Design and Analysis of Ship Exhaust Boiler Flue Cleaning System Based on Computer

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Abstract. In recent years, the country for ship emissions of exhaust gas control is relatively loose, but also relatively lack of specific and effective supervision and scientific exhaust emissions and treatment technology, so China's air pollution is increasingly serious. With the implementation of regulations on the emission of air pollutants from land-based sources such as motor vehicles and power stations, researchers have found that exhaust pollution from ships accounts for an increasing proportion of the overall air pollution, especially in port cities and coastal areas, causing great damage. In order to effectively reduce ship exhaust pollution in China, the Ministry of Transport through the establishment of ship emission control area program, stage by stage and regional limits on the sulfur content of fuel used by ships sailing in China's ports and coastal inland river waters. Through the implementation of the regulations of the ship discharge control area, all kinds of pollutants discharged by ships have been significantly reduced, and the environment of the port area has been improved to a certain extent. At the same time, it is also necessary to use the computer and other high-tech constantly develop new ship exhaust cleaning mode to deal with the increasingly serious environmental pollution problem.

Keywords: Computer, Ship Exhaust, Cleaning System, Design

1. Introduction
With the increase of the number of transport ships, ships emit more and more polluting gases. At the same time, countries all over the world attach great importance to environmental problems and energy crisis. With the further expansion of the ship emission control area, the problem of outdated ship exhaust monitoring technology is becoming more and more prominent. The way of collecting ship oil by personnel on board can no longer meet the daily monitoring requirements of the exhaust emissions in the port area and surrounding waters. Therefore, it is necessary to adopt computer and other high-tech technology to design the flue cleaning system of ship boiler to improve this situation.

2. Development and status quo of ship exhaust emission supervision technology

2.1. Development and status of international ship exhaust emission supervision technology
There are two main ways to measure ship exhaust in foreign countries: the first is to directly measure plume by carrying sniffer on helicopter or UAV; the second is to detect ship exhaust by carrying active differential ultraviolet absorption spectroscopy (DOAS) system on helicopter or on lighthouse buoys. The advantage of the first method of measuring the plume directly is that the sniffer directly collects the exhaust gas from the ship, so it can detect the concentration of the exhaust gas with high accuracy and is flexible when mounted on a helicopter or unmanned aerial vehicle. However, the defects of this method are also very obvious. The flying altitude of helicopter or UAV is too low, which will affect the normal navigation of the ship. The flying altitude needs to be 25 to 50 meters from the ship's chimney to effectively measure the exhaust content of the ship, and aircraft will seriously affect the normal navigation of the ship. In addition, it is necessary to stay in the plume for 15 to 20 seconds. Since the ship is sailing normally, the aircraft must keep a low speed and stable flight, so it cannot be guaranteed to effectively measure in the optimal plume sampling area all the time. In addition, the smoke plume measured by the sniffer is not the exhaust gas at the mouth of the ship's chimney. The exhaust gas temperature has dropped sharply, and the exhaust gas has also been significantly diffused, which is seriously interfered by the meteorological conditions. Therefore, the accuracy of exhaust gas detection is higher in the real port environment [1].

The advantage of the second method of DOAS system to detect ship exhaust is that it does not affect the normal navigation of the ship through long-distance detection, and the detection distance can reach several nautical miles by means of active laser emission. The disadvantage of this method is that the selected band needs to have obvious peak-valley structure, and the peak-valley band needs to be close to each other to reduce the influence of interfering gases, so the peak-valley band needs to be extremely accurate, and the accuracy needs to reach 0.01nm (nm) to ensure the accuracy of quantitative tail gas inversion results. Simply using narrow band filter cannot meet the precision requirements, the active laser fluorescence emission system and the spectrometer need to cooperate. Lasers need to have enough power, so the size of a mid-size truck is too large to be mounted on a mobile platform for tailpipe monitoring. On the other hand, USES is with the aid of spectrometer, observing system for band separation ways of working, accept to is the exhaust gas concentration of the Marine area, because it could not image, the resolution of the spectrophotometer is low, cannot accurately determine ship the chimney mouth exhaust gas concentration, and subject to the detection range, thus the detecting precision of the exhaust gas concentration is not high [2].

2.2. Development and status quo of domestic ship exhaust emission supervision technology

In China, the understanding of the harm of ship exhaust pollution is relatively late. Until the establishment of ship emission control area, the supervision of exhaust emission was gradually carried out in every region. Domestic researchers mainly use unmanned aerial vehicles carrying sniffers to carry out emission monitoring of ship exhaust pollutants. This is mainly because of the rapid progress of China's UAV technology in recent years, UAV has become a routine monitoring means of maritime authorities, and the price of sniffer is very low, the principle and monitoring method of the instrument is simple and clear, suitable for carrying out the monitoring work of the exhaust emissions of ships berthed in the port area [3].

Xu Shoji and others from the Pudong Maritime Safety Administration used the sniffer technology to measure the concentration of SO2 and CO2 in the exhaust gas of ships. Six ships were sniffed and detected at Shanghai port, and sulfur content data of oil in actual oil silo was collected by actual boarding. The error was found to be within 10% after analysis. However, the diffusion model of exhaust gas was not used for correction, so the distribution of SO2 and CO2 could not be accurately determined, and there was a certain error between the concentration of exhaust gas and the actual emission. Moreover, what the sniffer directly measures are the concentration of ship exhaust gas, and the model relationship between the concentration of SO2 in exhaust gas and the sulfur content of ship oil has not been established, so it cannot be used as the basis for law enforcement. Zhou Fan and other scholars from Shanghai Maritime University have designed a new UAV system, which consists of a movement control terminal, a video acquisition terminal, a small pod carrying a sniffer and a rotating UAV. It
realizes the real-time, efficient and accurate detection of pollutants such as SO2 and NO2 in ship exhaust gas. Compared with the traditional measurement method of sniffer, it can reduce the error interference of exhaust diffusion to a certain extent. However, it only provides a new method from the design of UAV system, which cannot completely eliminate the error interference in the measurement method [4].

3. Current situation of global ship exhaust control

Air pollution refers to the entry of certain toxic and harmful substances into the atmosphere caused by human production and business activities or natural processes, which reach a certain concentration and, within a certain period of time, endanger human life and health or the environment. At present, the problems caused by air pollution have seriously threatened the living environment of human beings and caused serious consequences. However, under the requirements of economic and social development, the emission of waste gas has not been effectively managed, and environmental problems have become the primary problem to be solved in today's society [5].

Regional environmental acidification is one of the environmental problems caused by waste gas emission and also one of the main problems threatening human living space. When the sulfur and nitrogen elements in the fuel are burned, they release sulfur dioxide and nitrogen oxides, along with other pollutants, into the atmosphere and mix with water vapor to form acidic precipitation, also known as acid rain [6].

With the increase of acidic precipitation, it has brought serious challenges to the environment of human life and development. With the development of the world's economic integration, ship transport shows a huge advantage. Low transportation cost, large storage capacity and other factors make the number and displacement of ships more and more large, and the pollution caused by the emissions has become an unavoidable problem for human beings to solve environmental problems. As an important way to alleviate air pollution, the International Maritime Organization (IMO) has issued relevant regulations in order to alleviate and solve the environmental problems caused by ship transportation. At the same time, many countries and regions have also made a positive response and taken various measures to limit the pollution caused by ship exhaust to the atmospheric environment.

![Exhaust gas treatment process](image)

**Figure 1. Exhaust gas treatment process**

4. Development trend of ship exhaust desulfurization technology

For the above problems, corresponding measures mainly in combination with the practical situation of different vessels distribution washing equipment occupied space, sailing on the high seas when using seawater desulfurization in designated areas using caustic desulfurization additives, and optimize the
desulfurization of a complete set of equipment structure, improve product quality, using alternative heavy oil clean fuels, desulfurization process using a certain amount of absorbent, such as magnesium based seawater method, etc. At present, due to the early development of relevant technologies, some breakthroughs have been made in foreign countries [7]. The performance of relevant desulfurization equipment is more stable and efficient than that of domestic equipment, but the price is relatively high. Most domestic desulfurization equipment is still in the research and development stage and has not been recognized internationally [8]. The research and development of a desulfurization technology with simple equipment structure, low operating cost, no secondary pollution, and good desulfurization efficiency and stability will become the main research direction in the future. For the research of ship desulfurization technology, we should learn from the relatively mature land desulfurization technology related desulfurization technology, combined with the characteristics of the ship itself, according to local conditions, research and develop suitable equipment and technology for ship. At present, it has become a main research direction that the seawater method as desulfurizer is an open-ring system and fresh water plus caustic soda as desulfurizer is a closed-loop system for ship exhaust desulfurization [9,10].

![Figure 2. Principle of tail gas desulfurization reaction](image.png)

5. Conclusion
At present, the research on ship exhaust treatment is still in the initial stage, and the technology is not mature enough. At the same time, due to some limitations of the ship itself, such as the type of ship, sailing waters, ship space, the type of fuel, etc., the current application of some desulfurization and denigration technology in ship exhaust gas treatment is restricted. Therefore, researchers can innovate, improve or optimize the desulfurization and denitrification technology used in the current industrial waste gas treatment according to the characteristics of ships sailing in the inland river or at sea. A new type of ship exhaust treatment technology will be developed to solve the pollution problem of ship exhaust emissions as soon as possible.

References
[1] Jin Y, Gao N, Zhu T. Techno-economic analysis on a new conceptual design of waste heat recovery for boiler exhaust flue gas of coal-fired power plants - ScienceDirect [J]. Energy Conversion and Management, 200:112097-112097.
[2] Guo Q, Ma Z, Yang D. Conceptual Design and Performance Analysis of an Exhaust Gas Waste Heat Recovery System for a 10000TEU Container Ship [J]. Polish Maritime Research, 2012, 19(2):264108-264108-4.
[3] Buschmeier W. Exhaust system for exhaust of flue gases from heat generating devices e.g. boiler has integrated heat recycling system and water is led in annular gap between flue gas pipe and external pipe for absorption of heat of flue gases [J]. 2006.
[4] Ing K, Ing S. Equipment for operating fresh air-flue gas system of steam boiler - has radiator and additional heating surface as heat exchanger system whose switching and control depends on exhaust temperature [J]. 1993.
[5] Tang, Yuanyxiang, Qiuping, et al. Calculation and Analysis on Performance of Boiler Thermal Sensor Based on Topological Structure of Fluid Network [J]. Sensor Letters, 2016,
14(12):1216-1221.
[6] Adamkiewicz A, Fydrych J. Application of An Exhaust Signal For Diagnosing A Ship Boiler [J]. 2008.
[7] Peng G. Boiler Bypass Flue to Adjust Denitration Inlet Flue Temperature Automatic Control System Design and Analysis [J]. DEStech Transactions on Environment Energy and Earth Science, 2021(pees).
[8] Jian L, Yu H, Gang X. Performance Analysis of New Bypass Flue Residual-heat Utilization System of Boiler in Power Plant [J]. Electric Power Science and Engineering, 2014.
[9] Zhou Y, Liu Z, Golyanin A. Simulation of Waste Heat Recovery From Ship Boiler Exhaust Gas [J]. Bulletin of Science and Practice, 2020, 6(4):232-242.
[10] Tien W K, Yeh R H, Hong J M. Theoretical analysis of cogeneration system for ships [J]. Energy Conversion and Management, 2007, 48(7):1965-1974.