Design of new energy-saving and environmental protection harrow suction dredger system

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Abstract: This project is to design an adaptive new rake suction dredger operating system based on soil and terrain conditions. The design is combined with high pressure water gun cutting and new rake heads. Adaptive high pressure water guns are installed on both sides of the rake head. After the substrate is cut in blocks by a high-pressure water gun, the new rake head digs it up more easily and sucks it directly into the mud tank through a high-pressure centrifugal pump. The device has strong adaptability, environmental protection, energy saving and high efficiency, and has broad prospects for popularization and application.

1. Introduction

According to the information disclosed in Document No. 1 "Decision on Accelerating Water Conservancy Reform and Development" and Document No. 2 "Opinions on Accelerating the Development of Inland Water Transport in the Yangtze River" issued by the State Council in early 2011, it is not difficult to conclude that the demand for dredging equipment is changing. The most obvious change is that although China currently ranks first in the world in the number and capacity of dredging vessels, with the completion of large-scale construction of coastal ports in China and the drastic increase in dredging capacity, dredging companies have put forward higher requirements for equipment. The second change worthy of attention is that the state will invest huge sums of money to develop inland waterway shipping, which will bring huge development opportunities to the construction of inland waterway dredging equipment and water conservancy dredging equipment. State Council Document No. 2 proposes that it takes about 10 years to build a smooth, efficient, safe and green modern inland waterway transportation system. According to relevant information, during the "Thirteenth Five-Year Plan" period, the state's investment in inland waterway construction will exceed 200 billion yuan, of which tens of billions will be used for inland waterway dredging and port construction. However, most of the existing dredgers for inland river dredging in China have low accuracy, high noise, outdated equipment, and poor environmental performance, which has brought new opportunities to dredger construction enterprises. In addition, the sudden emergence of hydraulic dredging deserves attention. State Council Document No. 1 proposed that the pace of water conservancy reform and development should be accelerated, reflecting the country's high emphasis on water conservancy construction. Relevant experts predict that if planned funds are in place, water conservancy investment will reach 4 trillion yuan in the next 10 years, of which water conservancy dredging funds will be considerable, which also means that dredger demand for water conservancy dredging will increase significantly. Relevant experts believe that in general, the needs of inland river and water conservancy dredging in the future are high operating efficiency, more flexible operation,
high precision, low noise, suitable for a variety of water environments, reliable and durable equipment, small impact on navigation or the surrounding environment, and humanity. Dredger. The new technology proposed in this paper has the characteristics of flexible operation, high operating efficiency, and suitability for a variety of water environments, and has good development prospects.\[1\]

2. Overall system design

2.1. Detachable tines and adjustable beams

Cutting force has an important influence on the production efficiency of rake suction dredger, which is mainly affected by the dredging speed, rake width and dredging depth. The choice of dredging speed must take into account the ship's propulsion power, operation safety, and equipment safety. Excessive speed will cause the harrow tube to float upward under the water current supporting force and reduce the cutting depth, but instead reduce the dredging concentration. There is an optimal ratio between the width of the rake head and the diameter of the rake tube in order to obtain the best flow state in the rake head. May increase arbitrarily. This project designed a high-pressure water gun system to cut the sediment deposited on the water bottom with a high-pressure water gun to achieve the purpose of deepening the cutting depth and optimizing the cutting force. The heating module uses plumbing and heating air devices, uses the cooling water of the fuel cell as a heat source, and introduces heat exchangers in the plumbing and heating air devices through hot water pipes to heat the air sent by the fans to generate warm air. The air duct, the air door, and the air pipe connected to the casing are sent out \[3\].
Because the rake teeth directly rub against the mud surface, we design detachable rake teeth so that the worn tooth tips can be replaced in time. In addition, the beam where the harrow teeth are installed also adopts an adjustable structure with bolts. The staff can adjust the front and rear positions of the harrow teeth according to different soil qualities, and can also use different harrow teeth combinations to meet the requirements of dredging sailing drag.

2.2. High-pressure water gun adaptive control system
Aiming at the complex water environment, we design an adaptive PLC control system to achieve the purpose of adaptive complex waters by automatic control of the water gun. The self-adaptive system first monitors the hardness of the mud layer in the water area and judges whether or not a high-pressure water gun is used to assist the operation. When the high-pressure waterjet operation is turned on, the adaptive system automatically recognizes the height of the water bottom mud surface, so as to adjust the height of the water gun, so as to avoid collision and damage to the water gun. At the same time, it cuts the mud surface to the greatest extent and reduces the difficulty of the rake head and mud.

3. Research Status at Home and Abroad
In recent years, the construction of shipping, ports and artificial islands has been booming, which has promoted the vigorous development of the world dredging market. Rake suction dredgers are widely used because they can independently complete the whole process of dredging, loading, transporting, dredging and other dredging operations.

In the early 1990s, the strong recovery of the Asian economy pushed the world's dredging market to flourish. In 1994, the world's first ultra-large rake suction dredger "Pearl River" came into being. From the seven years from 2000 to the end of the year, 11 super-large rake-suction ships, led by 33,000m³ jumbo-type rake-suction ships, were built in the world, meeting the needs of economic construction. Until the beginning of the new century, the decade before and after was hailed as the "Golden Decade" by the international dredging industry, and it was also a decade when the world's dredging equipment had achieved brilliant achievements. At the beginning of the new century, with the further improvement of the world economic situation, authorities in the dredging community asserted that the second "golden decade" would accompany it. With the accumulation of funds and experience in the first "Golden Decade", the world's four largest dredging companies known as the "barometer" of the world dredging market have invested in a new round in recent years with greater confidence and opportunity. At the climax of the equipment competition, this new round of development is by no means a simple repetition a decade ago. It will leave a new mark on both the scale of development and the technical connotation [4].

In response to the second "Golden Decade", the world's largest dredging companies, the four largest dredging companies in Europe, bear the brunt, and have spent huge sums of money to expand their equipment.

In order to maintain its strong position in the dredging fleet, the VanOord Group invested 1 billion euros at one time and ordered new cutting-edge equipment including 2 31200m³ giant harrow suction vessels and 24000kW giant self-propelled cutter suction vessels The first 31,200m³ rake and suction vessel "VoxMaxi ma" was built by IHC, with a deadweight of 53,800t and a total installed power of
31165 kW, which will be delivered by the end of the year. At the same time, the company also completed the extension of the HAM318 in early 2008, with a cabin capacity of 37,500m³, and ordered the world's largest hydraulic backhoe and grab boat.

Boskalis Group joined two new 15900m³ rake-suction vessels in 2004. In addition, two new 12000m³ double-mud tank-type new rake-suction vessels were delivered in 2009 and 2011, and one giant rake-suction vessel was also used. Under planning. At the beginning of 2009, the Group also successfully completed the transformation of the “Dutch Queen”, making its cabin capacity reach 35,500m³ in one stroke.

The impact of the measures of the four major companies on the world dredging industry cannot be underestimated. Malaysia's InaiKiara can only be said to be a medium-sized and regional company. Affected by it, it is also actively preparing for the construction of the 32,000 m³ giant harrow suction vessel "INAIKENANGA" . The driving role of self-evident. The equipment development of the four major companies, in addition to the super-large scale (harrow suction) and self-navigation of the open sea (cutter suction), has the following characteristics at a technical level: the characteristics of shallow draft vessels are increasingly prominent; the power equipment of dredging equipment Significantly increased and more efficient; dredging / driving integrated control technology is becoming more and more perfect; unilateral harrow suction vessels are popular; green shipbuilding and sustainable development concepts are deeply rooted in the hearts of the people [5].

4. Innovative and advanced

Compared with the current dredgers that use water guns to break up the mud layer and absorb the mud-water mixture, the advantages of this device are as follows:

① The rake head is digging a block mud layer, which increases the mud concentration and improves the dredging efficiency of the dredger.

② The blocky mud layer has reduced the area of the secondary pollution water area to a certain extent, and reduced the turbidity of the water area.

③ Due to reduced resistance and increased digging depth, this device reduces the use of fuel and improves the efficiency of dredging.

Due to the existence of the adaptive control system, the new high-pressure water cutting dredging device can reduce the difficulty of digging and over-excavation due to the hard bottom of the rake suction dredger during work. The secondary pollution generated during the work of the ship protected the ecological environment of the construction site.

The research of this project will promote the coordinated development of most waters, including the Yangtze River Basin, and at the same time improve the work efficiency of rake and suction vessels, and bring good news to the harmonious development of nature.

5. Conclusion

With China's transition from a dredging country to a dredging country, dredging vessels are facing this unprecedented development opportunity and expandable space, the adjustment of the dredging industry structure has accelerated, and the market demand for high-performance dredging equipment has risen. This design conforms to the development direction of efficient, green and energy-saving dredging equipment, and has the dual value of technological innovation and market promotion.

The promotion of the research results can greatly save the operation cost of dredgers, and in the long run, it will have greater economic and environmental benefits, which is in line with the concept of sustainable development. This research will also fill a gap in this area in China, and it is expected to do deeper research on some cutting-edge technologies.

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