Improvement of Defects in ZYFM type oil-water separator

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Abstract. The working principle and automatic control principle of ZYFM type oil-water separator are analyzed. It is found that the design of this type of oil-water separator is defective, which is easy to cause the crew to intentionally discharge excessive oily water. By improving the control circuit and changing the open three-way valve of the gas installation, the design defects are eliminated, and the phenomenon of the crew's malicious discharge of excessive oily water is eliminated.

1. Introduction
ZYFM vacuum oil-water separator is the latest product developed by Shanghai Shijiu Marine Equipment Co.Ltd. It uses vacuum and microfiltration technology to carry out secondary separation of engine room oily water[1], which can separate engine room oily water with high emulsion concentration, meet the requirements of Annex I of MARPOL 73 / 78 convention[2], the discharge standard of ship oily water stipulated by the Chinese government, and also the resolution IMO-MEPC107 (49)[3]. It is required to obtain the type approval certificate issued by CCS, which has the functions of high automation, simple maintenance, backwashing gathering elements, etc. It is loved by the majority of crew members, and it is widely assembled on Chinese ships. However, the author found that there are defects in the design of this type of oil-water separator during the work of the ship, resulting in the excessive discharge of oily water into the sea.

2. Working principle (as shown in Figure 1)
2.1. First separation
The oily water pump (screw pump) draws water from the bottom of the separator to create a vacuum in the separator. Under the action of atmospheric pressure, the engine room oily water are sucked into the separator from the three-way valve 3 (left bottom) on the upper part of the first stage separator for preliminary separation. The large oil drops float to the top of the separator, and the small oil drops and oily water enter the special coalescer together to form a larger oil droplets, and then float to the top oil collection chamber[4]. The oily water of the first level treatment is discharged out of the ship through three-way valve 5 (bottom left), oily water pump, three-way valve 4 (bottom left) and outlet pipe 20.
2.2. Secondary separation
If the oily water of the first level treatment does not meet the discharge standard, the oil concentration meter sends out an electrical signal, the solenoid valve 9 is powered on and opened, the compressed air enters the cylinder of the three-way valve 4, the three-way valve changes from the original "bottom left" to "left and right", the oily water enters the second level processor and continues to separate, the oily water reaching the standard is discharged overboard through the three-way valve 7 (bottom left) and returns to the first level separator every 30 minutes. If the oily water separated by the secondary processor still fails to meet the standard, the oil concentration meter will issue a command again, the solenoid valve 10 will be powered on and opened, the compressed air will enter the cylinder of the three-way valve 7, the three-way valve 7 will change from the original "bottom left" to "left and right", and the unqualified oily water will flow back to the engine room bottom.

2.3. Backwash
When the oil layer accumulated on the top of the first level separator reaches a certain thickness, the oil level sensor triggers the signal, the solenoid valve 8 is powered on and opened, the pressure air enters the 3-way valve cylinder at the same time, the 3-way valve changes from "bottom left" to "left and right", the engine room oily water is suspended from entering the oil-water separator, and the clean water enters the bottom of the first level separator for reverse flushing through the 3-way valve 5, oily water pump and 3-way valve 6. The internal part of the first level separator changes from vacuum...
to pressure. The oil gathered on the upper part of the first level separator is discharged to the sump oil tank from the three-way valve 3. When the high oil level sensor detects clear water, the backwashing is finished and the normal separation starts again.

3. Control Principle (as shown in Figure 2)

3.1. Main line
The main line is divided into two ways, one is the air switch of regional distribution board → power switch K0 of control box → main contactor C0 → thermal relay RJ → motor, the other is the air switch of regional distribution board → power switch K0 of control box → main contactor C1 → heating wire R.

3.2. Control line
Start button QA → stop button TA → relay J0 normally closed contact → main contactor C0 coil → thermal relay normally closed contact.

3.3. Motor operation
After pressing the start button QA, the motor will be operated by energizing the main contactor C0 of the above line. The normally open contact of the main contactor C0 and the start button QA will act as self-protection in parallel. The time relay JS1 will be energized and the normally open contact will be closed in delay, leaving the vacuum pumping time for the oily water pump.

3.4. Oily water pump protection
When the liquid level in the oily water tank is too low, the vacuum degree will drop to the atmospheric pressure, or when the suction filter is blocked, the vacuum degree on the upper part of the separator will rise sharply. When these two situations occur, the vacuum degree will change obviously, and it will be converted into electric signal through the electric contact vacuum meter. When the vacuum is too high, the actual vacuum degree pointer (black needle) and the high vacuum degree pointer (The green pointer is adjusted to -0.05mpa) for connection. When the vacuum is too low, the vacuum pointer and the low vacuum pointer (the red pointer is adjusted to -0.01mpa) are connected. The vacuum meter pointer is connected to the coil of relay J0, so that the normally closed contact connected in series on the coil of main contactor C0 is disconnected, so as to stop the pump.
3.5. Automatic control of waste oil temperature

The waste oil temperature in the oil collecting chamber is controlled by the electric contact thermometer. When the temperature is too low, the actual temperature pointer (black needle) contacts with the low temperature pointer (red needle is adjusted to 35 ℃), and the coil of main contactor C1 is
energized, so that the normally open contact connected in series on the coil of main contactor C1 is closed, and the heating wire is connected to heat the waste oil and protect itself. When the temperature rises to a certain extent, the actual pointer contacts with the high temperature pointer (the green needle is adjusted to 45 °C), the coil of relay J1 is energized, the normally closed contact is disconnected, the coil of main contactor C1 is deenergized, the normally open contact is disconnected, and the heating wire is deenergized to stop heating.

3.6. Automatic oil drain control
High and low limit oil level sensors are installed in the oil collecting chamber at the top of the first level separator. The conductivity of the oil level sensor in oil and water is different, so that different resistance values are generated between the oil level sensor and the oil-water separator shell. This resistance value is sent to the liquid level relay in the control box, and the liquid level relay outputs different electrical signals to control the on-off of the J2 coil of the relay. When J2 coil is powered on, normally open contact is closed, solenoid valve DF1 (Figure 1, solenoid valve 8) coil is powered on, compressed air enters three-way valve cylinders 3, 5 and 6, as shown in Figure 1, clear water is pumped into first level separator through three-way valve 5 and 6, vacuum is converted into pressure state, waste oil is discharged to waste oil tank through three-way valve 3, J2 coil is powered off, normally open contact is off, solenoid valve DF1 (Figure 1, solenoid valve 8) coil is powered off Close, three-way valves 3, 5 and 6 are turned over, and automatic oil discharge is finished. Automatic oil discharge and reverse backwash are carried out synchronously.

3.7. Secondary separation control
When the primary treatment oily water fails to meet the standard, the alarm contact of the oil concentration meter is closed, the coil of relay J4 is powered on, the normally open contact is closed, the coil of relay J5 is powered on, and the normally open contact is closed for self-protection; the solenoid valve DF2 (solenoid valve 9 in Figure 1) is powered on, the pressure air enters the air cylinder of three-way valve 4, the state of three-way valve 4 is turned over, and the oily water enters the secondary separation; the time relay JS2 is powered on, and the normally closed contact turns off 30 minutes later. When the secondary treatment oily water reaches the standard, the alarm contact of oil concentration meter is off, the coil of relay J4 is deenergized, and the normally open contact is off. Within the delay time of time relay JS2, the coil of relay J5 is on, and the solenoid valve DF2 is on for secondary separation. When the delay time reaches, the delay contact of relay JS2 is off, the coil of relay J5 is off, and the normally open contact is off, and the solenoid valve DF2 is off. Electric three-way valve 4 turns over to the original state, and the oily water returns to the first level separator for further separation. When the secondary treatment oily water fails to meet the standard, the alarm contact of the oil concentration meter is closed again, the coil of relay J4 is powered on, the normally open contact is closed, the solenoid valve DF3 (solenoid valve 10 in Figure 1) is powered on, the cylinder of three-way valve 7 is ventilated, the state is turned over, and the oily water exceeding the standard flows back to the bottom of engine room.

4. Existing Defects

4.1. Defect 1
When the oil concentration meter detects that the oil content of the oily water after the separation of the two-stage processor exceeds 15 PPM, the system will give an alarm. The solenoid valve 10 (DF3 in Figure 2) is electrified and connected with the pressure air circuit, the three-way valve 7 is turned over, the relevant pipelines are switched, and the oily water exceeding the standard returns to the bilge, but the oily water pump will not stop working immediately, and the pump can not be stopped until the
vacuum degree in the first level separator reaches the set value, which is not reliable. If the three-way valve 7 is not closed tightly or fails (such as the air source is not supplied), the system may still be able to work, resulting in excessive discharge.

4.2. Improvement measures
The original design of solenoid valve 10 was changed from normally closed type to normally open type, and the original design of three-way valve 7 was changed from air closed type to air open type, so as long as the air supply stopped, three-way valve 7 would automatically close and the oily water would return to the bilge. At the same time, an intermediate relay controlled by 15PPM over limit signal is added to the 15PPM oil concentration meter to expand the normally open and normally closed contacts of the monitoring device, so as to realize the functions of automatic pump stop for 15PPM over limit and audible and visual alarm at the far and near ends.

4.3. Defect 2
The test water connected to the oil concentration meter (one is clear water, the other is sea water) is not interlocked. That is to say, as long as the system is connected with clear water to test the oil concentration meter, the oily water after separator separation can be discharged out of the ship smoothly no matter whether it exceeds the standard or not. It is not the operator's idea or practice of intentionally exceeding the standard, but the defect of the system is objective.

4.4. Improvement measures
A normally open solenoid valve is installed on the clean water side, and the wire is controlled by the normally open contact of the oily water pump contactor. When the oily water pump is running, the solenoid valve is powered on to close the pipeline on the clean water side, realizing the interlock protection between the clean water and the oily water, preventing the clean water from entering the detection pipe of the oil concentration meter, diluting the concentration of the oil, and the oil concentration meter can not truly detect the oil content in the discharged oily water.

5. Precautions
After the above improvements, the practice of intentional over standard discharge by crew members and over standard discharge caused by lax closing of three-way valve are prevented to a great extent[5]. The effect is remarkable in practice. It is worth noting that the relevant columns on the attachment of IOPP certificate after the modification must be changed correspondingly, and the classification society should be applied for affixing the modification seal or replacing the certificate to avoid being listed as defects in the PSC inspection in the future.

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