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Design of Six Degrees of Freedom Active Wave Compensation Platform

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Abstract

Under the action of the waves, The ship will move in six directions, which seriously affects the normal operation in the ship. In order to improve the safety of ship operations, equipment is needed to compensate for fluctuations in these six directions. In view of the shortcomings of the existing wave compensation platform, a new type of six degrees of freedom active wave compensation platform is proposed, so that the equipment is as light as possible and the structure design is reasonable to meet the stability of the equipment. Consisting of drive cylinders and sensors, it is possible to simplify the compensation of six degrees of freedom into three compensation systems, and the three compensation systems are interrelated, reducing the compensation effect when the six degrees of freedom of coupling contract. The results show that six degrees of freedom can be compensated by the device, which provides a design reference for the follow-up study.

Keywords

Wave compensation; Platform; Six degrees of freedom movement.

1. Introduction

With the development of marine resources and the continuous expansion of offshore engineering construction, the requirements for surface operations are more stringent, so a safer, accurate and stable offshore operating environment is required. The irregular movement of the waves will cause the ship to move in six degrees of freedom, resulting in certain risks in offshore operations and seriously affecting the efficiency and safety of surface operations. People increase their stability through compensation equipment. The wave compensation platform is mainly used to compensate the movement of the ship. By moving the platform itself, it can offset the interference of the fixed platform to the ship, so that the moving platform is in the required motion state for work. Various equipment are placed on the moving platform, and the operation is also completed on the moving platform, so the moving platform needs to compensate the disturbance caused by external factors in real time to meet the work requirements.

The movement of the ship in the directions of rolling, pitching, yawing, surging, swaying and heaving under the action of the waves, seriously affects the normal operation of the ship. In order to improve the safety of ship operations, equipment is required to compensate for fluctuations in these six directions. The wave compensation platform changes its posture by adjusting the elongation of the drive cylinder to maintain the stability of the platform. It is used to reduce or eliminate the impact of sea waves on marine equipment on the platform.

In view of the shortcomings of the existing wave compensation platform, a new type of string-in-line six degrees of freedom active wave compensation platform is proposed, the equipment needs to be as light as possible, at the same time, the structure design needs reasonable to meet the stability of the equipment.

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The device has the characteristics of mechanical structure diversification, which can be compensated in multiple degrees of freedom. In the structure of the model, the device not only has a large advantage of the working space of the series mechanism but also has the advantage of the stiffness of the parallel mechanism. Because of the complexity of the conditions at sea, in order to improve the safety and reliability of offshore operations, it is very important to design the multi-freedom active wave compensation platform and its compensation method.

2. New six degrees of freedom active wave compensation platform design

Ships face very complex offshore environments on the surface, which requires a relatively strong anti-jamming capability and good stability. In the sea will produce the rolling, pitching, yawing, surging, swaying and heaving direction of the movement, so the equipment needs to be able to compensate for the fluctuations in these six directions, and the ship equipment in order to meet the use of functions at the same time, the equipment needs to be as light as possible, the structure design needs reasonable to meet the stability of the equipment. The Chinese patent "the crane device and compensation method with three degrees of freedom active wave compensation function" with the public number 105621275A discloses a crane device with the active wave compensation function of a ship, but the device can only compensate for the motion of three degrees of freedom; Open number 106744320A of the Chinese patent " A six-degree-of-freedom active wave compensation lifting method and lifting system", the use of equipment by servo motor-driven wire rope traction system and vision detection system, the use of cameras to detect relative position, the system structure is complex, the use of equipment, not easy to install and debug, and such a complex system prone to errors, will also affect the reliability of the results. The Chinese patent "A six-degree-of-freedom wave compensation platform" with the public number 108150782A is complex with a complex structure between the base plate and the upper platform through three electric cylinders, horizontal hinges, vertical hinges and the guide rods and guide sleeves on them. And when the platform panning, can not achieve the platform in time for the mid-reset, three electric cylinder ball head and the lower base connection, the outer cylinder and corresponding motor placed on the upper side, so that the upper weight is too large, making the overall structure of the center of gravity is too high, not conducive to stability.

In order to solve the above technical problems, the technical scheme of this design is: to propose a six degrees of freedom active wave compensation platform, divided into three compensation systems:

The first compensation system, which comprises: a base fixed to the hull, a first compensation platform, a first hydraulic cylinder, a second hydraulic cylinder and a third hydraulic cylinder fixed to the base, and is distributed at an equal angle on the base, the first hydraulic cylinder, the second hydraulic cylinder and the third hydraulic cylinder are connected to the first compensation platform respectively; The universal connector is far from the end of the central electric cylinder with a twisting motor, the twisting motor is fixed with the first compensation platform, the three displacement sensors at the bottom of the three are connected to the three hydraulic cylinders respectively, the middle part shift sensor is connected with the central electric cylinder signal, and the three motors control the movement of the hydraulic cylinder respectively. The first compensation system realizes the compensation of the direction of heaving, yawing, rolling and pitching.

The second compensation system, including the first rail groove, the second rail groove, respectively, fixed on the first compensation platform; The second rail and the second rail groove correspond to the placement, the fourth displacement sensor, connected to the first rail, the fifth displacement sensor, connected to the second rail, and the first electric cylinder, the outer cylinder is connected to the fourth displacement sensor, The inner cylinder is connected to the first rail slot, and the second electric cylinder, the outer cylinder, is connected with the fifth displacement sensor, and the inner cylinder is connected to the second rail slot. The second compensation system realizes the motion compensation in the direction of the horizontal.

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The third compensation system, including: the third rail groove, the fourth rail groove, respectively, is fixed on the second compensation platform, the third compensation platform, the third rail, the fourth rail, respectively, fixed to the third compensation platform, and the third rail corresponding to the third rail groove placement The fourth rail is placed correspondingly to the fourth rail groove, the sixth displacement sensor is connected to the third rail, the seventh displacement sensor is connected to the fourth rail, and the third electric cylinder, the outer cylinder is connected to the sixth displacement sensor, The inner cylinder is connected to the third rail groove, and the outer cylinder of the fourth cylinder is connected with the seventh displacement sensor, and the inner cylinder is connected with the fourth rail slot; wherein the first rail groove, the second rail groove and the third rail groove, the fourth rail groove are placed in a vertical direction to each other. The third compensation system realizes the compensation in for the direction of the swing.

Wherein, the base is placed on the wave simulator, the upper end of the first two-third hydraulic cylinder is spherical, and the first compensation platform high sub-connection. This six degrees of freedom active wave compensation platform also includes a control system that receives displacement signals from all sensors.

The design also provides compensation methods for the six-degree-of-freedom active wave compensation platform, including different sensors detect the movement of each drive cylinder, providing position feedback for more precise control.

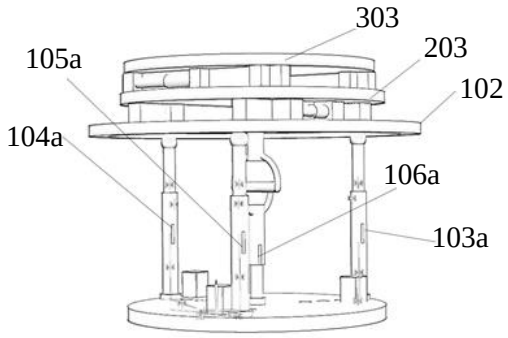

Figure 1

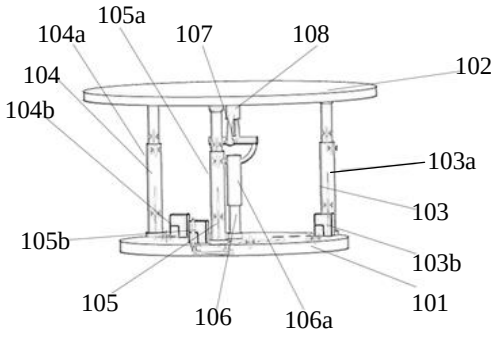

Figure 2

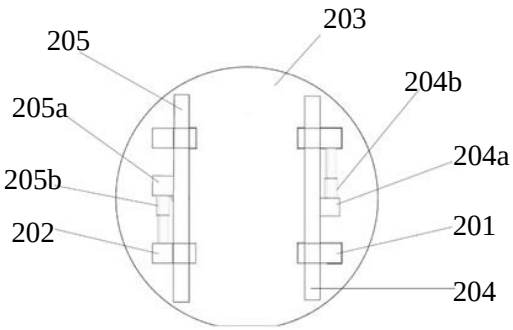

Figure 3

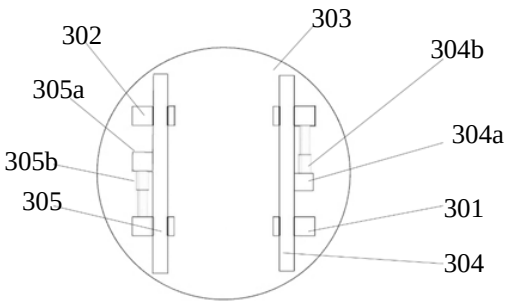

Figure 4

Figure1-4 Structural diagram of the six-degree freedom active wave compensation platform

This design provides a six degrees of freedom active wave compensation platform, the use of drive cylinders and sensors to solve the compensation problem, the structure is simple and reasonable, can simplify the six degrees of freedom compensation into three compensation systems, and three compensation systems division of labor cooperation and interrelated, can compensate for six directions of freedom, simplify the problem while enhancing the compensation effect. Powered by a

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central electric cylinder, the first compensation platform can be pulled to the center via the telescopic of the electric cylinder. In the design of the string and parallel six degrees of freedom active wave compensation platform, the second compensation system and the third compensation system provide a simple structural system, the use of four electric cylinders, two sets of rails and two sets of rail grooves can achieve the corresponding compensation effect, simple structure, so that the compensation efficiency is improved, convenient for post-maintenance and maintenance. In the first compensation system of this design, three outer cylinders and motors are placed on the base, which greatly reduces the overall center of gravity and improves stability.

The compensation method of the string-parallel six-degree active wave compensation platform provided by this design can monitor the displacement change of the hydraulic cylinder in real-time, and after the algorithm recognition analysis, it can more accurately predict and compensate for the displacement change. The design base and the first compensation platform between the three hydraulic cylinder and the middle hydraulic cylinders - universal connector connection, can achieve the compensation heaving, yawing, rolling and pitching direction four degrees of freedom at the same time, the lower part of the three hydraulic cylinders and the base through screw connection, so that the first compensation platform has more support, easy to achieve stability.

3. The design structure and implementation of the six degrees of freedom active wave compensation platform

With reference to Figure 1 to Figure 4, this design proposes a six degrees of freedom active wave compensation platform, including the first compensation system, which includes: base 101, fixed on the hull; first compensation platform 102; first hydraulic cylinder 103, second hydraulic cylinder 104 and third hydraulic cylinder 105 are fixed to the base 101, respectively, and the base 101 is distributed at an equal angle, The first hydraulic cylinder 103, the second hydraulic cylinder 104 and the third hydraulic cylinder 105 inner cylinder end are connected with the first compensation platform 102 respectively; The central position, the other end is arranged with a universal connector 107, the universal connector 107 away from the central electric cylinder 106 at one end is set to have a twisting motor 108, the twisting motor 108 and the first compensation platform 102 fixed The first displacement sensor 103a, connected to the signal of the first hydraulic cylinder 103, the second displacement sensor 104a, connected to the second hydraulic cylinder 104 signal, and the third displacement sensor 105a, and the third hydraulic cylinder 105 signal connection; mid-section transfer sensor 106a, connected to the central electric cylinder 106 signal connection; first motor 103b, control the first hydraulic cylinder 103 movement; second motor 104b, control the second hydraulic cylinder 104 movement The third motor 105b, control the third hydraulic cylinder 105 movement.

The second compensation system, including the first rail slot 201, the second rail slot 202, respectively, fixed on the first compensation platform 102; On 203, and the first rail 204 corresponds to the first rail slot 201, the second rail 205 and the second rail groove 202 correspond to the placement; The fifth displacement sensor 205a, connected to the second rail 205, the first electric cylinder 204b, the outer cylinder is connected to the fourth displacement sensor 204a, the inner cylinder is connected to the first rail groove 201, and the second electric cylinder 205b, the outer cylinder is connected to the fifth displacement sensor 205a, the inner cylinder is connected to the second rail 2022.

The third compensation system, including the third rail slot 301, the fourth rail slot 302, respectively, fixed on the second compensation platform 203; On 303, and the third rail 304 corresponds to the third rail slot 301, the fourth rail 305 corresponds to the fourth rail slot 302 placement; the seventh displacement sensor 305a, connected to the fourth rail 305, the third electric cylinder 304b, the outer cylinder is connected to the sixth displacement sensor 304a, the inner cylinder is connected to the third rail groove 301, and the fourth electric cylinder 3 The outer cylinder is connected to the seventh displacement sensor 305a, and the inner cylinder is connected to the fourth rail slot 302; The fourth rail slot 302 is positioned in a vertical direction towards each other.

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As shown in Figure 5, in this design, the first compensation system is used to compensate for the movement of four degrees of freedom in the direction of four directions, the second compensation system, which is used to compensate for the movement of a degree of freedom in the direction of swinging, and the third compensation system, which is used to compensate for the movement of a degree of freedom in the direction of horizontal. The above system combines to compensate for the movement of six directions of freedom.

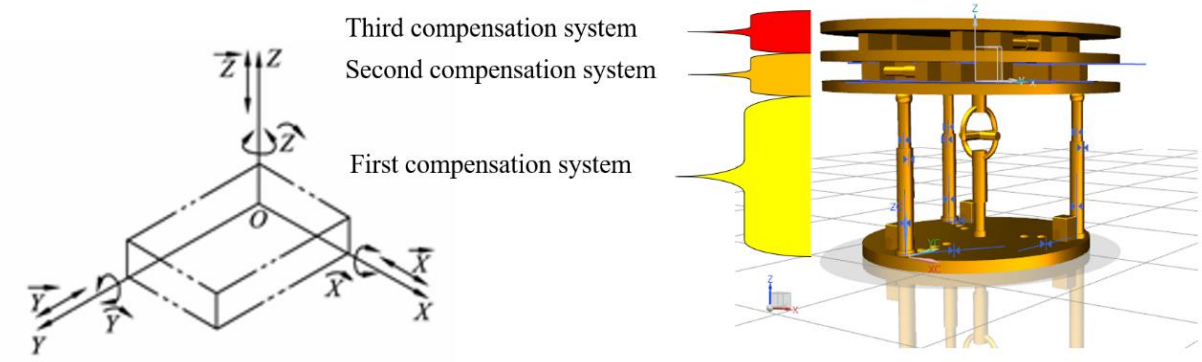

Figure 5 Wave Compensation Effect Description

The base 101 is used to connect with the ship, is fixed to the hull, facilitates the operation of the relevant equipment on board, or can be placed on the wave simulator for the implementation of the wave compensation-related experiment. The first hydraulic cylinder 103, the second hydraulic cylinder 104 and the third hydraulic cylinder 105 are fixed to the base 101, and the base 101 is an equal angle, used to support the first compensation platform 102 and compensate for the corresponding position change. In the first compensation system, the central electric cylinder-universal connector mechanism is used to reset it in the first compensation platform 102 after the movement of the horizontal and debauchery, while the universal connector 107 makes this mechanism does not affect the flexibility of the first compensation platform 102, and the motor twisting motor 108 is used to compensate for the movement of the direction of the rocker.

The first hydraulic cylinder 103, the second hydraulic cylinders 104 and the upper end of the third hydraulic cylinder 105 cylinder are spherical, connected to the first compensation platform 108 high sub-connection; Displacement sensor 103a, the second displacement sensor 104a, the third displacement sensor 105a, the medium displacement sensor 106a, the fourth displacement sensor 204a, the fifth displacement sensor 205a, The displacement signal from the sixth displacement sensor 304a and the seventh displacement sensor 305a.

4. Conclusion

(1) Using a combination of drive cylinder and sensor, it is possible to simplify the compensation of six degrees of freedom into three compensation systems, making the three systems work together and interrelated, simplifying the problem and enhancing the compensation effect.

(2) Provides real-time monitoring of the displacement of the device drive cylinder. Through the sensor to detect the displacement change of the drive cylinder, timely feedback to the control system, after algorithm recognition analysis, can more accurately predict and compensate for displacement changes.

(3) Reduce the center of gravity of compensation equipment, increase platform support, enhance stability. In the first compensation system, the work of three outer cylinders and electric motors placed

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on the base, reducing the overall center of gravity, and then by the equipment base and the first compensation platform through the three drive cylinder and the middle hydraulic cylinder - universal connector connection, the lower part of the hydraulic cylinder and the base through screw connection, so that the first compensation platform support increased, the two ways to use the joint use to enhance the stability of the equipment.

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