

## The Feasibility Study of Marine Diesel Engine Exhaust Gas for Ballast Water Treatment

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**Abstract.** All kinds of Marine creatures of ship's ballast water with the migration of vessels, globalization, and with the discharge of ballast water, invaded the local ecosystem, breaking the original ecological balance. Ballast water caused by biological invasion on the global diversity of ecological system, has brought the serious disaster on September 8, 2017, The 《International Convention for the Control and Management of Ships' Ballast Water and Sediments》 had into effect, the management of ship ballast water put forward the more strict requirements, reversed transmission of ballast water treatment technology to upgrade. Based on ship diesel engine exhaust gas residual heat as a heat source to heat pipe heat conduction technology as support, explores the feasibility of solution to heat the ballast water treatment of microbial, through calculation, the study found a wider application prospect.

### Introduction

#### The research background

Based on navigation safety, ship before shipment will need to press a number of seawater into the ballast tanks, to adjust the ship's longitudinal, heeling, draft, stability or stress, and on to another port, with the deployment of the goods and need to ballast water. Ballast water on cross-regional transfer at the same time, the water contains a large number of organisms (mainly all kinds of microorganisms, bacteria, and some species of eggs and larvae, etc.) are integrated into the local ecosystem, caused serious alien species invasion. With the development of shipping industry, ship is moving toward large-scale and automation direction, more and more large tonnage inevitably need to be more ballast water, organisms must also carry more water. By the ballast water caused by foreign biological invasion harm there have been numerous, brought huge disaster to global biodiversity, the international maritime organization and all countries to strict rules of ballast water discharge. As early as in 2004, the international maritime organization is the international ship ballast water management conference, by the international convention on ship ballast water and sediment control and management, the convention has to take effect on September 8, 2017, the convention requires new build ship must be equipped with ballast water management system (BWMS), and is now operating more than 55000 ships around the world, also must have installed the system in the next few years.

#### The research status

Since the 1970 s, biologists have begun to focus on the question of ballast water of biological invasion, therefore has carried on the exploration of unremitting efforts, many experts and scholars have done a lot of research in practice. At present, there are several types of available ballast water treatment methods:

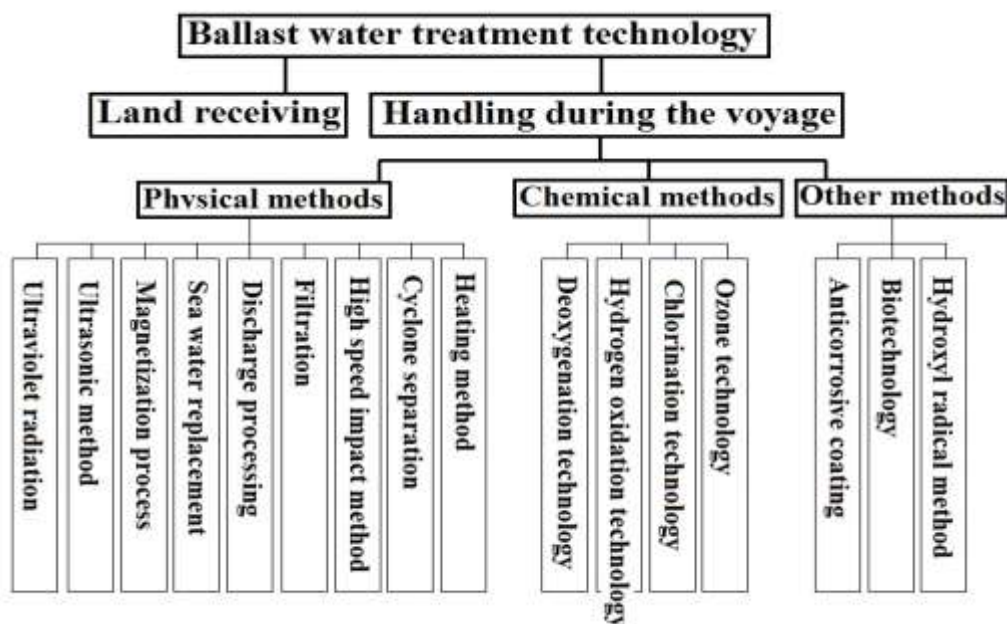


Figure 1 Ballast water treatment method

Types of ballast water treatment while more, but at present the ballast water replacement method, in addition to the sea there is no single technology can completely reach discharge standard of IMO, so more research is on the joint application of the above processing technology.

### The Diesel Engine Exhaust Gas Heating Ballast Water Treatment Method

#### Introduction of the ballast water heating process

The so-called ballast water heating treatment is to heat the ballast water to kill the microorganism according to the different survival tolerance of each microorganism to the temperature. According to the study found that when the water temperature of 50 °C, the vast majority of microbes will die within 10 minutes, when the water temperature of 65 °C, a considerable amount of microbes will die within few seconds. In addition, different heating time much the same effects on the survival of the microbes, for example, if you can heat the water temperature to 45 °C, keep 4 hours, can also be killed most of the microorganisms, but can not be inactivated bacteria dormant spores. Ballast water microorganisms inactivated completely need joint application of many kinds of processing technology, this paper explores how to use ship unnecessary waste of energy to heat water, reprocessing of microorganisms in ballast water combined with other technology application needs further study.

#### Analysis of the availability of diesel exhaust heat sources.

The exhaust gas from the diesel engine carries a lot of energy. According to the study found that the heat generated by the diesel engine fuel combustion, only about 40% to 45% was transformed into the effective work of diesel engine to export, and the burning 50-70% of total calories is taken away by combustion exhaust gas and cooling water directly to the outside world, caused a huge waste of energy. The fuel combustion heat distribution of diesel engine is as shown in the figure below:

Table 1: fuel combustion heat distribution table of Marine diesel engine

Diesel engine heat distribution	Low/medium speed diesel engine	High speed diesel engine
Convert to shaft power external output	35%-45%	30%-40%
The loss of heat from the exhaust gas	30%-40%	35%-40%
The loss of heat from the cooling water	10%-20%	20%-25%
Other losses (friction, vibration, etc.)	10%-15%	5%-10%

With the increasing energy intensity and the increasing progress of energy conservation and emission reduction technology, the energy taken away by exhaust is more and more efficient. For example, turbine increase technology, exhaust gas boiler and so on the energy of this part is utilized. But after the above two use, diesel exhaust still contains a lot of energy. With medium speed four stroke diesel engine as an example, the normal navigation when the exhaust temperature in 400 °C or so, through the turbocharger and exhaust boiler, boiler flue gas outlet temperature is still as high as 270 °C, limited to exhaust temperature not too low, otherwise easy to cause dew point corrosion of flue, we will eventually exhaust temperature limit set at 190 °C, even so, available from the exhaust gas temperature difference still have about 80 °C, there is a huge energy available. If we optimize the design of the exhaust flue and reduce its corrosion dew point, the available energy will increase a lot.

**The treatment plan for the heating ballast water of diesel exhaust gas.**

As stated earlier, the water temperature and temperature holding time of ballast water has a great impact on the survival situation of microorganism, enduring high temperature can certainly inactivated microorganisms in water reached maximum, but limited to ship conditions, to a large number of ballast water for a long time at high temperature, at the same time in the treatment of ballast water must also consider factors such as the stability of the ship. So, in this deal, we will be the temperature of the ballast water heated to 80 °C and keep the five minutes.

The main technical difficulties of this solution are as follows:

- (1) how to implement the heating coil in the flue without affecting the normal operation of the main engine exhaust system;
- (2) how to realize the five-minute thermal insulation of ballast water without affecting the overall stability of the ship;
- (3) because of the diesel engine exhaust chimney generally located in the engine room at the back, can decorate heating pipe flue location is much higher than ballast tank, and the upper stack space is relatively narrow, introducing ballast water into the chimney internal and through the entire living quarters, practical construction technology is difficult.

Based on the above characteristics, we introduced the relatively mature low-temperature heat pipe technology on land into the system, and the processing scheme is shown in the figure below:

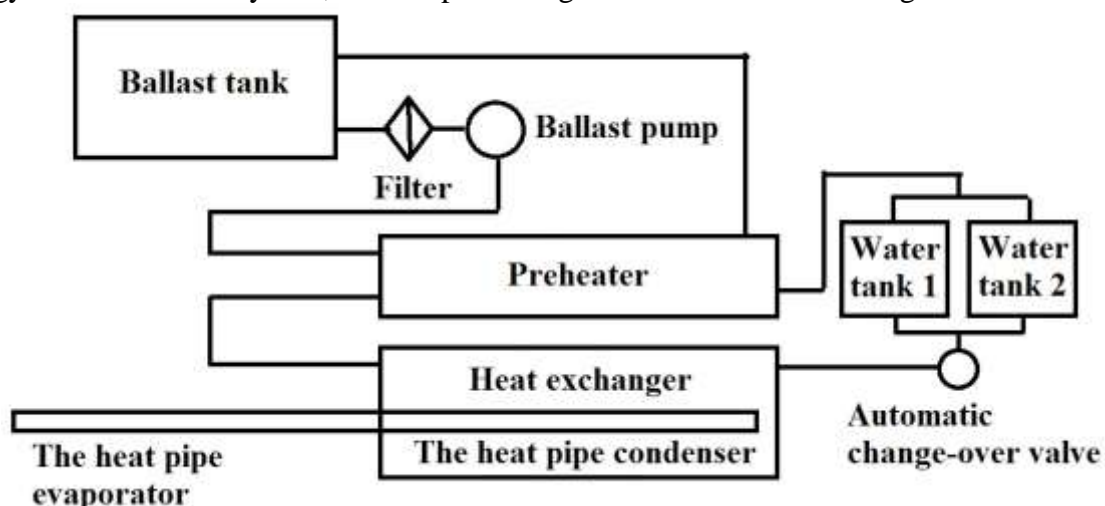


Figure 2 The principle diagram of the ballast water treatment system

On constant speed of the ship sailing, we will a ballast pump, ballast pump ballast water through the filter chamber, through the ballast water heater heating for the first time, then will lead to the ballast water heat ex-changer in secondary heating, heated to 80 °C or so, the automatic change-over valve will play to the ballast water either Water tank, automatic change-over valve setting once every five minutes automatic conversion, namely the ballast pump to Water tank 1 first, after five minutes, automatic conversion to Water tank 2, within the Water tank 2 water at the same time, high temperature water in the no. 1 Water tank the preheated flows back to the ballast tank; In this way, after five minutes, more

water is stored in the storage tank of no.2, and the ballast water in the no.1 storage tank has all returned to the ballast tank, so it is repeated. The storage tank is designed to carry at least 10 minutes of maximum heat flow capacity, and in order to ensure safety, we design a high level alarm and automatic cut-off device for the ballast pump.

The difficulty of this system is how to achieve heat exchange between waste gas and ballast water, and it is impossible to put heat exchanger in the chimney, whether from design or construction. And the very wide application of heat pipe technology in land has solved this problem for us. Heat pipe working principle is to rely on a closed tube inside the work liquid phase change to realize the heat conduction element,

Compared with ordinary thermal conductivity components, it has the following advantages:

(1) good thermal conductivity and high heat transfer efficiency. Because of the heat conduction principle is the use of liquid phase change for heat transfer, namely heating period heating, liquid into gas absorption of heat, in under the action of pressure difference, the gas flow of low-temperature, high-temperature gas is condensed liquid at low temperatures, the release of latent heat;

(2) due to liquefaction of working fluid backflow depend on capillary pumped principle, do not need any power equipment, so the heat pipe heat transfer equipment compared with the common heat transfer system, safer and more reliable, able to run continuously for a long time;

(3) the structure position of the cold and hot segment can be conveniently and flexibly arranged in the narrow space;

(4) the heat flux density can be adjusted, which can adjust the flow rate of heating work according to different work.

In this system, because of the heat transfer distance is long, we select separate copper and steel composite - water heat pipe, according to the design flow rate required for design and calculation of the volume of heat pipe and heat flow density heating area, heating of the heat pipe section of the evaporation side is actually the end of the waste gas chimney. The heat exchanger of ballast water is placed in the inside of the cabin. The tank is designed to partition the bottom of the ship, and the design requirements are basically realized.

## **Conclusion**

The purification treatment of water ballast microorganism requires the joint application of a variety of technologies. Compared with other methods its heat treatment technical requirements for the threshold is low, and therefore have become more widely used, this paper discusses the availability of ship diesel engine exhaust gas residual heat and heat source of heat for the ballast water provides a new way, make full use of the potential energy of the ship at the same time, achieve the goal of energy conservation and emissions reduction. Next, we will explore and implement the application technology of the system in the actual ship, and provide a new reference for the ship ballast water treatment system.

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