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Design and Research of Drilling Control System based on Seventh Generation Semi-submersible Drilling Platform

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Abstract: Drilling automation is a current development trend of offshore oil and gas drilling exploitation. It can not only save drilling time and improve drilling efficiency, but also optimize the drilling process and ensure drilling safety. Based on the seventh generation semi-submersible drilling platform, this paper conducts analysis and designs on each component of the drilling control system. This research provides a certain reference value for the future development of automated drilling platforms.

Keywords: Marine energy extraction; Semi-submersible drilling platform; Drilling control system; Automation

1. Introduction

Aiming at the development trend of international marine engineering equipment, in order to enhance the independent innovation capability of China's ultra-deepwater oil and gas exploration equipment, the design of ultra-deep water semi-submersible drilling platform is carried out systematically to solve the platform ship type design, overall design, structural design and safety status recognition, positioning system, integrated design, test technology and standard specification formulation of electric power and control system, develop a high efficiency, low energy consumption, low noise seventh generation semi-submersible deepwater drilling platform with double rigs design which suitable for the environmental conditions of the world's main ultra-deep water areas especially for the sea conditions in the South China Sea, complete the conceptual design and basic design and the basic design drawings documents approved by the classification society, form a global operation assurance solution, support the construction of real ships and form a design brand [1-4].

In this paper, according to the function and performance requirements of the seventh generation semi-submersible deepwater drilling platform, we carry out the integrated design and research of drilling control system.

2. Drilling Control System Configuration

2.1. Design and analysis of drilling control system

A drilling platform requires two drilling control rooms (DCR), and DCR is the control center on the drilling platform. Each driller's room has a separate drilling control system, operated by two operators in a comfortable workplace, with two surrounded consoles, including instruments for main drilling equipment and key drilling parameters.

The two locations of the driller will be equipped with a Cyberbase system that will extract drilling data trends, drilling rig settings, drilling control parameters, status, alarms, motor / pump start / stop, etc., which will be displayed on the color display. For other third-party equipments, for redundancy purposes, insert portable control station should be provided, and the portable control station should be usable in any situation.

2.2. Mud control analysis of drilling control system

The mud pump control system uses industrial programmable logic controller (PLC). The MP software is designed to control up to six MPs and auxiliary equipment of a PLC. For redundancy and safety reasons, the control of MP is allocated to two or more PLCs. For example, on equipment containing six MPs, MP, MP1, MP2 and MP3 (with auxiliary equipment) can be controlled by one PLC and MP4, and MP5 and MP6 (with auxiliary equipment) are controlled by the second PLC, and the auxiliary equipment is controlled automatically by the mud pump control system through the motor control center.

MP can also be controlled separately from the local control panel.

When operating locally, each function of pump differs in different modes. In local mode, there are functions including mud pump on / off, speed control, MCC control and Mud pump local emergency stop; in inching mode, there are mud pump on / off, speed control and MCC control functions.

2.3. Instrument control analysis of drilling control system

The instrument control system provides field-proven drilling instruments, and monitoring system provides real-time data collection, historical trends, flexible alarm functions, and a mechanism to store drilling parameters for post-project analysis. These systems provide drilling operators with the most comprehensive and data with complete graphs, which can ensure a profile of the success of the most demanding offshore drilling projects.

2.4. The analysis of drilling control system and drilling collision avoidance system (ACS)

The mission of ACS is to prevent collision accidental commands or other operator errors from the machines on the drill floor due to collisions. To this end, ACS monitors the location of contained machines and calculates the limit of the distance they can move. ACS is always active, but the key panels of ACS in the SMI cabinet can be used to ignore or release machines from ACS. ACS does not consider fixed structures or drill rods, and avoids the responsibility of using fixed structure machines for their respective control systems. Interlocking safety drill rods between machines is not part of ACS.

The CMC / DW in AHC mode prevent other machines from entering the lower area TD. To define the position of the machines included in the anti-collision system, the definition of a coordinate system will be used on the drill floor. The system is divided into two matrices to increase visibility. Both matrices are related to the same coordinate system. Some machines can operate in the center of two wells, and then the machines are located in two matrices. Such machines are: human resources perform normal collision detection on the related machines in the center of two wells.

The design standards of the drilling collision avoidance system are as follows:

The collision avoidance system only checks the moving parts of the machine. Each machine must individually prevent collisions with all fixed points.

All machines must be positioned in all directions of motion

From the control of each machine to all positions and stopping distances of the collision avoidance system, they must be given in floating point form, sent in meters, but the resolution is in millimeters.

The correct coordinates depend on healthy positioning system. The machine PLC generates healthy positioning signals, indicating when all positioning signals turn on the relevant machine. The number and degree of such measurements will depend on the type of machine.

Turn the yellow indicator of measuring unhealthy on the Cyberbase screen. When the unhealthy signal from the machine is valid or lost, communication with the PLC of the specific machine occurs.

Although there is the situation of measuring unhealthy, the most common situation is to use motion collision avoidance system. This will minimize the consequences of signal errors, but may lead to reduce the levels of operation.

Since the maintenance basket is not controlled by the PLC, the collision avoidance system cannot be stopped. But all other machines that may conflict with service and access will stop when the basket is not in the parking position.

Each individual machine control system is responsible for the correct response to stop the position limitation given by anti-collision system.

Each machine PLC is responsible for machine-specific interlocking.

If the machine PLC detects a communication failure of collision avoidance system, all must stop moving.

A RELEASE switch is connected to each machine involved in collision avoidance system.

An IGNORE switch is connected to the central collision avoidance system of each machine to participate in the anti-collision system

2.5. The analysis of drilling control system and mechanical control system (MCI)

PLC includes various small drilling rig machines, and it does not have its own PLC. These small systems are integrated into the entire drilling control network through this MCI 1 PLC.

Operation steps of the mechanical control system: the control system is delivered to the digital driller's operator station (eg. Cyberbase operator station) and portable radio operator station; the interface of the machine control system; the control integrator will be connected to the National Oilwell Varco Cyberbase station; The digital operator site acts as the interface to Cyberbase and it has the advantage of treating several customers as a complete and flexible system with extended and integrated messages and an alarm system, which is easy to implement changes; When using Cyberbase, the diagnostic buffer on the PLC CPU can be on the screen; the communication status and network diagnosis are displayed on the Cyberbase screen; the software is designed to perform the best interface with Cyberbase.

2.6. Drilling platform drilling smart machine integrated system (SMI)

Smart Machine Integrated System (SMI) is a platform for these additional software modules designed specifically for the automation and safety of the rig process, and part of SMI is also a machine controller that runs software and the hardware communicating with it. The Smart Machine Integrator hardware platform is a standard PLC cabinet with the necessary components for

connecting SMI and the machine controller (UDP communication) in the associated drilling control network.

2.7. Analysis of dry cargo control system of drilling platform

The control system can monitor and/or control the following functional systems from the mud control: pressurize the storage container by guiding the valve from the compressor; transfer dry bulk material queues between storage containers via valve routing; adjust the transmission rate by controlling the purge air valve; use the pinch valve to adjust the transmission rate and advanced alarm in the tank; monitor the weight of the tank; compensate the weight for heave and tilt movement; convert the weight to volume according to the defined gravity of the material ; monitor the pressure in the tank; monitor the valve position and system alarm failure.

The mud can monitor and / or control the following automatic function control systems: fill the tank to the specified amount; assign batch transfer between the specified number of tanks; refill the tank to the specified amount (constant level in the receiving tank); refill the fuel tank within the prescribed limits (high / low set point); arrange valves between tanks automatically; empty the dust collector automatically; flush the transmission line automatically after completing the transfer; ensure the automatic overpressure safety of the tank.

2.8. The remote diagnosis function analysis of drilling control system

Remote diagnosis of drilling control system provides services for customers. Establishing a communication link between the remote diagnosis support center of the drilling control system and the remote diagnosis of the drilling control system to support the remote system, experts can immediately provide services to the system according to customer needs at any time.

All of this is accomplished by establishing a communication link between the remote diagnosis support center of the drilling control system and a site that supports the remote diagnosis of the drilling control system, using a proven, safe and reliable network method.

The purpose of remote diagnosis of drilling control system is to provide better service and support, and it provides services to customers through remote diagnosis, update and training. However, the main role of the remote diagnosis of the drilling control system is to reduce the possibility of malfunction, and it ensures the downtime of the drilling platform by performing remote diagnosis immediately and making the correct decision in the early stages of trouble removal.

Drilling control system remote diagnostics specialists can conduct monitor and control safely according to customers' requirements, and the drilling control system remote diagnosis support center provide the system. Drilling control system remote diagnosis can provide immediate support control system, from sensors to machine control to graphical user interface, reducing waiting time and potential downtime.

3. Conclusions

Based on the seventh generation semi-submersible drilling platform, we conduct the design and analysis of each subsystem of the drilling control system in this paper, and accomplish the following innovations:

The design and implementation of the drilling control system integration. It has accomplished the realization of the ships' drilling automation system integration technology including mud control, instrument control, drilling anti-collision control, mechanical control, intelligent mechanical control, dry cargo control and remote diagnostic control.

The drilling control integrated system display page. The alarm display page of the alarm point of the distributed control system realized by software programming are vivid, easy to identify, easy to operate and judge, and it improves the monitoring of equipment and instruments, reduces the cost of on-site manual inspection and equipment maintenance, and improve work efficiency.

The remote diagnosis application of the drilling control system improves the safety and reliability of the control system, and also the efficiency of problem solving. At the same time, it can effectively monitor the operation of the equipment and prevent equipment failure in advance, providing a guarantee for the safe operation of the equipments.

With the development of computer technology and field bus, it will have a significant impact on the structure of the drilling control system. Open control system will be the focus of the next research and development.

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