Analysis and Treatment of Electrical Fault of Ship Windlass

Yanyang Wang *, Chongchong Liu, Linxiang Hu and Shuai Chen

(China Satellite Maritime Measurement and Control Department, Jiangyin, Jiangsu, 214431)

*Corresponding author’s e-mail: 948091562@qq.com

Abstract: This paper aims at the electrical failure of the ship anchor machine, the potential causes of the failure are summarized and summarized by analyzing the electrical principle of the anchor machine. After the on-site failure investigation, the cause of the failure is accurately located, so as to put forward a feasible plan for the use and daily maintenance of the ship anchor machine. Because of its simple structure, stable operation and easy maintenance, the anchor machine is used for anchoring and maintenance of ships. Port docking is very important for ship safety and is widely used on ships.

1. Introduction

1.1 Basic structure

The basic structure of the windlass is shown in Figure 1. The anchoring part is composed of a pair of open gears and an anchor sprocket, and the open gears are protected by a gear cover. The reel part is composed of a motor, a reduction gear box, a reel and a stranding drum. When the reel is working, close the reel clutch, release the reel brake, and the motor drives the closed gear box to drive the reel to run. When the windlass is working, close the movable clutch, release the sprocket brake, a motor drives the closed gear box, and the sprocket is driven to work through the movable clutch through the open gear.

Fig.1 Basic Structure of Electric Combined Windlass

1- spool shaft device; 2- reduction gear box; 3- electric motor; 4- open gear; 5- anchor sprocket; 6- cable drum;
1.2 Principles of Electrical Control

The electrical control principle of the electric windlass is shown in Figure 2. It is mainly composed of a power supply circuit, a protection circuit, a control circuit, an indicator light circuit, a brake circuit, a heating circuit, a master controller and a three-phase AC motor.

Fig. 2 Electric Control Principle of Electric Windlass

Close the power switch -Q1 and the power switch of the master controller, the indicator light -H1 of the master controller and the power indicator light -H1 on the control box will display. Turn the knob switch -S5 to "ON", the indicator -H2 is on, and the motor heats up. After waiting for the motor to start, the indicator -H2 is off.

1.2.1 Motor rotates forward (anchor)

a. The motor starts at one speed

(1) When the master controller handle is placed in the "up" first gear, its contact LK1 is opened, LK2, LK4, and LK7 are closed, so that the direction contactor-Q2 and low-speed contactor-Q4 and brake contactor- Q8 is powered on. At this time, the motor runs at low speed.

(2) When the master controller handle is placed in the "up" second gear, its contact KL4 is opened and LK5 is closed, so that the low-speed contactor -Q4 is cut off, and the medium-speed contactor -Q5, -Q6 is energized after delay. Close, the motor runs at medium speed. At the same time, the time relay-K8 loses power and its contacts are closed, ready for the high-speed contactor- Q7 to be energized.

(3) When the master controller handle is placed in the "up" third gear, its contact KL6 is closed, and the high-speed contactor -Q7 is energized, so that the middle and low speeds of the motor are disconnected in electrical interlock. At the same time, the relay-K9 is de-energized, the delay contact is opened, and the over-current relay-K4 is serially connected to the loop to provide overload protection for high-speed operation.

(4) When the high-speed operation is overloaded, the over-current relay-K4 will act to energize the intermediate relay-K6, the high-speed relay-Q7 will be de-energized, and the intermediate-speed relay...
will be energized, and the motor will automatically switch to the intermediate-speed operation.

b. Motor three-speed start

If the master controller handle is directly placed in the "up" third gear from the zero position, the contactors -Q5, -Q6 will be energized first, and the motor will start at medium speed. After a delay of -K8, the three-speed contactor- Q7 is energized, and the motor automatically switches from medium speed to high-speed operation.

1.2.2 Motor reverse (broken down)
Contrary to the forward rotation of the motor (anchoring), the principle is the same, so I will not describe it in detail here.

1.2.3 Master controller
The multi-position switch on the master controller has 7 positions to choose from: set to zero, the motor does not run; set to the first gear of the anchor, the low-speed winding works, at the same time the brake coil is energized to release the brake, the motor runs at low speed, and anchors; When placed in 2nd gear, the motor will run at medium speed; when placed in 3rd gear, the motor will run at high speed. The various gears of the anchor are basically the same as the anchor, but the motor turns in the opposite direction.

2. Failure Analysis and Treatment

2.1 Symptoms
At one time of anchoring, the staff found that the left windlass could break down but could not lift the anchor normally. When the anchor was lifted, the main controller handle was turned to low speed, medium speed, and high speed and all failed to work. In order to ensure the smooth anchoring and voyage of the ship, the staff was immediately organized to conduct inspections and repairs.

2.2 Failure analysis
According to the electrical control principle of the windlass, if the handle is pulled, the windlass can only drop the anchor, but cannot lift the anchor, and the main motor fault can be eliminated. However, the reasons for the system not working when the anchor is retracted may be the main loop failure and the control loop failure. The fault tree model is shown in Figure 3.

2.2.1 Main circuit failure
1. The main contact of the Q2 contactor is in poor contact
   The Q2 wiring of the AC contactor for the forward rotation of the anchor is faulty. If a phase line of the main contact is not connected or loosened, causing the line of that phase to be disconnected, the motor cannot start normally; if the line of a certain two phases of the main contact is lapped causing a short circuit, the motor cannot be started.
2. Start-stop button failure
   If the start and stop buttons in the circuit are not closed well, the contacts will be in poor contact and the circuit will be open.

2.2.2 Control circuit failure
1. The contactor circuit that controls the forward rotation of the motor is faulty and cannot be energized
   If the fuse in the control circuit is blown, the transformer is damaged or the circuit is broken, it will cause the control circuit to lose power.
2. Part of the electromagnetic brake fails to be released
   If the brake heats up or the pull-in failure occurs, and the windlass motor heats up severely, the -K1; -K2 thermal relay acts to cut off the power supply, and the corresponding normally closed contact will be disconnected, causing the K5 intermediate relay coil to lose power, which will cause the control loop
to fail connected.

3. Emergency connection circuit-S2 failure

If for emergency anchoring, press the emergency switch S2 to force the use of the motor to anchor, the circuit cannot be connected, the K5 intermediate relay coil will not be energized, and the normally open contact K5 will open the control circuit, which will cause the control circuit to fail to connect.

4. The master controller switch LK2 is faulty

(1) Poor contact closure. If the contact in the master controller that controls the speed of the windlass is not properly closed, the contact will not be connected and the master controller will not work normally.

(2) Poor contact of the terminals. If the terminal wiring of the master controller is loose or poorly connected, it will also cause the master controller to fail to work.

Fig.3 Fault tree model of single-side electric combined windlass master controller not working

2.3 Troubleshooting

The staff inspects the main circuit in the electrical control box, and detects the Q2 contactor inlet end and the three-phase power supply voltage. Disconnect the power supply of the equipment, check the performance and wiring of each component, and it is normal and not loose, so as to confirm that the main circuit power supply voltage is normal. Check the thermal relay -K, the overload protection is normal and not activated, and the overload current is set within the normal range value. Subsequently, the staff checked the control circuit and confirmed that the power supply voltage was normal, the wiring was normal and there was no looseness, and there was no obvious damage to the fuses, relays and other components. Considering that when the master control (anchoring forward rotation) handle is activated in the three gears of low speed, medium speed, and high speed, the motor cannot be started, so the staff conducts a power-off inspection.
The main command controller of the anchor windlass was disassembled and it was found that the contact base of the main controller controlling the windlass speed was broken and loose. The contact was removed and checked, and it was found that the main controller contact base was broken as shown in Figure 4, resulting in The contact cannot be energized. The staff replaces the contact base. After reinstallation, the starting test is performed, and the three gears of the master control (anchor forward rotation) handle low speed, medium speed, and high speed are all restored to normal.

3. CONCLUSION
The windlass is the main mechanical equipment of the ship. It is in the open air all year round, with high humidity, high salinity, and ship vibration. Electrical components are prone to failure. Combined with regular inspection and maintenance, it is ensured that the windlass remains in normal working condition to ensure the safe navigation of the ship.

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