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Design and Research of Ship Carrier for Three Gorges New Ship Locks

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Abstract: In view of the long time of passing the ship locks, this paper designs a new type of semi-submersible carrier. This carrier adopts electric propulsion drive, which can carry 4-6 ships at a time through the ship lock, shortening the crossing time; For the electric energy supplement problem caused by the semi-submersible ship adopting the electric propulsion system, this paper has designed a set of ship charging system in the gate. This system realizes the rapid charging during the lifting process of the internal carrier at the gate through the ship-end power receiving device, the shore power supply device and the tension self-sensing cable retracting device. For the lack of security measures and the means of monitoring the bottom of the dirt, this research has designed a new type of ship bottom visual monitoring system, which is realized by setting up a professional imaging device on the semi-submersible ship to collect clear image of the ship bottom, and assists the gate security personnel to realize the rapid and accurate monitoring of the explosives at the bottom of the ship, the damage of the bottom of the ship and the fouling of the ship. For the problem that the current ship support platform is not adaptive to all types of ships is not strong, this work designs an adaptive ship support platform that will be adaptive hydraulic support and semi-submersible The combination of carrier ships enables adaptive support for different ship types, ensuring stability during the process of passing the ship, and reducing the stress concentration at the bottom of the ship.

1. Introduction

The Three Gorges Ship Lock is an important part of the Three Gorges Dam and a necessary passage for the upper and middle reaches of the Yangtze River. The existing Three Gorges ship locks have the following problems in the operation process: (1) the ship has a long time to pass the gate, resulting in low efficiency of the ship's crossing, and the ship channel backlog is serious; (2) the explosives at the bottom of the ship are not easy to identify, resulting in safety risks of the gate; (3) Damage to the bottom of the ship is not easy to identify, resulting in safety risks of the gate [1].

In summary, it is necessary to propose a scheme that can shorten the gate time and have the security function while achieving the “zero discharge” of the gate. In order to solve the above problems, this paper proposes a ship carrier for the Three Gorges New Ship Lock. This research combines shore-based energy, adaptive dock and scanning camera in a semi-submersible ship, which greatly shortens the crossing time and solves the ship lock security problem while achieving the “zero emission” of the gate, which is of great significance for the development of the industry in the Three Gorges Ship Lock and the Yangtze River Shipping. The overall design idea is shown in Figure 1.

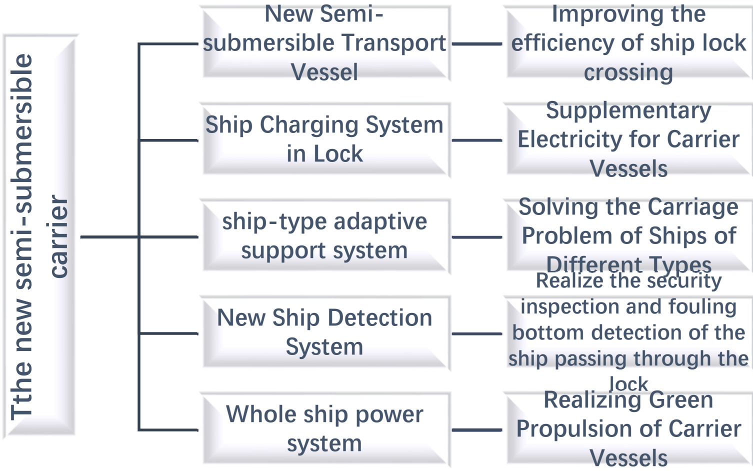

Figure 1 design Idea of The new semi-submersible carrier

2. New semi-submersible carrier

2.1 The function of the new semi-submersible carrier
The function of the new semi-submersible carrier is to provide the services of the Three Gorges Ship Lock to the vessels that are to be transited, and to provide security inspection and sewage monitoring for the vessels.

2.2 The composition of the new semi-submersible carrier
The new semi-submersible carrier in this paper consists of a carrier hull, a ship-end charging socket, a ship-type adaptive support system and a new hull monitoring system. Among them, the new hull monitoring system consists of a side track type camera monitoring device and a mid-deck telescopic camera; the ship type adaptive support system is composed of an adaptive hydraulic dock and a side hydraulic support. The system composition is shown in Figure 2.

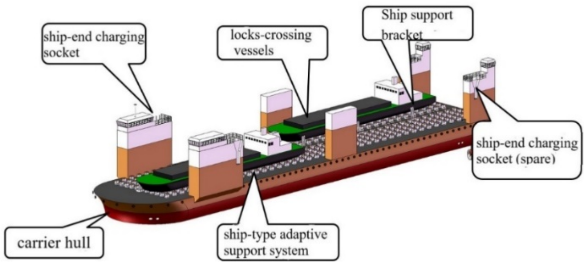

Figure 2 schematic diagram of The new semi-submersible carrier

2.3 Overall design of the new semi-submersible carrier
The new semi-submersible carrier needs to carry a certain number of crossing vessels on the upper deck, and also needs to have a strong power supply capacity for the ship's power, hydraulic support equipment, underwater monitoring modules and sewage monitoring modules. Therefore, a supercapacitor-battery composite energy storage device based on shore-based energy is adopted.

The passing ship is mounted on the deck of the carrier vessel and needs to be quickly loaded and unloaded by the vessel. Therefore, the whole layout design of the semi-submersible ship platform with a displacement of 18000t and a main engine power of 4050kW is proposed. The overall layout of the ship carrying the passing ship is shown in Figure 3.

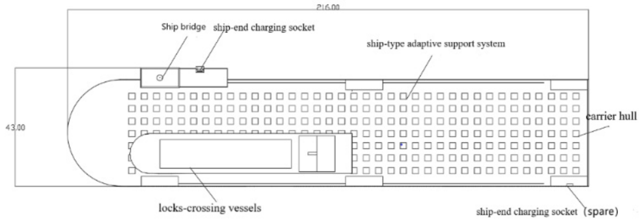

Figure 3 layout sketch map of the new semi-submersible carrier

3. Water level adaptive charging device

3.1 Water level adaptive charging device

The water level adaptive charging device is installed at the top of the first-class ship lock gate wall of the Three Gorges New Channel. It begins charging when the new semi-submersible transport ship enters the lock chamber and waits for the first-stage ship lock. The charging line retracting mechanism retracts the charging cable under the cooperation of the water level monitoring device to realize the function of adapting to the water level change in the ship lock [2].

3.2 Water level adaptive charging device

The water level adaptive charging device consists with two parts; one part is the water level monitoring device installed on both sides of the ship lock, the cable retracting device and the charging interface; the other part is the charging interface installed on the ship end. The overall layout is shown in Figure 4.

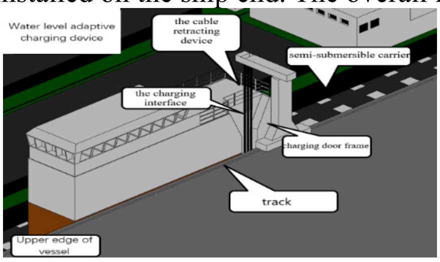

Figure 4 overall layout of charging device

3.3 Design of water level adaptive charging device

（1）Shore charging device design

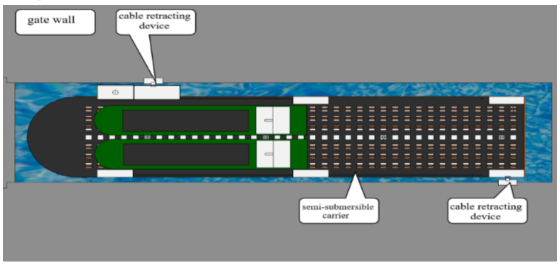

Figure 5 installation position sketch

As shown in Figure 5, the water level adaptive charging device is mounted on the gate wall. Considering that the new semi-submersible carrier may need to travel in both directions in the lock chamber, the two sets of charging devices are installed diagonally to meet the needs of the two-way charging of the carrier, while acting as a backup in an emergency.

The door frame, the discharge machine, the track and the corresponding winch are arranged along the brake wall; the charging interface is suspended under the charging cable; the charging cable drives the winch to realize the movement in the high and low directions to realize the automatic adjustment with the water level change of the ship lock; The charging cable and the discharger are mounted on a charging gantry that can move with the track. At the lowest normal water level of the lock chamber, the water depth sensor is arranged to realize the collection and return of water depth data [3].

After the new semi-submersible carrier enters the lock chamber, the carrier ship is close to the bottom of the charging device. The charging plug is dropped with the cable, falls into the ship's end interface, and is adsorbed to the ship's end interface for charging. A water depth sensor is arranged at the lowest working water level of the ship lock. When the water depth sensor detects a change in the water level, a signal is sent to cause the cable retracting device to adjust the cable length to achieve an adaptive adjustment of the charging device with the water level change. When the charging is completed, the cable retracting mechanism closes the charging plug and the carrier sails out of the lock chamber.

（2）Design of the ship's charging socket

The ship's charging socket is designed to meet the shore-based charging plug speed and accurate lifting access to the charging socket. The charging socket is arranged behind the bridge, which is convenient for the driver to observe the docking condition of the charging line; a sliding chute is arranged above the charging socket of the ship; and a charging socket is arranged at the bottom of the sliding chute. When the new semi-submersible transport ship enters the ship lock to be charged, the hull is close to the shore-based cable lifting device; the lifting device is used to lengthen the cable, and the charging plug is placed in the charging port chute. The charging socket is inclined to the wall of the slot and is aligned to the docking socket to complete the docking; the shore-based cable continues to release the cable to ensure certain redundancy [4].

4. Adaptive hydraulic support system

4.1 Adaptive hydraulic support system

The adaptive hydraulic support device is mounted on the deck of the carrier vessel to support and fix the over-trailing vessel carried by the carrier. In view of the large variety of over-trailing vessels and the large difference in ship type, it can adapt to different linear vessels through its own movement.

4.2 The composition of the adaptive hydraulic support system

The adaptive hydraulic support device consists of two parts: the bottom support device and the side support device. The bottom support device consists of 144 adaptive hydraulic docks. The side support devices consists of six groups retractable hydraulic support arranged in the side of the carrier and the middle of the deck. The system composition and working mode are shown in Figure 6.

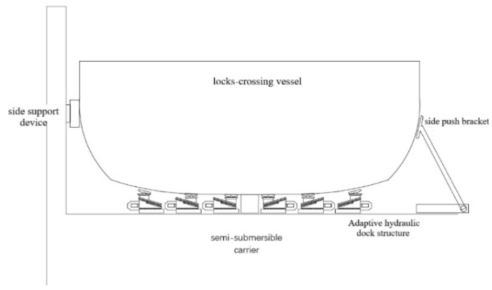

Figure 6 sketch map of adaptive hydraulic support system

4.3 Design of adaptive hydraulic support system

（1）Workflow design

All docks should be displayed at the lowest position before the ship is docked. When the ship is located at the keel pier, the keel pier signal is displayed. After a certain period of time, the motor is started, and the solenoid valve is turned on to make the power cylinder work. At this time, after the side pier rises and fastens the bottom of the ship, the signal of the contact between the side pier and the bottom of the ship is turned on, and the dock pier stops moving and self-locks. At this time, the side push bracket is erected to fix the passing ship. The specific workflow is shown in Figure 3.11.

(2) Adaptive hydraulic dock structure design

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The adaptive hydraulic dock consists of a tilting seat, a sliding seat, a base and a cylinder, as shown in Figure 7. Except for the power cylinders, they are welded steel structural parts of the plates and tubes. The top surface of the tilting seat and the underside of the base are fitted with hardwood to ensure good contact with the bottom of the ship and the lifting deck. The tilting seat can be swung within 15° to accommodate the slope of the bottom of the ship [5].

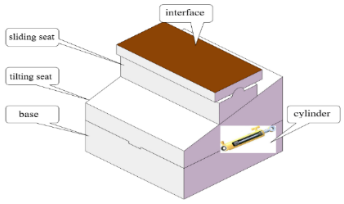

Figure 7 adaptive hydraulic dock structure

5. Hull imaging monitoring system

5.1 The function of the hull imaging monitoring system

The function of the hull monitoring equipment in this study is to effectively monitor the hull attachment of the ship and the safety of the hull by means of optical monitoring equipment arranged on both sides of the deck of the ship and in the middle, and return the monitoring image to the carrier ship. After the bridge is fed back to the crew of the ship.

5.2 The composition of the hull imaging monitoring system

The hull imaging monitoring equipment in this paper consists of a rail-type monitoring device arranged on the side of the carrier, a telescopic monitoring device in the middle of the deck, and a console for the bridge. The orbital monitoring device and the reduced monitoring device are used for hull monitoring image acquisition and return; the bridge control console is used to control the monitoring device and display the return screen for the operator to perform security inspection or master the hull attachment [6]. The specific system composition is shown in Figure 8

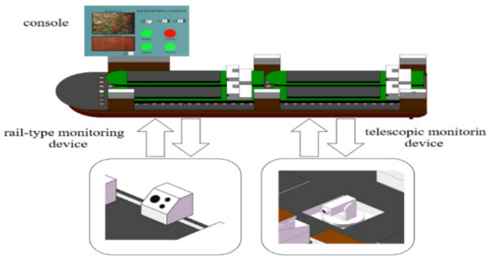

Figure 8 Composition of hull monitoring system

5.3 Design of hull monitoring system

（1）Side-side rotary monitoring device design

In order to realize the safety inspection work of the carrier vessel and the sewage bottom monitoring work, this research intends to install a sliding rail as shown in Figure 9 and a sliding monitoring device along the orbital motion on both sides of the carrier vessel. The sliding monitoring device is provided with a high-definition camera and a longitudinal servo mechanism. The high-definition camera realizes up and down shaking monitoring through a longitudinal servo mechanism; at the same time, the monitoring device slides on the ship's side rail to realize comprehensive monitoring of the mounted vessel.

（2）Lifting monitoring device design

The orbital monitoring device can only monitor the side of the ship, so this project has two sets of lifting monitoring devices in the center of the deck, as shown in Figure 10. The lift monitoring device includes a shaft disposed in the center of the deck and a lifting platform equipped with an imaging monitoring system. The imaging monitoring system is placed on the servo mechanism to realize lateral and longitudinal movement, and comprehensive monitoring of the hull angles is realized by the angular movement of the imaging device.

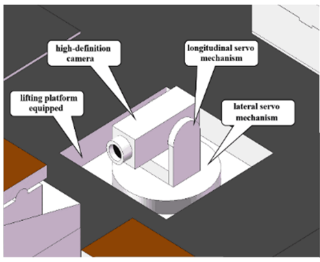

Figure 9

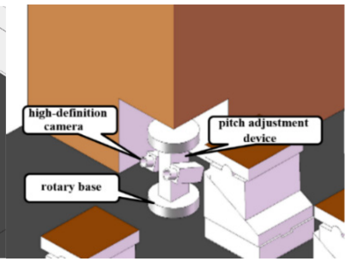

Figure 10

6. Conclusion

The ship carrier of the Three Gorges New Ship Lock passage is a new type of ship crossing method that uses the semi-submersible ship to transport multiple crossing ships at the same time to speed up the efficiency of the gate. It has been modified and applicated on the current mature semi-submersible ship technology. Nowadays, semi-submersible ships have been used in many transportation and engineering operations such as long-distance ship transportation, emergency maintenance of faulty ships, and installation of offshore drilling platforms. Its broad application fields and advanced professional science and technology provide reference and technical support for this work.

The adaptive hydraulic dock technology can adapt to a variety of different hull line shapes, which effectively improved the loading and unloading speed of the ship. At present, adaptive hydraulic dock support technology has been applied in large domestic docks. The successful application of this technology on large docks can provide technical support and case study for this paper.

Nowadays, electric power ships have become the development trend in the future. Electric power ships have been updated with multiple generations of technology, relevant technologies are also mature, and can achieve the effect of energy saving and emission reduction,which is in line with the national sustainable development strategy. In the field of electric propulsion ships, ships equipped with supercapacitor groups have been partially put into the market, and power lithium battery packs are also widely used in scenic cruise ships and rivers and lakes ferry ships promoted by power systems. The development of electric propulsion ship related technology provides systematic technical support for this research.

As an important part of the regular inspection and maintenance of ships, ship's pollution monitoring has always been highly valued by the ship operation industry. At present, there are a variety of ship pollution monitoring methods at home and abroad, which are widely used in all types of ships. The orbital sewage monitoring device of this work is mainly composed of a track-type camera monitoring device and a telescopic camera. Currently, there are a variety of camera devices available for real-time monitoring on the market, and many cameras for monitoring device suitable in different fields and environments are produced. Therefore, for the installation and improvement of the equipment of this project, the implementation process is relatively simple, and the related technologies are mature and complete.

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