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Research Summary of Jacket Cleaning and Detection Robot

Zhizhong Lv, Yawei Kang

School of Mechanical and Electrical Engineering, Southwest Petroleum University, Chengdu 610500, China

Abstract: In order to solve the jacket platform in the sea level for a long time by the platform pressure, seawater erosion, marine biological corrosion and other factors and the emergence of weld cracks, depressions, deformation, fracture and other defects, it is necessary to regularly carry out cleaning and testing to ensure the stability of the jacket structure. At present, the cleaning and detection of offshore platform jackets are mostly carried out by divers diving into the water. The operation is difficult, inefficient, costly, and greatly affected by the weather. When cleaning operations are carried out in areas with poor water quality, it will pose a threat to the lives of divers. Therefore, it is necessary to develop a new type of jacket cleaning and detection robot structure that can carry cleaning and detection devices instead of manual operation.

Keywords: Jacket platform, Cleaning, Detection, Robots.

1. Introduction

In the process of offshore oil and gas development, offshore drilling and production platform is an important equipment to support offshore drilling and production equipment. Its quantity is limited. Compared with onshore platform, offshore drilling and production platform has complex structure, large size and high cost. Offshore drilling platform can be divided into fixed type and floating type according to the way of movement. In the deep water area with a working depth of more than 500 m, the floating offshore platform is positioned by mooring system or dynamic positioning system, which has more advantages than the fixed platform. Fixed jacket platforms are mainly used in shallow water areas with water depth less than 200 m[1]. The jacket platform is on the sea level for a long time. Affected by platform pressure, seawater erosion, marine biological corrosion and other factors, there will be weld cracks, depressions, deformation, fracture and other defects [2, 3]. The economic losses caused by these problems are very large. Therefore, regular inspection and cleaning are needed to ensure the stability of the jacket structure. However, due to the particularity of the conditions in which the jacket is located, the use of manpower is time-consuming and laborious, and the cost is high. It is also a major test for the safety of personnel. Therefore, it is necessary to study robots that can crawl on the jacket structure to replace manual inspection and cleaning.

At present, the cleaning and detection of offshore platform jackets are mostly carried out by divers diving into the water, which is difficult, inefficient, costly, and greatly affected by the weather. When cleaning operations are carried out in areas with poor water quality, it will pose a certain threat to the lives of divers. Due to the particularity of the jacket structure and the complexity of the underwater working environment, it is necessary to replace the manual operation with the automatic underwater detection and cleaning robot, which will improve the economic value and practical value of offshore oil exploitation.

The underwater vehicle is a carrier that can carry various observation devices, sensors, operating tools and control systems, and can move in underwater space and replace manual completion of specific tasks [4]. The underwater robot is not only equipped with manipulators, manipulators and other actuators to perform specific tasks, but also can be equipped with various professional underwater equipment, such as underwater high-definition cameras, underwater infrared induction devices, optical fiber compasses, high-precision depth meters, etc., to jointly complete the relevant underwater operations. According to the structure, underwater vehicles can be divided into six types : cabled floating underwater vehicles, towed underwater vehicles, submarine crawling underwater vehicles, attached structural underwater vehicles, cableless underwater vehicles and hybrid robots [5]. Nowadays, many countries are studying underwater robots, which are used to replace manual completion of oil exploration, underwater shooting, salvage operations and even military fields. However, there are few underwater robot applications for jacket cleaning and detection. At present, most of the jacket cleaning operations still need to be completed manually. It is not only necessary to consider the weather conditions, but also to worry about the diver 's physical and safety issues. It is difficult to work for more than 10 minutes at 50 m underwater for a long time. The purpose of this paper is to study the cleaning and detection robot, which can replace the manual cleaning and detection of the jacket platform.

2. Development Status of Underwater Cleaning Technology

The underwater cleaning technology is divided into three stages. At first, it is mainly manual operation [6].It is mainly aimed at the aquatic organisms attached to the metal surface of small equipment. The surface of the equipment is cleaned by the diver 's launching operation cleaner. However, with the emergence of large marine equipment, it not only increases the workload of divers, but also increases the water depth and low visibility. The difficulty of divers ' operation has also increased significantly. In the second stage, it is mainly the manual operation of mechanical cleaning stage [7].Professionals operate special cleaners and large coating machines to complete the cleaning of large equipment, which not only has high cleaning efficiency, but also has high

cleanliness. However, this cleaning method is suitable for the use of equipment when it is docked in the port, which takes a certain amount of time. The third stage is the stage of manual operation of robots, which is the direction of current and future development [8, 9].

The initial cleaning tool is that people use manual removal of fouling [10], the use of some chemical agents on the corrosion of attached organisms, with a scraper for cleaning, but this cleaning method is not only difficult to clean, but also easy to cause damage to the equipment itself because of corrosive chemicals. Later, it was gradually replaced by gas sandblasting cleaning. This method mainly sprayed the pre-prepared abrasive onto the surface of the equipment to be cleaned, and used the high-speed impact and friction of the abrasive to remove the waste coating on the surface metal surface. However, this method is destructive, difficult to control accurately, and easy to pollute the environment, which is harmful. However, compared with manual cleaning, its efficiency is still greatly improved. With the progress of science and technology, the use of high-pressure water cleaning technology has gradually developed, high-pressure water jet cleaning is now the main cleaning method. Cavitation jet underwater cleaning technology is widely used in various underwater cleaning operations [11], including civil ships, naval ships, offshore oil platforms, and submarine oil pipelines [12], because it does not harm the original anticorrosive coating and does not harm the diving construction personnel.

At present, the underwater cleaning work is still dominated by manual cleaning. When the water depth is deep, the ROV operation will be used instead of manual operation.

3. Research Status of Jacket Cleaning and Detection Robot

3.1. Foreign Research Status

The jacket cleaning and inspection robot has been developed and used abroad for a long time. It is mainly used for the inspection of the jacket steel structure and the cleaning of marine organisms on the jacket surface. This is the key to extend the service life of the jacket structure, especially for offshore wind turbines and offshore jacket platforms. In the 1950 s, the Americans developed the first generation of underwater robots to complete underwater exploration missions. This has also promoted the development of modern underwater robots and jacket cleaning and inspection robots. A patent for a U.S. jacket cleaning robot uses a semi-enclosed mechanism [13], and three sets of rollers are distributed at three important moving joints, which can move along the circumferential direction of the jacket. As shown in Fig 1.

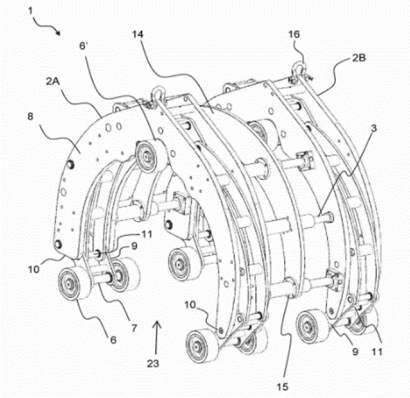

Figure 1. U.S. patent structure

In a Korean patent [14], a device for cleaning the underwater pipe structure is proposed. The device adopts an equilateral triangle surrounded structure. Each of the three vertices of the triangle has a set of magnetic suction wheels, which can realize 360 ° detection and cleaning of the pipe structure. As shown in Fig 2.

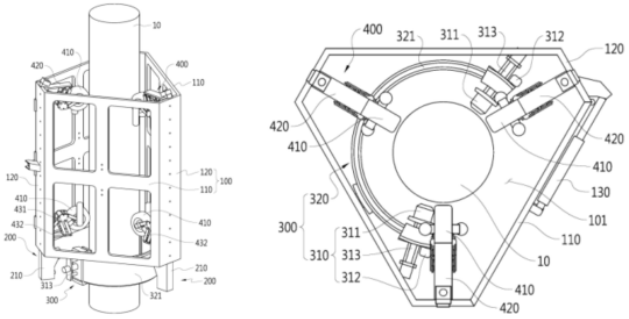

Figure 2. Korean patent structure

3.2. Domestic Research Status

Harbin Engineering University has designed a cleaning robot with thrust adsorption and propeller propulsion, servo motor drive and mechanical arm cleaning brush [15].This robot adopts the method of thrust adsorption and propeller propulsion, and adds a holding arm mechanism on both sides of the robot. By means of high-pressure water jet, the cleaning and detection of steel structure can be carried out in the water area of 4-5m deep underwater. As shown in Fig 3.

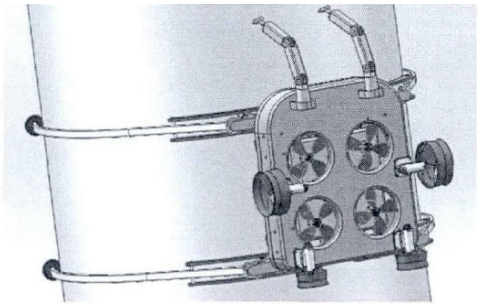

Figure 3. Robot structure of Harbin Engineering University

Zhejiang University has developed an underwater robot 'Hamm (HOME) Marine Organism ' [16, 17] with an adaptive mechanism for cleaning variable diameter steel pipes. The robot uses four rockers to connect the rear axle to the robot 's body and absorber, ensuring that the robot 's body moves up and down to maintain contact with the pipe surface, and is adsorbed on the surface of the jacket with a magnetic suction wheel. The cleaning method of cavitation water jet can complete the cleaning of underwater marine organisms and the detection of jackets. As shown in Fig 4.

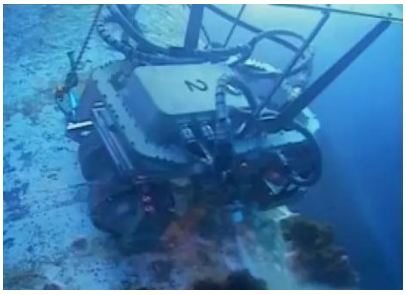

Figure 4. Hamm (HOME) sea bio-robot

In 2019, CNOOC Energy Equipment Technology Co., Ltd.proposed an underwater robot that can be used to clean and detect the jacket platform structure [18].This robot combines two sets of permanent magnet adsorption wheels in different directions, and adopts a combination of floating and magnetic crawling. As shown in Fig 5.

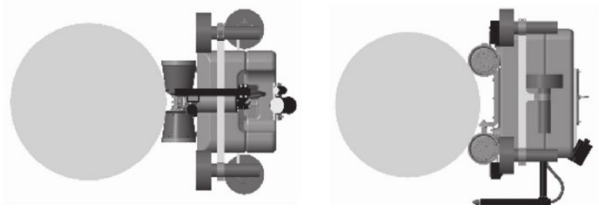

Figure 5. Robot structure designed by CNOOC

A company in Shenzhen proposed a jacket sea biological cleaning robot [19]. The robot adopts the combination of magnetic suction and mechanical leg. When working, the magnetic suction mechanism leg realizes the walking and obstacle surmounting on the jacket. During cleaning, the large suction cup adsorbs the entire robot on the surface of the jacket steel structure to complete the cleaning work. As shown in Fig 6.

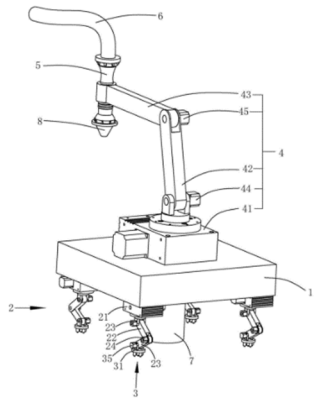

Figure 6. Jacket marine biological cleaning robot structure

Shandong University has developed a wheeled mobile mechanism for offshore oilfield wellhead platform jackets. [20] The robot consists of two upper and lower fuselages. Each fuselage is fixed with a clamping mechanism, and the clamping mechanism is equipped with two rows of rollers and speed regulating motors. The speed of the motor can be adjusted to control the speed of the movement, and the cleaning equipment is carried to carry out the cleaning operation of the underwater jacket. As shown in Fig 7.

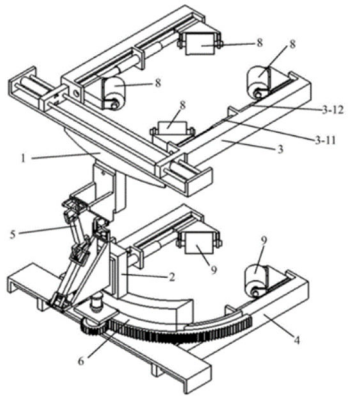

Figure 7. Structure of wheeled jacket robot

Ocean University of China has designed a jacket detection robot without magnetic field interference [21]. The robot includes a guide rail mechanism, a slider and a hammer. The slider can move along the guide rail, and can move from the bottom of the inner guide rail to the top of the inner guide rail. The inner guide rail can also make linear reciprocating motion along the outer guide rail. The detection unit is installed on the slider and moves synchronously with the slider. As shown in Fig 8.

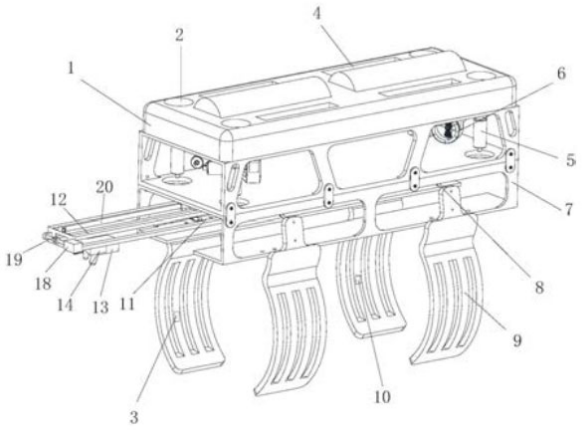

Figure 8. Jacket detection robot proposed by Ocean University of China

4. Summary

Through the analysis of the above research status at home and abroad, relevant scholars have done a lot of research work on the jacket cleaning and detection robot, and have also achieved a lot of results, which has made outstanding contributions to the application of the jacket cleaning and detection robot in engineering. However, there are still some technical improvement problems in the jacket cleaning and detection robot.

(1) At present, most of the jacket cleaning and detection robots use magnetic adsorption. This adsorption will cause insufficient adsorption force in the thick area of marine organisms, resulting in failure of the robot during movement.

(2) From the point of view of node geometry, it can be divided into K nodes, Y nodes, N nodes and X nodes. Due to the concealment of the nodes, it increases the difficulty of the cleaning operation, which requires the robot to have the function of flexible obstacle crossing.

(3) The camera, high-pressure water cleaning nozzle and non-destructive testing equipment on the underwater manipulator should have waterproof and compressive performance. The design of robot walking and driving scheme needs to be improved and improved.

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