality analysis method, etc.[2-3] Purification technology mainly includes high precision filter core filtration technology, electrostatic filtration technology, centrifugal filtration technology and so on.

But the detection and purification of hydraulic oil are two completely independent systems. The main steps are as follows. First of all, the sample was extracted in hydraulic oil and detected in the specific environment. If the result is not qualified, then the hydraulic system in the hydraulic system will be purified. The process was complex that requires a lot of time, manpower and material resources. And in the process, hydraulic oil was repeatedly transported, and the equipments were not placed according to the technological requirements, which easily caused the secondary pollution.[4-10]

2. Analysis of Design Requirements for Marine Hydraulic Oil Detection and Purification System
In view of the shortcomings of the traditional oil detection and purification system and refer to the existing hydraulic oil detection and purification system technology to analyse the design requirements
of the hydraulic oil detection and purification system. The design requirements are as follows: (1) Mature technology and good adaptability: the detection technology must have high precision, fast speed and short cycle for detection; The purification technology requires high cleanliness and high speed. And applicable to the general type of ship. (2) The system requires simple structure, easy and automatic operation and low technical requirements for operators. (3) The initial and operation cost of the system is low, and it needs easy maintenance.[11-14]

3. Design of The Marine Hydraulic Oil Detection and Purification System

3.1. Operational principle
As shown in Fig.1, the operational principle of marine hydraulic oil detection and purification system was designed by Auto CAD.

![Diagram of the system](https://example.com/diagram.png)

In Fig. 1, the hydraulic oil is temporarily stored in the oil sample container 1. After the system starts, the adjustable throttling valve 2 opens. The hydraulic oil first flows through the water removal device 3 to remove the water, and the wastewater is stored in the aqua storage tank 9. The liquid level detecting device 10 detects the water quantity in the aqua storage tank 9 and is connected with the control device 8. When the water level in the aqua storage tank 9 is too high, the control device 8 judges that the device needs to remove water. Then controls the opening of the electric globe valve 11, and drives the electric machinery 13 to drive the pump 12 to work, so as to drain the removing water device 3. After removing water, the hydraulic oil passes through the oil pipeline 4 to flow into the detection device 7.

The working principle of the detection device is as follows. A transparent window is arranged at the position of the pipeline corresponding to the level of the laser diode 14. The laser emitted by the laser diode 14 passes through the transparent window and is collected by the silicon photodiode 19. When the oil containing impurities passes through the transparent window, a part of the light is shielded by the impurity particles. Then the intensity of the light received by the silicon photodiode 19 is weakened, and the voltage pulse signal will be generated. The voltage signal is enlarged by signal amplifier 15 and operational amplifier 16. Then the signal comparator 17 compares the amplified voltage signal with the standard signal. After that, the result was transferred to the microprocessor 18.

Control device 8 accepts test results from detection device 7 and judges the current state of hydraulic oil. If the hydraulic oil meets the using standard and does not need purification, the control device 8 controls the electric three-way valve 6 to connect with the output of the hydraulic system. If the hydraulic
oil needs purification, then the output of the purification device is connected. The hydraulic oil that needs purification is removed from the hydraulic oil by high precision oil filter 22.

3.2. Components and parts

1) Removing water device

Removing water device consists of Titanium dioxide thin film tube, ultraviolet emitter and liquid level detection instrument. The structure of Titanium dioxide thin film tube is shown in Fig.2.

![Fig. 2 The structure of Titanium dioxide thin film tube](image)

The titanium dioxide film 24 is fixed vertically in a layered form and filled with the whole water removal device, and an ultraviolet transmitter 25 is also installed inside the titanium dioxide film. Main procedures of detection are as follows. Firstly, turn on the ultraviolet transmitter to emit ultraviolet rays. Because of the super hydrophilic property of the titanium dioxide film during ultraviolet radiation, when the hydraulic fluid flows through the fluid, the titanium dioxide film can absorb the tiny water droplets in the oil and get the hydraulic oil without water, which can remove the interference from the water drop. The liquid level detection instrument 10 is used for detecting the water level in the removing water device and it is linked to control device. The control device determines whether the removing water device needs drainage at present. When drainage is needed, the electric globe valve 11 is opened, and the electric machinery 13 is driven to drive the pump 12 to work, thereby emptying the water in the removing water device.

2) Detection device

As shown in fig.3, the detection device includes laser diode 14, signal amplifier 15, operational amplifier 16, signal comparator 17, microprocessor 18 and silicon photodiode 19.

![Fig. 3 Structure diagram of detection device](image)

After removing the moisture, the hydraulic oil flows through the transparent window and is irradiated by the laser beam from the laser diode 14. Silicon photodiode 19 are affected by reverse voltage. In the absence of light, the reverse current is extremely weak. In the presence of light, the reverse current
increases rapidly to tens of microamperes. As the intensity of light increases, the reverse current increases. The change of light causes the voltage change of silicon photodiode 19, which can convert light signal into voltage signal. When there is no impurity particle in the oil flowing through the transparent window, the output voltage is a certain value. When impurity particles in the oil pass through the transparent window, the amount of light received by the silicon photodiode 19 decreases because part of the light in the dirty oil is blocked by impurity particles. Therefore, the pulse produced by output voltage is proportional to the projected area of the particle. After the signal amplifier 15 and the operational amplifier 16 magnify the signal, the signal is transmitted to the signal comparator 17, and the amplified voltage signal is compared with the standard signal. Finally, the result is transferred to the microprocessor 18.

3) Purification device

In Fig. 4, purification device consist of shut-off valve 20, pressure gauge 21, high precision oil filter 22 and one-way valve 23.

![Structural diagram of purification device](image)

20. Shut-off Valve 21. Pressure Gauge 22. High Precision Oil Filter 23. One-way valve

**Fig. 4** Structure diagram of purification device

The key technology of the device is to install several special high precision oil filters 22 in the oil pipeline. When the hydraulic fluid flows through the oil filter, the particles in the oil are removed. In addition, the cut-off valve 20 and one-way valve 23 are installed in the pipeline to improve the filtering accuracy. Thermometer and alarm can also be added to remind operators to replace the filter element in time.

4. Feasibility Analysis of Marine Hydraulic Oil Detection and Purification System

4.1. Technical feasibility

The detection method of hydraulic oil used in the system is light transmission method. The intensity of the laser through the transparent window is measured by a silicon photodiode, and the optical signal is converted into a voltage signal. Then, the contamination degree of the hydraulic oil is detected by signal amplifier, operational amplifier and microprocessor. Moreover, the removing water device removes the influence of water and improves the detection accuracy.

The hydraulic oil purification method used in this system is high precision filter core filtration technology. The key of the technology is to install several high precision oil filters in the oil pipeline. It can filter out impurities such as glue and other products below 3μm in hydraulic oil. High precision oil filter has the advantages of high precision, high automation and convenient operation.

These technologies have been used in related industries for many years, with good effect and mature technology. Accordingly, the technology of the system is feasible.

4.2. Structural feasibility

The system composed of container of hydraulic oil sample, adjustable throttling valve, thin film tube, oil filter and other components. The system has less components and parts and its components are universal or standard parts, which can be directly selected in the market. The strength, stiffness and other parameters of the system or components also meet the requirements. The specific parts selection of the
4.3. Operational feasibility
The working steps of the system are as follows: 1) The hydraulic oil flows into the container and regulates the opening of the adjustable throttling valve until the hydraulic oil flows from top to bottom without bubbles, maintaining the opening of the adjustable throttling valve; 2) The hydraulic oil flows through the remoing water device to remove the water in the hydraulic oil and eliminate the influence of the water droplets on the accuracy of the hydraulic oil detection; 3) Hydraulic oil is tested by the detection device and the results are passed to the control device to determine whether the oil needs to be purified; 4) Hydraulic oil that needs to be purified flows into the purification device. Under the work of a high-precision filter, the impurities in the hydraulic oil are removed, and the hydraulic oil is transferred to the hydraulic system after purification.

From the analysis of the work process of the system, the system is simple in structure, highly automated and simple in operation. Therefore, the operation of the system is feasible.

4.4. Economic feasibility
A majority of the system’s components and parts are general or standard parts and they have high service life and simple maintenance. Therefore, the cost of system can be estimated and controlled, and the daily use and maintenance cost of the system is also low. So the system is economically feasible.

5. Conclusion
1) This text aimed at improving the problems and shortcomings of present hydraulic oil detection and purification. By looking up for relevant information to design a system which can achieve the integration of detection and purification of hydraulic oil and applied in actual marine;
   2) It discussed the feasibility of technology, structure, operation and economy;
   3) But the system belongs to the early stage of theoretical research. If applied to a real ship, further experiments and improvements are needed.

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