A Study Of The Technical Treatment Within Environmental Appetency For The Ballast Water

Chung Do Nam

Korea Maritime University
1 Dongsam-Dong Youndo-Ku, Busan 606-791, South Korea
kmunam@hhu.ac.kr

ABSTRACT

In accordance with adoption of new Convention for the control of ship's ballast water at the diplomatic conference held in February 2004, every country has to regulate the ballast water and deposit matters.

When this Resolution comes into effect in 2009, all vessels engaged in international voyage must have a ballast water control program, ballast water records and equipment that is suitable to the standard of exchange and performance for the ballast water.

This study estimates objectively their performances, merits and demerits of the ballast water treatment technique and exchanging techniques for safe operation of ships.

It is desirable to design an equipment to control the ballast water using the brush-type vacuum suction nonstop reverse cleaning system to overcome the clogging phenomenon and the direct disc filtering to maximize filtering area for the optimum process considering biological availabilities.

It will be expected to protect against marine pollution and to maintain clean sea if it is secured to develop new ballast water treatment techniques.

And it will also cope with the Resolution and each regulation of the developed countries from the ballast water.

1. Introduction

It brings about main issue of the marine environmental sides to destruct marine ecosystem due to coming microorganism included in the ballast water.

Therefore some developed countries like U.S., Australia and etc. are going to reinforce the regulation of ballast water discharge from the ship coming into their ports for the protection of marine ecosystem and marine environment.

The Resolution was made for the control of ballast water discharging from the ship to protect the marine environment and marine ecosystem and to minimize occurring from all kinds of danger which are generated from harmful organic substances and deposit matters.

The Resolution consists of the standard of the exchange of ship's ballast water including deposit, discharging regions, standard of discharging and treatment, survey to the control of the ballast water and required conditions for the certificate.

In accordance with adoption of new Convention for the control of ship's ballast water which was approved at the 49th Meeting of IMO MEPC

held in Feb, 2004, every country has to regulate the ballast water and deposit matters.

When this Resolution comes into effect in 2009, all vessels engaged in international voyage must have ballast water control program, ballast water records and equipment that is suitable to the standard of exchange and performance for ballast water.

When the Resolution comes into effect, securing the technique of the ballast water treatment has a great influence on the receiving orders of shipbuilding. And their relevant markets in Korea, Japan, and China will become red-hot due to explosive demands of ballast water treatment equipments. That time is expected to be between 2005 and 2010. And it will be on the arena of competition of marketing those goods including technical competition for the advanced countries.

Some of companies around the world send hundreds of their samples to domestic shipbuilding yards for the prior occupation of the market in spite of incompleteness of practical use and performance.

And their kinds will be increased as their technical developing project become to produce on a commercial scale. The present technique for the ballast treatment will be versioned-up and settle down with a stabilized technique going through trial and error, but ship owners and shipyards put off selecting the equipment owing to their initial trial and error watching another company's record of performance and experiences.

Thus this study estimates objectively their performance and merits and demerits of the equipments produced inside and outside of the country about treatment technique and exchanging technique for the ballast water.

It will be expected to protect against marine pollution and to maintain clean sea if it is secured to develop new ballast water treatment technique.

And it will also cope with the Resolution and each regulation of the developed countries from the ballast water.

2. IMO's Recommendations and a Developing Tendency on the Ballast Water Treatment Technology

2.1 IMO's Recommendation

Reballasting at sea, as recommended by the IMO guidelines, currently provides the best-available measure to reduce the risk of transfer of harmful aquatic organisms, but is subject to serious ship-safety limits. Even when it can be fully implemented, this technique is less than 100 % effective in removing organisms from ballast water. Some parties suggest that reballasting at sea may itself contribute to the wide dispersal of harmful species, and that island states located 'down-stream' of mid ocean reballasting areas may be at particular risk from this practice.

It is therefore extremely important that alternative, effective ballast water management and/or treatment methods are developed as soon as possible, for the replacement of reballasting at sea. Significant research and development efforts are underway by a number of scientific and engineering research establishments around the world, aimed at developing a more complete solution to this problem. Options considered by IMO include as follows.

- Mechanical treatment methods such as filtration and separation.
- Physical treatment methods such as sterilization by ozone, ultra-violet light, electric currents and heat treatment
- Chemical treatment methods such as adding biocides to ballast water to kill organisms.
- Various combinations of the above.

All of these possibilities currently require significant further research efforts. Major barriers still exist in scaling these various

technologies up to deal effectively with the huge quantities of ballast water carried by large ships. Treatment options must not interfere unduly with the safe and economical operation of the ship and must consider ship design limitations. Any control measure developed must meet a number of criteria, including as follows:

- It must be safe.
- It must be environmentally acceptable.
- It must be cost-effective.
- It must work.

One of problems currently faced by the global R&D community is that besides the general criteria above, there are currently no internationally agreed and approved performance standards or evaluation system for the formal acceptance of any new techniques developed. In addition, many groups are working in isolation from each other, and there are no formal mechanisms in place to ensure effective lines of communication among the community, governments and ship designers, builders and owners. These are vital if the R&D effort is succeed (IMO Global Ballast Water Management Program, 2003).

2.2 An Overseas Developing Tendency of the Ballast Water Treatment Technology

Recently those equipments such as ballast water treatment filtration, ultraviolet sterilization and etc. have been developed in U.S. and Europe, and it is increasingly in demand of those ones centering with passenger ships.

Global Ballast Water management Program for the developing countries is underway by UNDP and IMO. Most of those technologies are underway of testing for the stage to put them to practical use.

They are under development according to the way of mechanical, physical, chemical and etc. There are the ways of filtering and centrifugal separation in mechanical treatment. And also there are the ways of treatment by ozone, ultraviolet, electric, and heat for disinfection in physical treatment.

There are the ways of aiding chemical materials such as biocide, harmful gases and etc for chemical treatment.

The numbers of companies come to about 120 which have sent samples made by the mixed processing type such as connected filtering and sterilizing for the commercial purpose to domestic shipyards (Sang Gil Kang et al, 2003).

The matter of adoption has been left open owing to lack of reliability of those goods for the practical use and economical side and then even the classes watch the development of the situation and states of those equipments without suggesting any clear examination standard for fear of trial and error.

3. Existing Ballast Water Treatment Technologies and Assessments for Their Application

3.1 Ballast Water Treatment System

3.1.1 Ballast using treated water

As the method of the ballast water treatment using treated water, ballasting with city water and loading from the water treatment facility in port before ship's departure was suggested (Carlton et al, 1995). These two methods need piping system’s net of water and its supporting facilities to supply enough fresh water for all berths.

Because all ships need ballasting for safe operation before departure, it will be delayed to load cargos, and additionally increased charter fee and potential demurrage with additional water fee (Oemeke, D., 1999).

3.1.2 Onboard treatment under ballasting

This is the method to remove or sterilize the objective biota using filtration and sterilizing technology during loading ballast water onboard.

It should be considered first, not to hamper to ship's operation when ballasting or deballasting with balance between incoming ballast water quantity and ballast water treatment quantity. Secondly it should also not cover much space, and it needs not excessive maintenance expense (Oemeke, D., 1999).

3.1.3 Onboard treatment at seagoing

This is the method to treat ballast water during the navigation and this is also the way to put biocide into the ballast tank, or heat treatment.

The method of heat treatment is to heat ballast water using remained heat on the cooling process of engine or to heat ballast water using the heat from the exhaust gas equipments.

For the case of using biocide, the method is effective for the treatment, but there might be worry about second contamination by biocide when ship discharge ballast water.

3.2 Exist Ballast Water Treatment Technologies

The method is roughly divided up two within physical treatments and chemical treatments using sterilizing for the ballast water treatment by now.

There are filtration, hydro-cyclone, UV irradiation, ultrasonic, heat, electrolysis, electro-magnetic and etc for the physical treatment, and there are chlorine, ozone, hydrogen peroxide, copper silver ion, lack of oxygen, pH control, salt control and etc. for the chemical treatments.

Disinfection means to destruct selectively microorganisms causing sickness. In this process, it is not to kill all kinds of organisms. This is a point of difference between disinfection and sterilization, which means the destruction of all kinds of organisms.

Because microorganisms, zooplankton and phytoplankton are organisms in the end, they are go to dead underway of oxidation finally.

If we see microorganism and plankton as an organism, they consist of oxygen, carbon, hydrogen, nitrogen and etc, and then change into CO_2 and H_2O in the end when they are disintegrated with help of oxygen.

Therefore, a good oxidant gives no effectiveness to ship's safety (operation) within effective removal of aquatic lives and no harmfulness to the human body.

The broadly used methods of sterilization by now are heating (boiling) and usage of chemical chloride, ozone, hydrogen peroxide, chlorine dioxide and etc. They are representative chemicals. Among these chemicals most cheap one is chlorine, but recently it produces THM as a problem of by-product, so it is going to replace it with ozone or hydrogen dioxide, and use in parallel with chlorine and ozone.

4. Merits and Demerits of Treatment Technologies, and Analysis of Their Performance

The most difficult problem of most of ships in connection with ballast water treatment onboard is that the quantity of treatment has to be a huge capacity and volume, weight and expenses in supplement with their treatment systems.

The capacity of ballast pump of the large ship is 500 - 3000 m^3/hr, but the case of oil tanker and bulk carrier is available more than 60,000 m^3/hr.

The flow-rate decreases and ballasting time is increased because the available delivery water head of the ballast pump in the existing ship is increased by the added treatment system.

As external problems of ballast water treatment equipments, besides the problems of treatment technologies and economic expenses, the limitation of huge capacity pump onboard about the problem of applying area and space owing to such a large capacity and increased water head comes to the fore.

The ballast water treatment technologies suggested by now consist of composite

connections with the greater part of primary treatment and 2nd treatment.

The primary treatment means to remove large organisms or buoyant solid bodies from the ballast water to enhance the effectiveness of the 2nd treatment.

And the 2nd treatment is defined as the process to make inactively remained organisms and to sterilize ballast water in order to satisfy for delivery.

Sometimes there is the case in which the treatment procedure between the primary treatment and the 2nd treatment is changed.

4.1 Primary Treatment

4.1.1 Filtration

Filtration is a famous technology that is effective to the sediments and various organisms as well as filtration of sand, pre-coat, membrane and screen.

The big problem when we use filtration process for the ballast water treatment is the coping capacity with the clogging.

There is a difficulty for the ship of which should treat huge capacity of ballast water in a short time. Meantime it is more difficult as international convention comes to reinforce.

Especially, if the limitation on the convention is decided less than 10μm, for the case of the ship needed to treat more than 1000 ton per hour, it needs huge size of filtration due to the loss of increased water head of the pump.

So those conditions cannot be satisfied by the generalized filtration technologies.

By the prior studies, for the effective 2nd treatment it is a prior condition that should be separated enough 50 - 100 μm solids from primary treatment.

Filtration process should have automatic reverse cleaning ability and the loss of reverse cleaning water, as a major parameter, has to be less than 1% of the total filtering water.

And the loss of the reverse cleaning water will be more increased if the size of the particle limitation of filtration is limited 10μm as the nowadays standard.

It is found that the loss of reverse cleaning water as the size of particle goes to bigger increase linearly proportion.

In order to solve these problems, disc type filtration equipment, which has maximum filtration area, was developed and is in use, but it has demerits like the problem of durability and decrease of the effectiveness of reverse cleaning.

Therefore, the standard of performance limitation about the size of biologic bodies of the international convention should be decided after considering the level of present technique and economical side and effectiveness.

And it is desirable to reinforce the standard step by step along with the extent of the development of technique.

4.1.2 Cyclonic separation

Specially designed hydro-cyclone demands less pump's delivery pressure than filtration and can separate about the 50μm of sediments and solids.

The merits of this process are that first of all its equipment is very simple and minimized the loss of pump's water head and it is not necessary for reverse cleaning.

Additionally it is effective to sterilize a part of zooplankton on inactive.

It should be studied and developed with concentration from now on, due to having various merits like compactness of volume, good for durability and simplicity of separation between solids and liquids.

But existing hydro-cyclone can’t separate the solid of which specific gravity is higher than

water's, and it needs additional process due to existing various benthic (bacteria, pathogen, zooplankton, phytoplankton) which is not separated from the water by cyclonic separation.

There is a demerit that now adopted treatment system is used to sterilize and then for the next process to remove solids for application other than for the primary use.

4.2 Secondary Treatment

There are many cases to use more than 2 processes including electro-chemical treatment and UV irradiation for the secondary treatment by now, considering heat, de-oxygen, high intensity ultra-sonic and low frequency, physical corrosion and shearing stress, cavitation, electro-chemical treatment, chlorine, ozone, hydrogen peroxide, and inclusion of other's biocide (Euk Jo Kim, Doctor thesis, 2003).

4.2.1 UV irradiation

Ultraviolet rays' sterilization is inexpensive and very effective in sterilization and if used in parallel with ozone, hydrogen peroxide, chloride and etc., it goes higher sterilizing effectively.

It is best using process because its equipment is simple, no problem in durability, possible to treat large capacity in series.

For the demerits, there is a possibility that a variation of biota comes out from the survivals after treatment.

If there are particle materials like sediments the effectiveness decreases and it needs to a certain degree contact time due to the effectiveness of sterilization increase exponentially.

If there are muddy materials and contaminated ones, the sterilized effectiveness decreases rapidly.

4.2.2 Heat treatment

There is a result of a study result that it is possible to perish all kinds of organism s if the heat system using exhaust heat of cooling water for internal combustion engine with large capacity heat exchanger and its piping system stays at an extent of 40°C for two days. Those studies are actively in progress.

It is a merit that does not need primary treatment like filtration, low energy consumption and a certainty of sterilization. But actually there is much limitation for practical use.

First of all it is impossible to increase more than 1000 tons of seawater from 20°C to 40°C in the side of energy balance.

And it is far from practical use to re-circulate salt water in tank to heat exchanger due to the problem of expense to set up piping system and navigation condition.

4.2.3 Ozone, chloride and other's biocide treatment

Direct chemical sterilization with ozone and chloride is the most effective and it's no need treatment equipment.

There are merits to decompose organisms as well as it can perish lives within minimum additional equipments.

The function of ozone has sterilizing power to interrupt cell's respiration and to destroy cells by intensive oxidizing power of an hydroxyl.

Chlorine is the cheapest biocide and it has a function of powerful sterilization, but there is a residue and chlorine induces THM (Trihalo-methane) causing cancer.

Even though the price is high, ozone is highlighted as a sterilizer.

The treatment equipments for ozone consists of ozone generator, pump, piping system, large reaction tank for ozone's treatment of which material is stainless steel or steel applied epoxy inside.

For the demerits, it is very corrosive and needs comparatively much operation fee and for the case of chloride it should be set a liquid chloride tank onboard.

And there is a possibility to make another kind of organisms from the unresolved ones resulted by ozone.

4.2.4 Electrolyte treatment

It's possible to sterilize effectively without necessity of additional chloride tank because of electrolyte treatment of salt water with DSA electrodes of interrelated titanium, which has no elution of electro-board generate chloride from the salt water.

The sodium chlorite generated by electrolyte is an effective biocide of which prevents revival of sterilized lives at sea due to having remaining and can sterilize continuously remaining lives.

In spite of big consumption of electric energy, the problem of energy does not matter so much because ship can use her own power economically, so it uses small size and compacted electrolyte equipment.

For the demerits, there is an anxiety of hull corrosion and it can give effect of no good to the life system by remained chlorine while ballasting overboard, and the price of the equipment is high and difficult to treat large capacity.

4.2.5 Deoxidizing treatment

The study has proceeded about the way of perishing lives caused dry up oxygen solved in salt water using ballast water by many researchers centering U.S. which does not need any kind of pre-filtration treatment and is so simple.

As sprayed salt water comes into the vacuum chamber, it delivers dissolved oxygen with difference of pressure and then it becomes the state of no oxygen where lives can't exist.

Within this process, in general the aerobe were perished completely, but compounded treat method is used with mixed engineering method because there is a problem on the phytoplankton's destroy. But there is a difficulty when applying it to the ship of which should set up a large vacuum tank onboard because ballast tank cannot be used as a vacuum maintaining room.

4.2.6 Ultra sonic or low frequency treatment

The technique of perishing lives by ultrasonic treatment or low frequency treatment induced recently is not verified completely, but test results from the laboratory looks very effective.

For the merits, this technique is operated by simple equipment with low energy, so it is economical and does not need pre-treatment and it is possible to have fixed use after setting up that one interior of the ballast tank.

While on the other there is a demerit of hull weakness of endurance due to erosion by ultrasonic equipment.

This treatment technique is a part of the up-to-date technology, which should be studied henceforth and by now in progress between industry and school from KMU.

4.2.7 Physical collision, shearing force and cavitation treatment

The Special pipe developed in Japan generates collision, cavitation and shearing force from the baffle plate posted in the high speed running salt water in order to perish lives.

Above all, pre-treatment is not necessary, more effective as running high speed, fit for large capacity, compact, easy set up progress, but it's not inspected for the practical use undergoing developing equipment.

It's a problem of endurance of equipment by collision and cavitation and has demerits that should add ozone and the other's

sterilizing process to perish phytoplankton and microorganisms.

5. Conclusion

In accordance with the adoption of the international convention about ballast water management at the last diplomatic conference, all ships engaged in ocean going have to establish equipments which are suitable to the standard of performance or to satisfy the standard of ballast water exchange as provided by new convention.

It needs much time and big labors for ballast water exchange, and it's impossible to work when ships navigate shortly. There is a possibility to bring deep danger to ship's safety.

Emphasis is laid on the development of ballast water treatment technologies fundamentally.

Therefore it is required to develop techniques to satisfy the standard of treatment for the ballast water that is more reinforced.

According to the new convention of the ballast water treatment performance standard, the preliminary process needs to satisfy those standard of more than 10μm live organisms and 3cfu.

The economical and effective ballast water treatment technology development should be carried out for the satisfaction of the standard of filtration process and the subject which can filter to 10μm alive organisms by centering the sterilizing process.

It should be considered the limitation of ship's design to adopt the optimum process for the ballast water treatment. And first of all those treatment technologies should not obstruct ship's safe and economical operation.

Therefore the principle standard should be satisfied to the safety of the ship and crew, environmental acceptability, economic, and practical use.

The big problem with most ships is that they need large capacity for treatment, and its volume and weight and expense to the when ballast water treatment was carried out.

According to the capacity of ship, their due date is different, both of the exist ship and new ship should satisfy to the Regulation D-2, Ballast Water Performance Standard, of the new convention.

For the case of exist ship, available pump delivery water head increases due to added treatment system, so it generates some problems that decrease flow quantity and increased ballasting times.

Besides the problem of treatment technology and economic expense, there comes to the fore the limitation of huge capacity pump according to large capacity and increasing water head.

Onboard applying area and spatial problem come to the fore.

In this study, it is recommended to suggest optimum process for the ballast water treatment considering biologic effectiveness, application onboard onto treatment technology, through collecting data about ballast water treatment technology and conducting their performance estimation.

For the first treatment, filtration process which has automatic reverse cleaning system to remove more than 10μm alive organisms, and for the second treatment, it's a combined process united UV irradiation and electrolytic to extinct or to render inactivate remaining alive organisms in the ballast water.

Because size limitation was reinforced as 10μm at new convention to live organisms, it could not satisfy that condition by generalized filtering technology.

Therefore it is desirable to design equipment which uses disc type filtration to maximize filtering area and used brush-type vacuum suction nonstop reverse cleaning system to overcome clogging phenomenon in order to solve such as effective problems.

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