Research on Active Control Technology of Skidded Loadout for Large Marine Module

Xiankang Wang[1], Peng Jie[2] and Qing Zhang[2,*]
[1]Qingdao Ocean Engineering Technology Research Institute of Tianjin University, Qingdao 266000, China
[2]Tianjin University, Tianjin 300000, China
[*]Corresponding author

***Abstract*—The shipment of offshore oil platform is a very important part of the process from construction completed to the offshore installation. As the large marine module moves in the process of the skidded loadout, Different positions of wharf produce different degrees of deformation. We need to improve the stress condition of the wharf according to the deformation of the wharf, otherwise the wharf will bear too much force, which will crush the wharf, and even cause large marine module to capsize. This paper proposed an active control technology, which is mainly used to adjust the force on the wharf during the sliding and shipping process of large-scale Marine structures. It ensures that the slipper will not be suspended and bear too much load. What's more, it prevent the structure from capsizing, and make the sliding and loading process of structures more stable.**

Keywords*—marine structure; skidded loadout; active control; stable analysis

I. INTRODUCTION

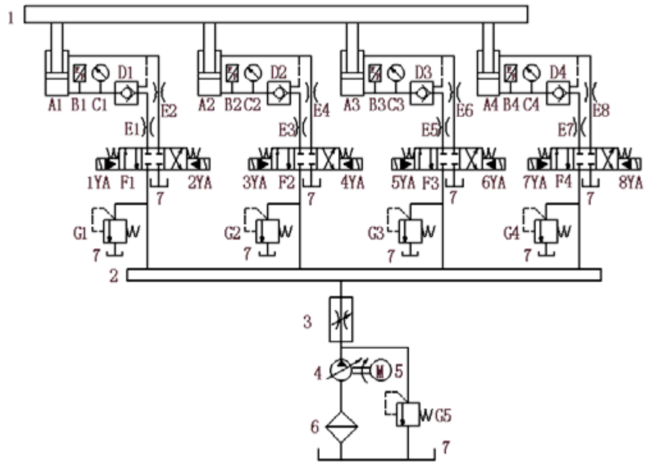
In this paper, an active control technology for the slip loading process of large marine structures is introduced. Aiming at the problem that the traditional slip loading process has no regulation of wharf force and the loading process is complicated and the effect is not ideal, an active control technology for Wharf force and structure loading process is provided. This technology can solve the problem of slip displacement and load adjustment of Wharf at the same time. By adjusting the lifting of each hydraulic jack leg separately, the lifting of each jack leg can be controlled independently. By adjusting the lifting of all jack leg according to the need, each jack pile can be coordinated. The force exerted on the legs can control the sliding displacement of the structure and the loading process smoothly. At the same time, the suspension of the jack leg can be prevented, and the excessive force exerted on some jack leg can be avoided, which will cause damage to the wharf and lead to the overturning of the structure[1].

At present, there is no method to adjust the force of Wharf in the process of sliding and displacement of large marine structures. For the loading process, the pressure of wharf can be adjusted by adjusting the suction and drainage of barge ballast tank, which can be divided into the center of gravity of structure before boarding ship, the center of gravity of structure when boarding ship and the center of gravity of structure when boarding ship. The last three processes are adjusted, but this method belongs to the method of indirectly adjusting the force on the wharf. The adjustment process is tedious, not timely, and the adjustment effect is not ideal[2].

II. ACTIVE CONTROL OF SKIDDED LOADOUT PROCESS FOR LARGE MARINE

Firstly, a large marine structure is built on the scaffolding, and then a hydraulic jack is installed on each of the four sliding boots. The hydraulic jacks are numbered in turn. Pressure sensors are installed on the top of each hydraulic jack. Pressure sensors are connected through RS-485 network. At this time, there is no contact between the bottom of the four hydraulic jacks and the structure.

The four hydraulic jacks are used to jack up the large marine structures. First, the system is judged to be in the jacking state, and all the relief valves are set to an overflow pressure. The overflow pressure should be greater than 0 and less than the pressure required for the jacking structure. Then, the industrial computer PLC controls the motor to drive the hydraulic pump to supply pressure oil, and then controls the four. Three four-way electromagnetic reversing valves work; pressure oil is divided into four routes, each way through the corresponding three four-way electromagnetic reversing valve, non-adjustable flow valve, hydraulic control one-way valve into the corresponding hydraulic jack rodless chamber, so that the piston rod of hydraulic jack is lifted without load, and when touching the bottom of the structure, the hydraulic jack rodless. The pressure of the chamber begins to rise. When the pressure of the rodless chamber is greater than the set overflow pressure, the overflow valve begins to overflow. At this time, the hydraulic jacks all support large structures, and the first stage ends. FIG.1 is the schematic diagram of the active control hydraulic system for the skidded loadout process of large marine structures[3].



1. Large marine structures; A1, A2, A3, A4-hydraulic jacks; B1, B2, B3, B4-pressure sensors; C1, C2, C3, C4-pressure gauges; D1, D2, D3, D4-hydraulic control one-way valves; E1, E2, E3, E5, E6, E7, E8-non-adjustable restrictor; F1, F2, F3, F4-three-way electromagnetic reversing valves; G1, G2, G4, G5-relief valves Flow valve; 2. Multi-channel distributor; 3. Speed regulating valve; 4. Hydraulic pump; 5. Motor; 6. Filter; 7. Oil cylinder

FIGURE I. THE SCHEMATIC DIAGRAM OF ACTIVE CONTROL HYDRAULIC SYSTEM IN SKIDDED LOADOUT PROCESS

The overflow pressure of the relief valve is set to be greater than the pressure required by the lifting structure. The four hydraulic jacks are lifted synchronously for a certain period of time. The industrial computer controls the left-end electromagnet of the four three-four-way solenoid reversing valves to lose power. The three-four-way solenoid reversing valves are in the middle position. The hydraulic oil enters the three-four-way reversing valves directly[4]. Flow back to tank.FIG.2 is a sketch of the first stage of jacking-up before and after the completion of the construction of a large marine structure.

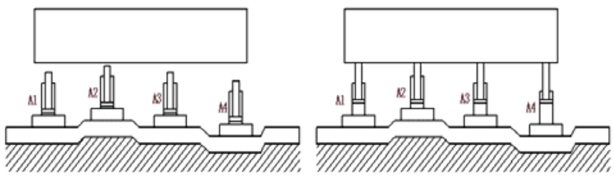


FIGURE II. SKETCHES OF THE FIRST STAGE BEFORE AND AFTER LIFTING

When the linear winch tracts the sliding displacement and loading of large marine structures, the slide way of the wharf will be deformed to varying degrees after bearing pressure, so it is necessary to adjust the lifting of four hydraulic jacks in real time. In the process of shifting, the pressure sensor collects the pressure of four hydraulic jacks in real time, and the industrial computer is divided into PLC. The real-time pressure and initial pressure of the four hydraulic jacks collected are compared.FIG.3 is a sketch map of the second stage of jacking-up before and after the completion of the construction of a large marine structure[5].

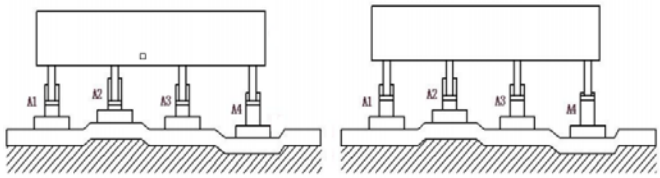


FIGURE III. THE SECOND STAGE SKETCH BEFORE AND AFTER LIFTING.

For the hydraulic jack whose force is reduced and greater than 0, the piston rod is lowered and adjusted. The industrial computer PLC controls the right position of the three-four-way electromagnetic reversing valve. The hydraulic oil enters the rod cavity of the corresponding hydraulic jack through the three-four-way electromagnetic reversing valve and the non-adjustable flow valve, which makes the hydraulic jack drop. When the real-time pressure equals the initial pressure, the PLC controls the three-way and four-way electromagnetic reversing valve in the middle position at the initial pressure. After the hydraulic oil enters the three-way and four-way electromagnetic reversing valve, it flows directly back to the cylinder, and the hydraulic jack stops falling[6]. FIG.4 is a sketch of the pre-and post-adjustment of the slip displacement of a large marine structure.

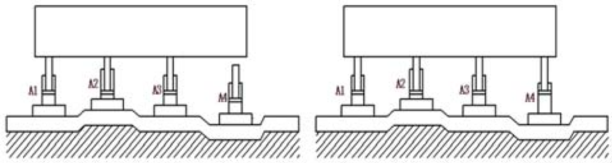


FIGURE IV. SCHEMATIC DIAGRAMS BEFORE AND AFTER ADJUSTMENT DURING SLIP DISPLACEMENT.

For the hydraulic jack with reduced force and zero lift adjustment, industrial computer PLC controls the left position of electromagnetic three-way and four-way electromagnetic reversing valve to work. Hydraulic oil enters the rodless chamber of the corresponding hydraulic jack through speed valve, multi-way distributor, three-way and four-way electromagnetic reversing valve, non-adjustable flow valve and hydraulic control one-way valve to make the hydraulic pressure work. The Jack starts to rise. When the real-time pressure equals the initial pressure, the PLC controls the three-way and four-way electromagnetic reversing valve to be in the middle position. After the hydraulic oil enters the three-way and four-way electromagnetic reversing valve, it flows directly back to the cylinder, and the hydraulic jack stops rising. FIG.5 is a sketch of the adjustment before and after the barge is higher than the wharf in the loading process of a large marine structure.

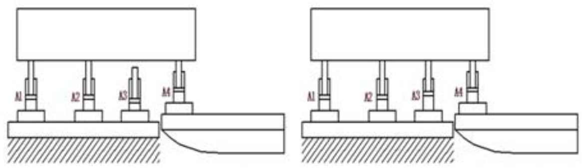


FIGURE V. SCHEMATIC DIAGRAMS OF BARGES BEFORE AND AFTER ADJUSTMENT WHEN THEY ARE HIGHER THAN WHARF DURING LOADING.

For the hydraulic jack with increased force, the industrial computer PLC controls the left position of the three-way and four-way electromagnetic reversing valve, and the hydraulic oil enters the rodless cavity of the corresponding hydraulic jack, which makes the hydraulic jack start to Jack up. When the real-time pressure equals the initial pressure, the PLC controls the three-way and four-way electromagnetic reversing valve to be in the middle position. After the hydraulic oil enters the three-way four-way electromagnetic reversing valve, it flows directly back to the cylinder, and the hydraulic jack stops jacking.FIG.6 is a schematic diagram of the adjustment before and after the barge is lower than the wharf during loading of a large marine structure.

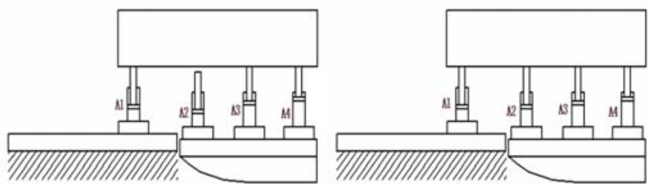


FIGURE VI. SCHEMATIC DIAGRAMS OF THE BARGE BEFORE AND AFTER ADJUSTMENT WHEN IT IS BELOW THE WHARF DURING LOADING

III. ANALYSIS OF SYNCHRONIZATION ERROR IN LOAD-SHARING CONDITIONS

According to the schematic diagram of hydraulic system, the model of hydraulic synchronous jacking system is established in AMESim and Simulink software. The model of hydraulic synchronous jacking system is shown in the FIG.7.

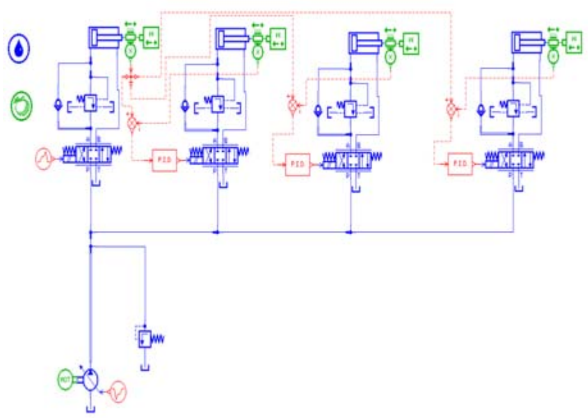


FIGURE VII. HYDRAULIC SYNCHRONOUS JACKING SYSTEM MODEL DIAGRAM

According to the established model, the operation parameters are set, and the working processes of the model are simulated and analyzed

The simulation starting point is 1 m, the lifting speed is 3 mm/s, and the simulation time is 50 s. Under the same model, the PID neural network controller and the ordinary PID controller are used to simulate and compare[7].

A. *Synchronization Error Analysis*

From FIG.8(A), it can be seen that the synchronization error between the two lifting points gradually decreases from 2.7 mm to nearly 0 mm, accompanied by small fluctuations. At 9 s, the error convergence is close to 0 mm. This phenomenon is mainly caused by the elastic deformation, damping characteristics of the strand and the inertia of the lifting point load. The maximum error of the process appears at the starting point of lifting, which is 2.7 mm, and the maximum fluctuation range is 0.7 mm during the adjustment process. From FIG. 8(B), it can be seen that under the same working conditions, using ordinary PID to synchronize the lifting control, the control effect shows a significant decline. Although the convergence time of the two methods is not very different, the maximum error is 4.4 mm. In addition, in the adjustment process, the error fluctuation is larger, the maximum value is 1.5 mm.

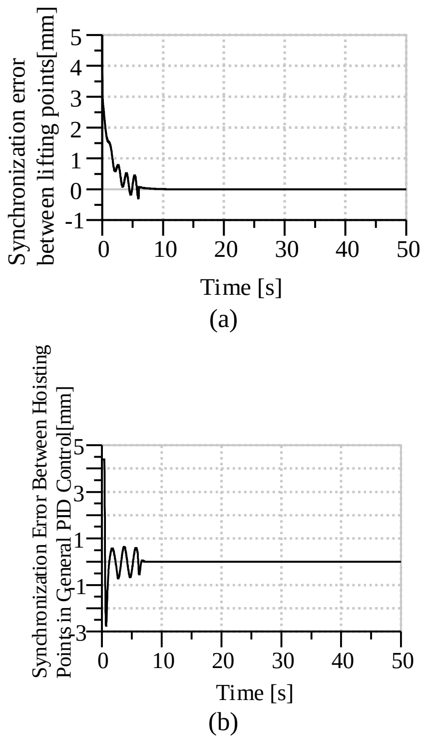
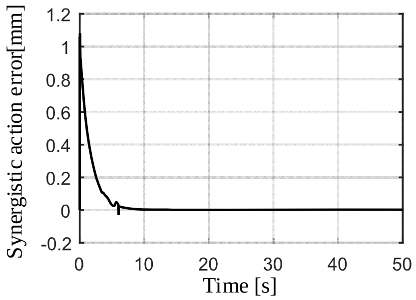


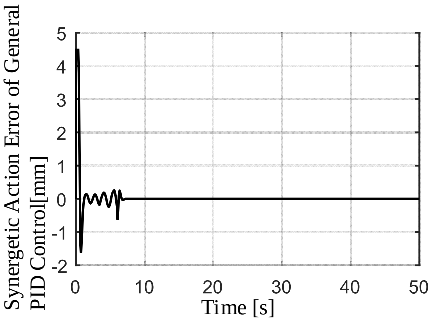
FIGURE VIII. (A) SYNCHRONIZATION ERROR CURVE BETWEEN LIFTING POINTS IN AVERAGE LOAD CONDITION (B) SYNCHRONIZATION ERROR CURVE BETWEEN LIFTING POINTS IN AVERAGE LOAD CONDITION BY PID CONTROL

B. *Collaborative Control Error*

The error of cooperative action is mainly the error between the actual displacement of the main jack-up point and the calculated ideal displacement (which is calculated by the coordinate function of the actual coordinate of the main jack-up point). According to FIG.9(A), the maximum error of coordinated action is 1.1mm under the condition of load sharing, the error fluctuation is small and the operation is stable. From FIG.9(B), it can be seen that under the same working conditions, using ordinary PID to control the cooperative action, the maximum error is 4.5 mm, and accompanied by large fluctuations[8].



(a)



(b)

FIGURE IX. (A) COOPERATIVE ACTION ERROR CURVE IN AVERAGE LOAD CONDITION (B) COOPERATIVE ACTION ERROR CURVE IN AVERAGE LOAD CONDITION BY PID CONTROL

IV. CONCLUSION

In summary , compared PID neural network control with ordinary PID control under the same working condition,, the synchronization error and synergistic action error under the control of PID neural network are obviously reduced, and the error fluctuation is smaller in the error adjustment process, so the system has better stability. Compared with ordinary PID control, PID neural network control shows better adaptability.

REFERENCES

[1] Peng Zhixiang,Technical Research on Sliding Shipping and Loading of Large Structures [D]. Tianjin University, 2012.

[2] Ruiying Zhao,Research on large module shipment control system based on multi-cabin control [D]. Tianjin University, 2016.

[3] Haizhong Wu,Development of roll-on equipment for steel piles on offshore platforms [J]. Petroleum and chemical equipment, 2016, 19 (01): 20-22.

[4] Zhixia Fan,Truss Spar Platform Sliding Shipment Research [A]. Excellent Papers Collection of China Shipbuilding Engineering Society in 2011 [C]: China Shipbuilding Engineering Society.,2012:7.

[5] Xiongbiao Wei,Brief discussion on shipment mode of large structures in offshore petroleum engineering [A]. China Steel Construction Society, National Engineering Research Center of Steel Structures.'Papers of the 2009 National Academic Annual Conference on Steel Structures [C]. China Steel Construction Society, National Engineering Research Center of Steel Structures: China Steel Structure Association,2009:4.

[6] Xiaogang Zhai,Optimal Control of Sliding Shipping Process for Large Structures [D]. Tianjin University, 2005.

[7] Zhao Zikun, Baihe, Wu Qiang, Wang Xiwei,Application of slipper modification technology in ocean engineering [J]. Standards and quality of China Petroleum and Chemical Industry, 2019, 39 (10): 187-188+190.

[8] Du Lifeng,Development trend of traction displacement and shipment technology for large structures in deep-sea oil and gas fields [A]. Tianjin Science and Technology Association. [C] Papers collection of the 2017 "Innovative Binhai SEW Cup" High-end Equipment Innovative Design Competition. [C] Tianjin Science and Technology Association: Editorial Department of Mechanical Design, 2017:3.