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Design of Marine Automatic Leakage Stoppage System Based on Artificial Eddy Current

Design of Marine Automatic Leakage Stoppage System Based on Artificial Eddy Current

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Abstract. This paper analyses the problems existing in the traditional methods of blocking leakage of ships, breaking through the ideological framework of "blocking" only. The design of ship automatic leak stoppage equipment based on artificial eddy current is put forward, and the experimental verification is carried out. The whole leak stoppage system is designed from the idea of automatic control. The experimental results show that the method can greatly reduce the pressure of seawater on the break and the water inflow per unit time by artificially forming local high-speed eddy flow field at the appropriate position outside the break, thus creating favorable conditions for the plugging of the break in the cabin. The research conclusion can enrich and perfect the method of blocking leakage for ships.

1. Introduction

Ship leak plugging refers to the use of various equipments and tools to plug the ship's holes to prevent seawater from entering. It is the main method to maintain buoyancy after the ship breaks into water. It is also an important part of the research on ship damage management. After being attacked by torpedoes, missiles, bombs and other weapons or damaged by marine accidents, the mechanical equipment in the cabin will not only lose its effectiveness, but also seriously affect the buoyancy and stability of the ship, and even directly cause the capsizing and sinking of the ship and other serious consequences. Therefore, once the ship is damaged, different methods must be adopted to plug the leakage immediately according to the different damage conditions. According to the different locations of leak-plugging devices, leak-plugging methods can be divided into two categories: in-cabin leak-plugging and outboard leak-plugging. In-cabin leak-plugging mainly includes supporting leak-plugging method, screw leak-plugging method, cement leak-plugging method, loose-leaf leak-plugging method, welding leak-plugging method and small hole leak-plugging method. Outboard leak-plugging mainly includes canvas blanket leak-plugging method and air bag leak-plugging method.

2. Traditional Leakage-plugging Technology and Vortex Flow Leakage-plugging Thought

2.1. Main Problems of Traditional Leakage Stoppage Technology for Ships

1) The deficiency of basic theory research. As a practical operation, ship leak stoppage has been focused on the research of leak stoppage equipment at home and abroad, but the research on the theory of leak stoppage is obviously weak, which leads to the fact that the research on the theory of leak

stoppage is weak.For a long time, there has been no birth of more advanced plugging ideas, methods and technologies.

2) Insufficiency of leak stoppage equipment. At present, most of the plugging devices are products developed before 1990, which have low mechanization and strong dependence on the professional quality of damage management personnel. Especially for the large and medium-sized holes above 0.05 m which cause the rapid loss of ship buoyancy, there has been no better plugging method. This directly leads to the low efficiency of ship leak plugging, which cannot meet the needs of modern new ships for high efficiency leak plugging equipment.

3) There are few methods to plug the leakage. On the one hand, most of the traditional methods of leak plugging are mainly in cabin, which must face huge sea water pressure, leading to difficulties in leak plugging, inefficiency, and difficulties in achieving complete water tightness. At the same time, it will make operators face a great psychological burden. On the other hand, the existing methods of leak plugging out of the board are usually only applicable to small and medium-sized ships with relatively low dry side, but larger ones with relatively high dry side. The existing outboard leak stoppage methods are often difficult to implement for ships and fully enclosed ships.

2.2. Vortex Flow Leakage Stoppage Thought

Because of the huge pressure of sea water (especially called lateral pressure for convenience of writing), it is difficult to plug the break, and the fast water intake speed and less time for plugging are the main reasons for the low efficiency of the ship's leakage plugging. Therefore, if the seawater pressure at the break can be reduced, the plugging time can be prolonged, the difficulty of plugging can be reduced, and the efficiency of plugging can be improved. According to Bernoulli's principle, the greater the velocity of sea water along the horizontal tangent direction of the ship's outer plate, the smaller the lateral pressure acting on the break. As a common phenomenon of fluid flow in nature, the formation of eddy current is relatively easy, and its tangential velocity is also easy to meet the requirements of improving the speed of seawater at the break of ships. For this reason, considering the actual environment of the ship, after thorough discussion and communication with relevant experts of the user unit, a new method of ship leakage plugging based on artificial eddy current is studied. The basic idea is shown in Figure 1.

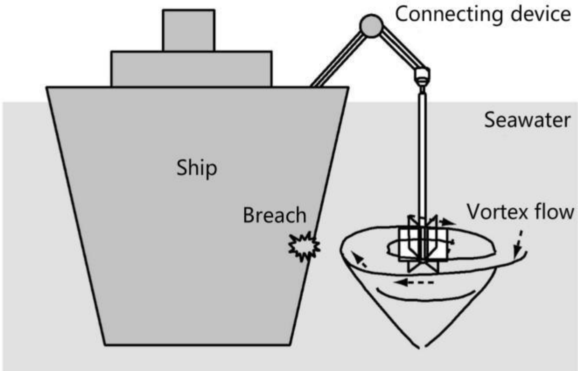

FIGURE 1. Flow chart of automatic leak plugging.

2.3. Ship automatic leak stoppage process

When the leakage is detected by the induction line in the cargo hold, the alarm of the leakage sensor is triggered, and the leakage sensor transmits the leakage information to the central control system. When the control system receives the signal, it opens the leak alarm. The control system identifies the initial alarm coordinates through analysis, displays them graphically on the cockpit workbench, and sends the coordinates to the water supply and drainage manipulator. After receiving the information, the manipulator moves to the corresponding deck coordinates. After receiving the signal from the

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cockpit workbench, the controllers immediately go to the cargo hold leakage level to check the situation. Drainage manipulator can start work when it moves to the designated position. If the controller finds that there is a leak in the cargo hold after checking, the drainage manipulator can be closed. If the seawater does leak into the cargo hold, the leak stoppage work will be started until the leak stoppage is completed, and the drainage manipulator and the leak alarm will be closed.Flow chart of automatic leak plugging is shown in Figure 2.

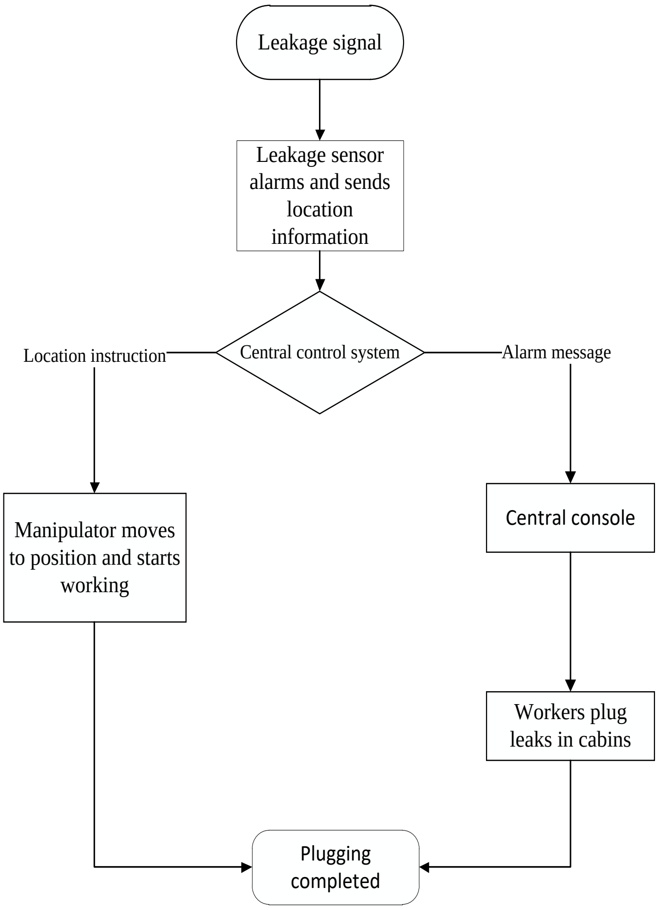


FIGURE 2. Schematic Drawing of Ship Leakage Stoppage.

3. Design and experimental verification of experimental device

3.1. *Design of experimental device*

The experimental equipment includes water tank, simulated ship break device, blade adjustable eddy current generator, eddy current generating power device, liquid level automatic measurement timing device, automatic drainage device, etc. The experimental schematic is shown in Figure 3.

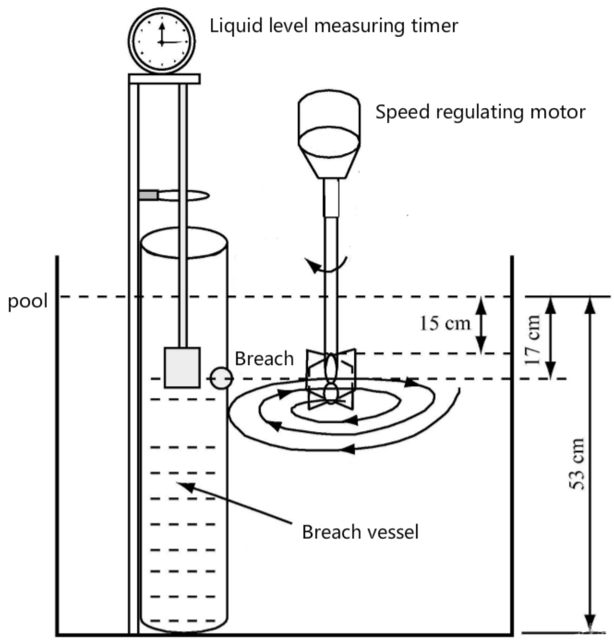


FIGURE 3. Schematic diagram of experimental device.

3.2. Design of experimental method

In the experiment, the influence of the eddy flow field generated by the flexible blade and the rigid blade on the water intake at the break is studied successively, and the relationship between the distance of the break and the water intake at the break is studied quantitatively under the two conditions of the eddy flow field. The specific experimental methods are as follows:

1) Ships should fix each device well, keeping the position of the simulated ship break device in the pool unchanged.

2) The water depth of the experimental pool is 53 cm and the break distance is 17 cm. First, the flexible blade (then the rigid blade) is selected as the vortex generator to measure the water entry depth of the blade and adjust the distance between the break and the axis of the blade (known as the "break distance").

3) The breaks in the simulated ship break device are tightened with rubber plugs. One end of the rubber plug is connected with a thin line. The function of rubber plugs is to prevent water from entering the simulated ship break device before the experiment starts.

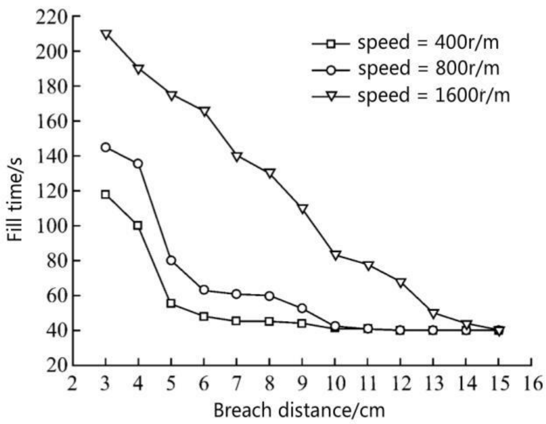
4) Ships should turn on the motor, turn on the vortex generator, pull out the rubber plug after forming a stable eddy current (about 30 seconds), and turn on the switch of the liquid level automatic measuring timer to start the timer.

5) When the liquid level reaches the specified height, the liquid level automatic measuring timer alarms, stops the timer, turns off the liquid level automatic measuring timer switch, closes the motor switch, and records the experimental data.

6) The water in the simulated ship break device is pumped out by automatic drainage device, and the discharged water is recycled back to the experimental tank to ensure that the relative position of the simulated ship break device and the experimental tank remains unchanged, and the water level of each experiment is the same.

7) Change the break distance and carry out the next group of experiments.

3.3. Verification of experimental results



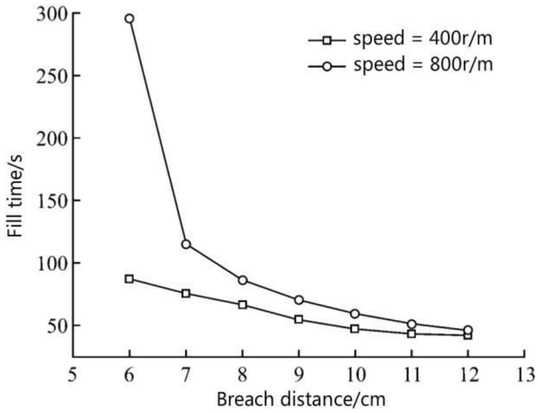


FIGURE 4. The relationship between water intake time and break distance using flexible blades.

FIGURE 5. The relationship between water intake time and break distance using flexible blades.

From the analysis of the experimental charts, it can be seen that as long as the local high-speed eddy flow field can be formed artificially as close as possible to the break on the outer side of the ship break, so the pressure of seawater on the break can be greatly reduced, the water inflow per unit time at the break can be greatly reduced, and the available plugging time can be effectively prolonged. Thus favorable conditions for the plugging of the break in the cabin is created. This shows that the proposed idea of eddy current plugging is feasible.

4. Conclusion

In view of the inherent problems such as the difficulty and inefficiency of traditional plugging methods, which are mainly based on "plugging", breaking through the ideological framework of "plugging", an automatic ship plugging research based on artificial eddy current is proposed, which is not limited by the cabin environment and can effectively overcome the influence of sea water pressure at the break, thus facilitating the efficient implementation of ship plugging, especially for medium and large breaks. The plugging of the orifice has also achieved good results, which will be conducive to the enrichment and perfection of the theory and equipment of ship plugging. Of course, the conclusion that good plugging effect can be ensured as long as the scroll generator is close enough to the break mainly shows the feasibility of the principle. Its specific engineering applications, such as whether the device is suspended or floating, still need to be further studied.

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