Research on Synchronization of Jacking up based on Programmable Logic Controller (PLC) to Replace Bridge Bearings

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Abstract: Bridge bearing is an important component of bridge structure, which has the effect of continuity, the design, construction, traffic load and natural aging, tend to produce a variety of diseases. Based on the PLC computer control synchronous jack-up replacement is a kind of advanced technology to replace the current method, it uses the computer to do the control center, through the programmable controller) preprogrammed function module, realize the logic operation, sequence control, timing, counting and arithmetic operations such as user-oriented instructions, and through the digital or analog input/output control various types of machinery or production process.

Keywords: Bridge bearing; Programmable Logic Controller; Style; Synchronization jacking up

1. Introduction

Considering the safety of the bridge, bridge bearing disease need for repair or replacement in a timely manner. But it needs to lift the upper structure of the bridge to a certain height, repair or replacement before falling restorable. Using a variety of jack-up method at present, but these jack-up method all has certain disadvantages, such as synchronous jack-up poor, poor controllability, security is poor. [1] Sync jack-up system to the total controller as the control center, are connected by a data bus each control station and the hydraulic system, through the displacement and pressure sensors to collect data and transport instructions, electromagnetic valve under the general control machine instructions to oil supply and oil return of oil cylinder, the oil cylinder piston to synchronize ejection and retraction, so that the top beam body rise to the required height, will be damaged after bearing replacement for the new bearing, cylinder synchronization drop again, restorable.

With the rapid development of social and economic and industrial automation level unceasing enhancement, automatic control is also more and more used in the industry. No authority currently has classified the hydraulic synchronization system. [2] And the current classification of hydraulic also depends on different points of view. But this has no effect on the actual function of hydraulic and, only to facilitate people understanding and the understanding of them. Hydraulic control system: in order to ensure the safety of the bridge at the top of synchrony and operating, adopting PLC to control the jack-up system. This method has been widely applied in the domestic many large Bridges jack-up construction. [3]

2. Introduction of Synchronous Jack-up System

Synchronous jack-up system usually uses the way of control are: hydraulic frequency control of motor speed control, stress and displacement closed loop control. By the method of the control, the system achieves balance control. This system adopts the valves with flow in the form of a plunger pump as hydraulic pump, pump station on the even load of the valve, can be guaranteed in the process of jack-up and landing. Jack is in a state of feed speed control, can improve the control precision of the jack and can reduce the influence of the beam of the bridge structure. At the same time, because of the valve are no leak, can very good to jack lock, ensure unexpectedly fell beneath because of power outages, and so on and so forth. When jack produce displacement, can through the system installed in the transmitter measured corresponding numerical, at the same time, its actual displacement can be measured, according to these data will be able to detect Bridges jack-up height.

PLC synchronous hydraulic jack-up system is mainly composed of the following parts: the system through the electrical control and variable frequency speed regulation system of industrial control bus, variable frequency speed control system consists of a number of the same unit of hydraulic drive, frequency conversion speed control unit consists of motor, reversing valve, hydraulic pump and

oil cylinder, hydraulic pump connected to the motor and reversing valve, variable frequency speed control unit also includes displacement sensors, frequency converter, and pressure sensors, pressure sensors and displacement sensors are connected to cylinder.

PLC applied the top at low speed and high speed zero control, the system sets the multipoint sensor to ensure that work in high reliability, including pressure sensor, oil cylinder built-in displacement, etc. The adoption of uniform loading valve, thereby avoiding common expansion cylinder when in multi-cylinder jack-up appear. The adoption of distributed control, all operations on the control of computer implementation, so the system control and operation is very simple and intuitive, can also be inserted into the touch screen control system, to show that in the process of jack-up various load. In addition, the system control output point can be extended, so as to realize the control of more than state, and different output point which can be controlled separately, and also can realize the synchronization control between them, the whole system has the advantages of superior performance, simple operation and high reliability.

3. Technical Features and Process Principle

1) The whole process is controlled by computer. And it coordinates work in three systems which contains machine, electricity, liquid system .Furthermore, its oil cylinder moves in same step, which keeps in high synchronicity.

2) The technology uses the displacement and pressure controlling, achieved the goal of synchronous jack-up/decline.

3) Synchronous jack-up system which controlled by computer is a kind of machine, electricity, liquid integration of complex system, it is through the information open or close the valve control signal to raising and lowering the weight, and keep the increase point of synchronization errors in the operator to set the range.

4) Because the structure is checked, the part of displacement may affect bridge simulation displacement, used for reinforcing the jack-up, can ensure the safety of bridge structure. The whole process of jack-up is the displacement of the whole PLC hydraulic synchronous control system, the double control of jacking force condition, do the structural displacement and stress are under control, which ensures that the displacement of bridge under safe and stable state. Construction period is short. During the preparation phase can be in does not affect the normal use conditions, jack-up transformation in the process of single cross framing jack-up renovation, don't interrupt the traffic. Economic benefit, social benefit is remarkable: general cost is about one-third the cost of reconstruction. Because the construction period is short, the impact on the surrounding environment is small, saves the resources of society to the greatest extent.

5) Proportional valves, pressure sensors and an electronic amplifier consist of pressure closed loop. According to different each jack-up cylinder bearing, set pressure of the pressure reducing valve group of several jack a jack-up, lift up the beam body, but if only strong balance, the bridge lifting location is not stable, to stabilize the position, installed in each group of grating ruler for precision position measurement, the position feedback, closed loop of position, once the measuring position and instruction position there is a deviation, will produce the error signal, the signal after amplification, by adding to the command signal to the group overall lifting force increase or decrease, so the oil cylinder position changes, until the position error to eliminate. As a result of the position of the group of jack-up system between signal given by the same numerical integrator, so can keep the top of group of synchronous jack-up, just change the number of integrator time constant and can easily change the rate of rise or fall.

4. Sync Jack-up Construction Technology

4.1. PLC control bridge sync jack-up construction technology and procedure

Construction preparation → jack-up preparation → weighing →try to top up →keep the pressure→ formal top →installation of temporary support → replace the bearing of the bridge→ check on the bridge deck elevation → dismantling temporary support fall beam → remove the jack-up equipment.[1]

4.2. Construction Operation Points

1) Bearing frame and other civil engineering auxiliary facilities

Cylinders should be placed on the basis with enough bearing capacity. In general, when the capping beam or the abutment and the bottom of the beam have enough building height, it can install cylinder and construct conveniently. What's more, it should give preference to place the cylinder above the capping beam or abutment. When the upper structure of space between the girder and the abutment or capping beam, the oil cylinder was laid up structure, depending on the bridge structure, transportation, clearance under the bridge which can be used to build bearing bracket, attached type bearing frame, expanding base etc. Bearing bracket is easy to take down, clear force, quick construction, reusable, etc. The selection of the bearing frame should be calculated and determined according to the top of the force, meet the requirements of strength, stiffness, and checking the stability. For the convenience of dismantling and repeated use, people usually choose the module type steel pipe scaffold, according to the bridge pier clearance flexible spellers each unit. [4] Moreover, bearing frame foundations also need to meet the requirements of bearing capacity, and

try to be uniform, compact. And if there are the following caps or expand the foundation that it is appropriate to set in it. Construction can be invisible when turns the soil above the pile caps, above the top of the pile caps, pouring concrete, as a support base, concrete top surface must be level.be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

2) Lift bridge constraints

Bridges remove possible constraints before starts to jack up, these constraints may come from the bridge structure itself, such as railings, anti-collision pier, sound barriers, bearing steel plate between the up and down link plate, etc. It also includes constraints which may be caused by the construction, such as running pulp, steel bar binding, loss of function of seismic pin rods, etc. It still needs to loose rail fastener article if we jack up rail bridges.

Set up temporary piers on the beam end jack, the temporary piers should be conducted with top booster, when to stop working when the temporary piers should be instant wedge tight, in order to prevent the accident, to ensure that the structure and construction safety. When jack up top beam, should be loading slowly and in stages, with 5 MPa to load a class, when the beam body rise to meet the design value, the timely adjustment and eventually stop pressure and voltage stabilizing treatment. After every load in time carefully check whether jack, oil pipe, oil pump leakage.

3) Jack-up

Trial jack-up test should be in advance before formal jack-up homework. And to the whole project observation and examination of the jack-up construction condition, also can check weighing results at the same time, the height of the jack-up set to 10 m. In all aspects of the original bridge structure present situation of the linear measurement to start jack-up homework, for subsequent formal jack-up reference contrast to provide data support.

At the top of the jack-up operations first will lift load rapidly to the theory of top lift 80% slowly again after loading. Until you can according to the displacement sensor to determine the separation between the various points have, further implement the jack-up homework until the jack-up points to keep 5 mm vertical displacement. In turn it off after 10 minutes, respectively from the top of the bridge to check and jack-up stents has deformation and load point if there's any damage.

It can start formal jack-up homework if it detected no problem after trial jack-up. It can start formal jack-up homework if it detected no problem after trial jack-up .And its single top jack-up scope is 100 mm, maximum jack-up rate is 5 mm/min. [5]

Place the cylinder in the design of location, and it needs to implement the processing base if the foundation is uneven. When oil cylinder body height and the sum of jack-up height is less than abutment or bottom of a small beam and plate beam steel supporting net, it still needs to add a certain height of circular plate oil the cylinder top. To increase the force area, reduce the beam bottom stress, and eliminate the girder stress concentration caused by slope and roughness, the top should set up a circular plate rubber support. Moreover, oil cylinder use limit pin stuck in case of the dislocation and sliding.

4) Replacement

When the top of the beam body lift to dismantle bearing replacement, then immediately replace the damaged bearing, replace the bearing can only be a single, complete a replacement and then go to the next, not at the same time.

Bearing before installation, should check the product certificate of quality and technical performance indicators, such as do not meet the design requirements, shall not be used. For different forms of bridges should adopt different ways of jack-up, for composed of T beam or h beam cross section form, generally in the girder plate was laid not directly evaluated using the method of one thousand catties bumps rise, but the top board, box girder into heart, must pay attention to the jack-up site, avoid direct jack-up beam at the bottom of the body, and easy on the underside and box girder web site, to prevent damage to the girder. Strictly control the top height of the beam body, avoid high top rise through bad of bridge deck and ancillary facilities. Jack-up process, should strengthen the patrol work, shall designate personnel to observe the working condition of the whole system. If there is abnormal, inform pumping station operators directly.

When it have been jacked to the desired location, people also use steel plugged the gaps between the pier and the beam body immediately, in order not to make the oil cylinder load for a long time. A specialized production of expander works together with flat steel and hook to eliminate the old support rapidly. Using acetone to remove rust on the plate and wipe clean. Using epoxy resin paste bearing, and require dense paste and filled with paste liquid. It daubs silicone evenly on the top surface of the four fluorine board. If it found that its bearing escaped after new bearing replaced, and then sync jack up again, further slowly fall beam. If the original bearing cannot take out with edge shovel gently poke around the bearing, for adhesion, and then with a small hammer to knock out. Processing of bearing pad stone adopt high grade cement mortar.

5) Bridge Restoration

According to the requirements of the bearing replacement steps, complete the other bridge across the bearing replacement. After all completed, check the bearing qualified replacement, oil returns, gradually remove the jack-up system[6].

PLC hydraulic synchronous jack-up technique to replace bridge bearing is to eliminate the current existing jack-up technique when oil cylinder can't sync jack-up artifacts caused additional stress by artifacts caused by the failure

of safety link, is a kind of feasible bearing replacement technology, can be applied.

After the paste of the bridge, high pressure air purges the expansion joint and the bottom of the beam, making the beam bottom falling things without any constraints. And when all the work finished, it restarts the synchronous jack-up system, recovers the hydraulic oil cylinder, to reset the beam body.

6) Recovery Structure

Bridge restores as required after restoring rail fastener, anti-collision pier, track structure, etc.

4.3. Construction and data analysis

To measure the position of the original support record, in order to convenient for subsequent use professional tools installing new bearing in the original position, the use of professional tools to take out the damaged bearings, then check that the installation location is correct, highly appropriate, contact good or not. It should be replaced by bearing consistent with the original support position, but the height should higher than the original pedestal is advisable

Bearing replacement construction can choose grating ruler to control, namely in each one grating ruler as elevation observation point which set at the top of the main girder. After the per level, measuring the vertical displacement of the beam at any time, according to the displacement conditions at any time to adjust the power works at the next lower level each jack, in order to make sure the beams to rise as much as possible. [7] PLC control hydraulic cylinder Bridges synchronous jack-up system adopts microcomputer monitoring system of jack-up dynamic real-time monitoring data that can be displayed on the monitor screen. According to the parameters of the main factors are as follows: pump station pressure, jack grouping, jack load and poor jack displacement and displacement of the top. Jack pressure and displacement difference are set up transfinite alarm function, to prompt the system causes of accidents, such as: human touch sensor installation deflection, displacement, etc.

5. Control of Construction Safety

1) In the process of the jack-up modes, traffic of vehicles need to the temporary line breaks.
2) Reliable anti-sliding measures of aluminum alloy ladder is necessary for the upper and lower bearing frame.
3) Protection device set around the scaffolding.
4) Job safety protection measures should be perfect.
5) It is strictly prohibited people working fatigue.
6) Homework must implement the safety technical disclosure, and no safe certification homework is strictly prohibited.
7) It must use protective equipment according to regulations, and strictly abide by the disciplines construction site.
8) Oxygen and acetylene cylinder space greater than 5 m. Two bottles with welding, the spacing is greater than 10 m. 9) In the event of accidents, immediately implement the safety emergency plan, timely rescue, protect the scene, and report to the superior.

6. Conclusions

1) PLC whole hydraulic synchronous control system in the condition of displacement, the double control of jacking force to complete the whole process of jack-up, due to the PLC ensures the whole hydraulic synchronous control system in the working process of the structural displacement and stress are pushed to the real controlled, so that the bridge reinforcement is accomplished in the safe and stable state displacement change, reinforcement, bearing replacement.

2) The construction is simple, practical. The whole process does not affect the normal use, the implementation of the jack-up transformation process does not need to interrupt the traffic, is conducive to the actual application.

3) Construction period is short, applicable, which saves resources, improve efficiency, has a certain popularization value.

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