Design of hull ultra high-pressure water ejector derusting system

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Abstract. In this text, the system takes the hull of the 82000 DWT bulk carrier as the research object, this system analyses the common methods and existing shortcomings or problems of the existing hull rust removal methods. In view of the shortcomings or problems of these methods, the design requirements of the hull rust removal system are set out. Based on AutoCAD design platform, a high-pressure water jet rust removal system is designed, its working principle and main components are introduced, and the main parts of the system are selected for calculation.

1. Introduction

Derusting is the first step of ship painting, and it is also an important step to maintain the performance of ship steel material. The statistical results show that the following factors affect the service life of the coating: The rust removal quality is about 49.5%; The coating process conditions are 26.5%, and the coating thickness is 19.1%; The kinds of painting are 4.9%.It can be seen that the quality of ship surface treatment is the key factor that affects the life of ship surface, and the author propose that the new type of ship high pressure water rust removal system has greatly improved the efficiency and quality of ship surface treatment. It has the characteristics of low cost, high speed, high cleaning rate, wide application, and environmental protection, etc. Its essence is that high-pressure pumps generate high-pressure water through the pressure control valve and then shoot from the nozzle to achieve the purpose of removing rust from the surface of the ship.[1-2] It has high energy density and adjustability. The rust collected by the separation, recovery system can be reduced to obtain low-quality iron, which can be plated back to the surface of the ship again.

2. The formation of hull rust layer and the common method of ship rust removal

2.1. Formation and hazard of rust layer

The ship rust is caused by ship steel plates and air oxygen, water vapor, etc. The hydrates of various oxides that produce iron, and the formation of rust layer will reduce the thickness of the steel plate, thus greatly reducing the mechanical properties of the hull. Secondly, rough rust layer condenses water vapor in the air, it absorbs and stores water vapor, making the rust layer easier to expand, forming a vicious circle. The stripping of the rust layer everywhere can also pollute the environment, endanger the health

of human, and even cause major accidents. [3-4]The loss is unpredictable. Therefore, ship rust prevention has very important economic and social significance.

2.2. Common methods of derusting of hull and their advantages and disadvantages

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2.2.1 Manual rust removal. Hand-made rust removal tools include hammers, shovels, scrapers, steel brushes, etc. Common rust spots are first loosened with hammers and then removed with shovels. Its labor intensity is high and the efficiency of rust removal is low, generally 0.2-0.5 m^2/h . The environment of rust removal is bad, which has great harm to the health of the workers. Secondly, the surface oxide of the hull is difficult to remove, the effect of rust removal is not good, and it is difficult to achieve the required cleanliness and roughness. It has been gradually replaced by mechanical and chemical rust removal. The advantage of manual rust removal is simple and convenient. In the process of working, especially for repairing local defects, this method is usually used. For areas where mechanical rust removal is difficult to reach, such as narrow cabins, the edge of the opposite corner of section steel, manual rust removal is mostly used.

2.2.2. Mechanical derusting. Mechanical rust removal is carried out by small wind motor. Driven mainly by electric or compressed air, it installs appropriate rust removal device, carries out reciprocating or rotating movement to meet the requirements of rust removal in various occasions, but can not remove the oxide layer, its surface roughness is higher, so it can not meet the quality requirements of high-quality surface treatment, Abrasives generally can not be recycled, and then affect other operations, rust removal site cleaning is more troublesome. Environmental pollution is serious, which has a great impact on the health of workers, so its use has been gradually restricted in recent years. Compared with manual rust removal, mechanical rust removal has its unique advantages: its rust removal efficiency has been significantly improved, and the cost is also lower. It is also the most widely used rust removal mode nowadays.

2.2.3. Chemical derusting. Chemical rust removal mainly uses acid and metal oxide chemical reaction to remove the surface of metal rust products, it usually called as acid cleaning rust removal, the concentration of acid pickling solution and acid pickling time are the keys to this method. This kind of rust removal method is only carried out in the workshop. It is obvious that it is not easy to be widely used in ship rust removal. Its high cost of pharmaceutical equipment also limits the promotion of chemical rust removal. However, this method has low labor intensity and good rust removal effect. The surface of steel plate after rust removal can meet the required roughness and cleanliness [5-7].

3. Design of a super high pressure water rust removal system for ship hull

3.1. Analysis of design requirements

The design scheme is based on mechanical rust removal and combined with chemical treatment. In mechanical rust removal, shaft motor and magnetic filter are used. In chemical treatment, the dosing box is used. The design of this system must satisfy the bearing capacity of the hull steel of 82000 DWT bulk carrier, and take 3-4 hours as the processing time. The design of magnetic filter must satisfy the cleaning of fine particle impurities above 50 micron, and has good iron removal performance and strong adsorption capacity, which is convenient for cleaning iron chips. The design power of the axle-belt motor must meet the actual market standard: no less than 160 kw. And reducing the influence of water quality in the dispenser.

3.2. Working principle

Due to the disadvantages of the existing rust removal methods, a new type of ship super high pressure water jet rust removal system is proposed by combining three traditional rust removal methods. The system is briefly described from its working principle and its important components. The principle process of the system can be divided into three parts.

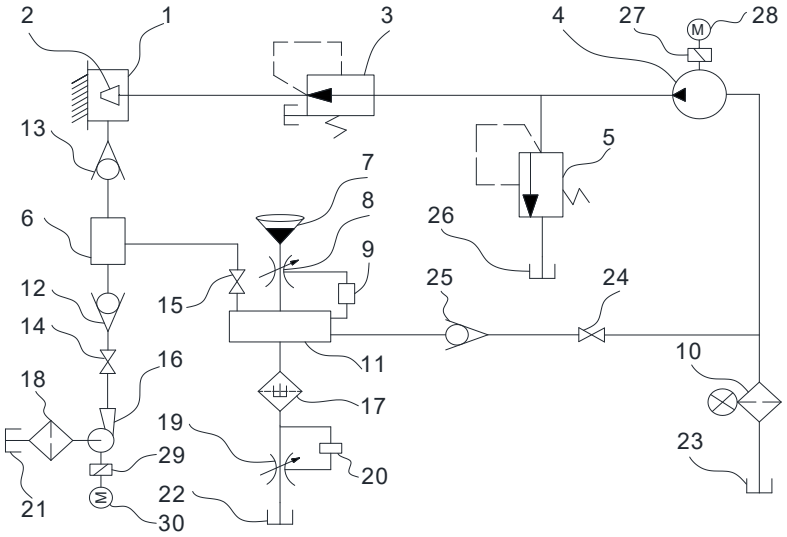

Figure 1. Working principle diagram.

1-rust removal chamber; 2-high pressure nozzle; 3-pressure relief valve; 4-high pressure pump; 5-safety valve; 6-jet pump;7-drug storage place; 8,19-throttle valve;9,20-sensor; 10-filter with pollution indicator;11-dosing box;12,13,25-one-way valve; 14,15,24-connection valve; 16-pump; 17-magnetic filter; 18-filter; 21,22,23,26-tank; 27,29-Coupling;28,30-motor.

3.2.1. Rust removal by ultra-high pressure water. As shown in figure 1, High-pressure water jet ejected from a high-pressure nozzle 2 scours the rusty layer of the hull surface. Under the combined action of high pressure derusting chamber 1 and jet pump 6 with good sealing performance, the working liquid drains to the dosing box 11.The working liquid in the jet pump 6 is extracted from the water tank 21 by the centrifugal pump 16 .The water in the high pressure rust removal chamber 1 is pumped from one way high pressure pump 4 to the high pressure nozzle 2, one-way hydraulic pump 4 driven by motor 28 and coupling 27, and it is equipped with safety valve at its outlet 5,which can adjust the pressure reducing valve 3 to control the water pressure of high pressure nozzle 2,so that achieve the washing of the different thickness of the rust layer.

3.2.2. The rusty sewage is treated by dosing. At the bottom of the cabinet 11,there is a large number of solid zinc powder, After the mixture of rust water enters the tank, By dripping dilute hydrochloric acid from the drug store 7 above, the acid dissolves the ferric iron in rust, then the active zinc will react with ferric iron and formate elemental iron, After reaction we will get some low-quality iron, the water in the tank 22 is far more than in the medicine cabinet 11, So the dilute hydrochloric acid in the dosing box 11 will dilute to a very low concentration when it enters the tank 22, the acidity can be ignored. The content of trivalent iron in the dosing box 11 is checked by the inductor in the ion sensor 9, and the opening of the throttle valve 8 can be controlled automatically, so as to control the amount of dilute hydrochloric acid implantation.

3.2.3. Recovery and utilization of iron and water after dosing treatment. The replaced low-quality iron can be removed from the top of the dosing box 11 and electroplated back to the surface of the ship, and the solid zinc powder in the dosing box 11 can be added in this way. After dosing box 11, further reaction of rust water by magnetic filter detection device 17 into the water tank 22, the throttle controller is composed of a throttle valve 19 and ion sensors 20, Then inspecting the reaction of KSCN solution and trivalent Fe to see whether the excessive rust is fully resolved or not, to prevent its reaction with iron on the surface of the ship, The series of processing ensures that there is no impurities ferric iron ion liquid in the tank.

3.3. Main components

Spiral high-pressure nozzle. As shown in Fig. 2, the high-pressure nozzle in this device adopts a conical cylindrical spiral nozzle. After the liquid passes through and collides with the continuously decreasing spiral surface, it becomes a small liquid bead and forms a mist. The streamlined design of the nozzle chamber from inlet to outlet minimizes the drag coefficient and maximizes the flow of liquid over a given size of pipe. It can avoid the common nozzle clogging problem under bad working conditions, and is suitable for injection with large flow and multi-particle impurities.

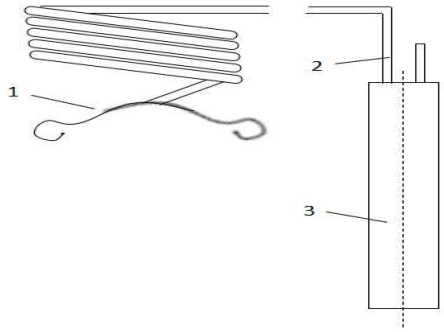

Figure 2. Cone spiral high-pressure nozzle

Figure 3. Structure of throttle valve controller

1 - diaphragm;2- pressure transfer thin tube;3- ion sensing package

Throttle valve controller. As shown in figure 3, The bottom end of the diaphragm 1 is connected to the top rod of the throttle valve, and the ion sensing package 3 converts it into force through the sensor according to the measured iron ion concentration in the liquid, which is transferred from the pressure transfer tube 2 to the diaphragm 1, and the diaphragm 1 will deform and cause the rod to move downward. A needle valve that opens the throttle valve, thus controlling the opening of the body closure area, thus achieve according to the influence of the concentration of ferric iron ion in the cabinet of automatic control acid reagent drip into the amount of purpose. To making sure that there are no impurities in liquid ,the throttle controller is used in this system twice, The first time is before the acid reagent entering

the medicine cabinet, according to the influence of the ion concentration in the cabinet to automatic control and o-phenylenediamine, And the seond time is before it entering the tank for the aimed at ion concentration of the automatic control according to the pipe into the tank valve opening, to ensure pure without impurities on the tank of liquid.

Filter. Three different types of filters is adopted in this texts, magnetic filter, ordinary filter and general filter containing pollution indicator, Ordinary filters use ordinary groove lines of intersection between adjacent disc filter for solid particles interception, the filter head is in parallel when it runs, Under the pressure of water and spring, the filter plate of the filter element is compressed, the water enters from the end of the disc, and the particulate impurity in the water is intercepted by the compressed disc, which plays a role in filtration. The magnetic filter is equipped with a magnetic filter element consisting of a magnetic ring and a nylon spacer to filter out the magnetic material.

4. Selection of main parts and components of a hull ultrahigh pressure water derusting system

4.1. technical parameters of one-way high-pressure pump

This design takes the ballast water of 82000DWT bulk carrier as the design ballast water treatment system. According to the query data, the technical parameters of one-way high-pressure pump are as follows: output water pressure is 120MPa, flow rate is 35L/min, unit power is 160-200kw, working medium is clear water, rust removal width is 300mm, rust removal quality is Sa2.5.

4.2. pipe wall thickness

By the device of the nature of the work, the device inside the pipe need to meet certain pressure and corrosion resistance, so the combination of economy, factors such as mechanical strength can be used with two phase austenite and ferrite of duplex stainless steel, In addition, a certain amount of corrosion inhibitor can be added to reduce the anticorrosion of pipeline to the minimum. According to the data of pipe wall thickness calculation formula:

$$S_0 = \frac{PD_0}{2[\sigma]_t \Phi + 2PY} \tag{1}$$

Type P for design pressure in this equipment is 120 Mpa, D_0 is a straight tube diameter is 1350 mm, as the design temperature for the allowable stress of straight pipe, Φ for weld coefficient, the seamless steel tube Φ = 1; Y is the temperature correction coefficient that can be set as, so the pipe wall thickness of 20mm can be selected.

4.3. selection of water tank

According to the technical requirements in the code for classification and construction of steel ships, it can be seen that:

$$V_{\text{Water tank}}=12\times Q_{\text{Pump}} \tag{2}$$

The pump flow is 35L/min, so the volume of the water tank should be 420 dm^3. It can be designed as a cube with side length of 7.5dm.

4.4. material selection for vacuum chamber

In addition, it is necessary to ensure the vacuum tightness of the high-pressure vacuum chamber 1 when working, and the sealing rubber can be set at the contact between the body and the hull. The vacuum chamber is made of duplex stainless steel, which can resist pressure and corrosion [8-11].

5. Conclusion

This new type of high pressure water descaling device combining three traditional cleaning methods from home and abroad, it makes up for the traditional manual serious cleaning dust and the low efficiency faults, overcome the disadvantages of chemical cleaning only operate indoors, can solve the problem of mechanical cleaning waste cannot be recycled, this device with the actual handling, and the application range is wide, it can be applied to all kinds of steel ship, as intelligent technology to further improve the device performance will be better.

The design of the marine high pressure water rust removal device in this paper is a preliminary study, and the rationality of the new high pressure water rust removal device has been verified from the aspect of high pressure circulation, but it also has some shortcomings, such as the reliability of the super high pressure pump. The internal layout of the high-pressure rust removal chamber, intelligent crawling system, integration of the device and so on need to be further discussed and analyzed. Therefore, in the future, the research and development of the rust-removing mechanism, the research and development of the ultra-high pressure pump body, and the new experimental model of rust removal can be carried out. Further research on the structure optimization design of new high pressure rust removal device.

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