Optimization Study on Limit Detection of Anti-collision Warning Device of Three Gorges Shiplock

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Abstract. The anti-collision warning device of Three Gorges Shiplock is a kind of protection device for miter gate of shiplock. Which can absorb the energy of impacting, and slow down the ship before the crossing ship hits the miter gate because of the operation error or sudden fault. The limit detection of the anti-collision warning device is the key link to ensure the safe operation of the anti-collision warning device. By combing the operation characteristics of the anti-collision warning device of the Three Gorges Shiplock, this paper analyzes the advantages and disadvantages of the existing limit detection device of the anti-collision warning device, puts forward the optimal scheme of limit detection, and carries out an empirical test. The test data show that the optimized scheme meets the function and performance requirements of the limit detection of the anti-collision warning device of the Three Gorges Shiplock.

Keywords: Three Gorges Shiplock; anti-collision warning device; limit detection; empirical test.

1 Introduction

The anti-collision warning device (as shown in Figure 1) is arranged on the upstream side of miter gate of the second and third locks of the Three Gorges Shiplock[1]. This device drives the movable wire rope support and the arresting wire rope to rise and fall through the hoisting mechanism, so as to adapt to the change of the water level in the gate chamber. The blocking steel wire rope is a group of steel wire rope which can rise and fall with the change of water level, and it is also equipped with warning sign, which plays a warning role to the descending ships. At the same time, it can also absorb certain collision energy and slow down the ship to avoid or reduce the possible damage when the ship hits the miter gate[2].

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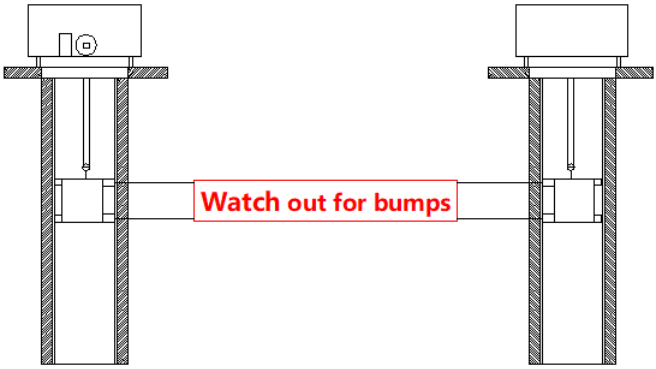


Fig. 1. Anti-collision Warning Device of Three Gorges Shiplock

At present, the existing anti-collision warning devices in china and abroad can be divided into flexible cable and rigid beam according to the different forms of structural components colliding with ships. Mazurek Paweł, Uflaz Esma, etc introduce the application and advantages of flexible wire rope in the field of anti-collision[3][4], Cheng Yong, Cheng Shengpeng, etc introduce the application and operation of limit detection switch in the Three Gorges Shiplock[5][6]. The flexible cable arresting device has the advantages of compact structure, high cost and strong anti-collision ability. The rigid beam device is easy to operate, economical and simple, but the anti-collision ability is weak. The anti-collision warning device of the Three Gorges Shiplock is in the form of flexible retaining cable, and its operation process is shown in Figure 2.

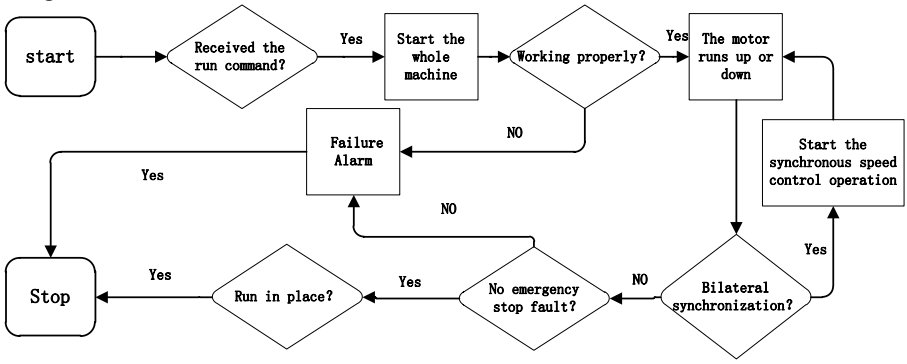


Fig. 2. The Process Flow Diagram of the Anti-collision Warning Device

2 Analysis of existing limit detection device

2.1 Existing limit detection device

The existing anti-collision warning device's limit detection device is shown in Figure 3, in which we use the LX36-84 crane limit switch as the upper-reach switch and

upper-limit switch. This limit switch consists of a main shaft through a gear reduction system, a camshaft with an adjustable cam assembly and a fretting switch arranged symmetrically side by side on both sides. During the operation of the equipment, maintenance personnel found that the limit switch has the following obvious disadvantages:

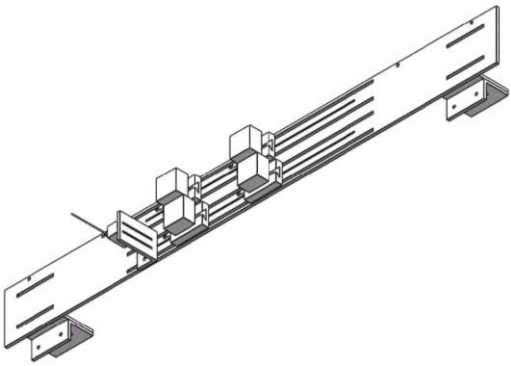


Fig. 3. The Existing Anti-collision Warning Device's Limit Detection Device

(1)Adjusting the switch position is imprecise and tedious. When the Three Gorges Shiplock is at the 175m operating water level, the position of upper reach and upper limit must be adjusted to prevent the steel wire rope and warning sign of the anti-collision warning device from being immersed in the river water. In the adjustment, loose round nut, can not make the cam in the free rotation state. After the cam set is fully adjusted and checked correctly, it must be fastened with a round nut to prevent loosening and dislocation. When fastening the round nut, the whole cam group and the fretting switch will produce certain displacement, which will cause the error of the adjusted anti-collision warning device in position signal.

(2)Installation or replacement of high process requirements, time-consuming. We must ensure the axis of the crane's rotating mechanism coincides with the input axis of the limit switch in order to avoid the additional stress caused by the installation error. Before debugging, we must check the rotation flexibility of limit switch and whether other parts are in normal working state.

(3)Limit switch wiring for plug-type, plug is relatively easy to loose, increasing the rate of equipment failure. According to the electric control principle of the upper-position and upper-limit of the anti-collision warning device of the Three Gorges shiplock, DC24V and AC220V are used respectively as the control signal output, thus, the AC and DC signals are mixed in a switch box with narrow space, which is easy to produce signal interference and even short circuit fault.

(4)It is not intuitive to judge whether the limit switch is working properly and whether the corresponding protective action is carried out. As the gear mechanism, the cam mechanism and the fretting switch of the limit switch are all in a closed housing, once there is mechanical jam, wear or fretting switch contact bad and arcing phenomenon can not be found in time, for the safe operation of the lock there is a certain risk.

2.2 Existing anti-punching device

Anti-collision lifting mechanism in the lifting process, sometimes there is a need for lifting height higher than the height of the lifting mechanism of the lifting operation. At this time, if the improper operation may lead to the lifting of heavy objects and lifting mechanism collision, resulting in a problem of roof. There are hidden dangers and even safety accidents in the problem of punching the top, so it is necessary to add a set of anti-punching limit protection device on the basis of setting up upper and lower travel limit devices, as the last reliable protection of the anti-collision device to enhance operational safety.

3 Research on modification of limit detection

3.1 Optimization of limit detection scheme

Based on the analysis of the present situation of the limit detection switch for the anti-collision warning device of the Three Gorges Shiplock, this paper optimizes the disadvantages and retains the advantages, the detection mode is proposed to determine the anti-collision running position by directly detecting the change of wire rope length to detecting the change of wire rope running cycles. The modification design of the limit detection switch of the anti-collision warning device of the Three Gorges Shiplock is shown in Figure 4.

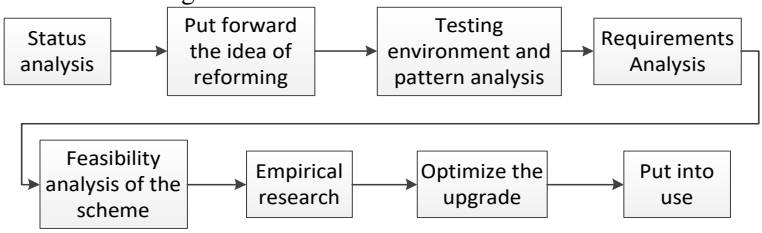


Fig. 4. Optimal design of limit detection scheme

3.2 Research on type selection of limit detection device

In this paper, according to the sensing distance, installation mode, temperature and humidity of the anti-collision warning device, we select the detection components which meet the requirements of the use and parameters as shown in Table 1.

Table 1. Type selection of limit detection switch

Name of limit detection switch	Upper-reach signal switch	Upper-limit signal switch	Mechanical-limit signal switch
Models	NBB20-L2-A2-V1	NBB15-30GM60-W0	WLCL
Induction type	Inductance type	Inductance type	Adjustable rod type swing rod type
Sensing distance	0 ~ 20mm	0 ~ 15mm	0 ~ 50mm
Operating voltage	DC 10 ~ 30V	AC 20 ~ 253V	AC 250V

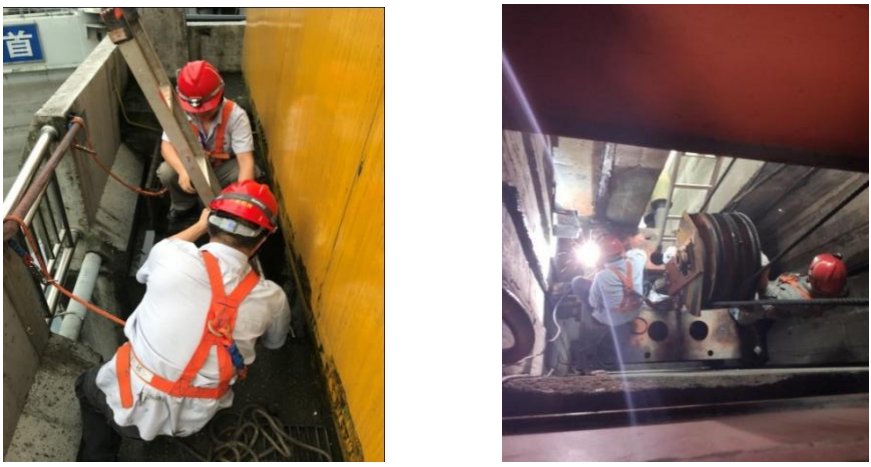
We select the BEICAFU NBB15-30GM60-A2 model as the upper-reach signal switch. Which is DC 4-line, PNP inductive sensor. The induction distance is 0~15mm, the operating voltage is DC 10~30V.And there is independent free interface, the operating environment temperature is -25~70℃, the compatibility is strong. The protection level is IP67, can fully meet the working environment.

(1)We select the BEICAFU NBB15-30GM60-W0 as the upper limit switch. The induction distance is 10-15mm, the working voltage is AC 20-253V. It has reverse polarity protection of short circuit protection, strong compatibility with the ambient temperature of -25 ~70℃, and IP67 protection grade fully meets the working environment.

(2)We select the OMRON WLCL model as the mechanical-limit signal switch. The contact form is adjustable rod type swing rod type, which can meet the field use of anti-collision warning device, and has the advantages of large action stroke and large process stroke. Its working voltage is AC250V, strong anti-interference ability, stable working.

4 Empirical testing

An empirical study on the retrofit of the position limiter of the anti-collision warning device is shown in Figure 5. An empirical test scheme is developed to test the application effect of the retrofit of the position limiter. The empirical test data are shown in Table 2:



a)Demonstration test construction drawing b)Site layout of limit device

Fig. 5. Site installation drawing of modified limit device

Table 2. Test data sheet for limit detection device (Unit: cm)

Test sequence number	Upper-reach height	Actual height	Error △	Upper-limit height	Actual height	Error △	Mechanical-limit switch height	Actual height	Error △
1	17484	17486	2	17489	17491	2	17520	17520	0
2	17485	17486	1	17490	17493	3	17520	17520	0
3	17482	17484	2	17487	17487	0	17520	17520	0
4	17480	17481	1	17489	17490	1	17520	17520	0
5	17484	17486	2	17488	17490	2	17520	17520	0
6	17484	17486	2	17488	17490	2	17520	17520	0
7	17485	17488	3	17489	17490	1	17520	17520	0
8	17483	17483	0	17490	17492	2	17520	17520	0
9	17482	17483	1	17487	17487	0	17520	17520	0
10	17482	17484	2	17489	17492	3	17520	17520	0

According to the test data of limit detection in Table 2, it can be concluded that: The detection and communication functions of the modified limit detection device are normal. The absolute error of upper limit and upper limit detection is less than 3cm and the relative error is less than 0.02%. Which meets the function and performance requirements of the limit detection of the anti-collision warning device of the Three Gorges Shiplock.

5 Conclusion

(1)In view of the problems existing in the limit switch of the anti-collision warning device of the Three Gorges shiplock, we carry out the limit detection modification research. We Select NBB20-L2-A2-V1 as upper-reach detection switch, NBB15-30GM60-W0 as upper-limit detection switch and WLCL as mechanical-limit signal switch.

(2)This paper makes an empirical test and application of the optimized limit detection scheme of anti-collision warning device. The results show that the optimized scheme can meet the requirements of high precision, rapidity and timeliness for the limit detection of the anti-collision warning device of the Three Gorges Shiplock.

(3)The limit detection scheme provided in this paper is universal, and the research results provide reference and reference for other ship lock anti-collision warning facilities.

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