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Comparative feasibility study on retrofitting ballast water treatment system for a bulk carrier

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ABSTRACT

Use of ballast water in ships causes harmful effects on marine environment accompanied by economic loss and negative impact on ecosystem and human health. To solve these problems, the international convention on ballast water management will take into force in September 2017. In this study, a comprehensive feasibility of retrofitting the ballast water treatment system for an ocean-going bulk carrier was conducted. The technologies involved, installation and operational aspects of direct flow and side stream electrolysis, UV, and ozone type BWTS are described in detail. The principal concept of each BWTS is explained and probable arrangements of retrofitting in engine room are suggested. The cost analysis is carried out for retrofitting 4 types of BWTS onboard the target ship by examining each processes of installation and operation.

1. Introduction

Ballast water is essentially used for controlling trim and stability of a ship. Offloading of ballast water loaded in other regions incidentally releases unwanted microorganisms such as phytoplankton, zooplankton, etc. (Hallegraeff, 1998; Hayes and Sliwa, 2003). Some of these nonindigenous species are known to cause serious ecological damage on marine environment (Drake et al., 2007). In addition, this also causes huge economic losses and negative effect on human health (Globallast).

There has been a lot of effort around the world to solve these problems. In particular, many discussions in International Maritime Organization (IMO) led to the establishment of International Convention for the Control and Management of Ships' Ballast Water and Sediments in 2004 (BWM Convention) (IMO, 2004). The convention is scheduled to take effect on September 8, 2017 (IMO, 2016a).

Many ideas of ballast water management have been suggested as port-based and shipboard treatment (Tsolaki and Diamadopoulos, 2010). Shipboard treatment includes ballast water exchange and onboard treatment which can be further divided into physical separation and secondary treatment using mechanical and chemical means.

However, once the BWM Convention comes into force, a ballast water treatment system (BWTS) shall be installed for both new ships and existing ships covered by the Convention (IMO, 2004). As a result, it is anticipated that there will be exponential increase in demand for BWTS.

Various types of BWTS have been introduced in many studies focusing on the treatment technology (Matousek et al., 2006; Liebich et al., 2012; Herwig et al., 2006). However, to authors' knowledge, although the entry into force of the BWM Convention is imminent, no comprehensive feasibility analysis of retrofitting BWTS on an existing ship was performed. In this paper, a comparative feasibility study was conducted for retrofitting BWTS on an international ocean-going ship by applying different types of BWTS.

2. Types of BWTS

There are 69 BWTS which are reported to IMO to have acquired government approval as of November 2016 (IMO, 2016b). The portion of UV type BWTS ranks the first with more than 50% followed by 23% of electrolysis type which can be divided into direct flow and side stream electrolysis. 4 types of BWTS with these three mostly used types and ozone type BWTS additionally are analyzed in this study. Concepts of ballast water treatment flow of each type in vessels are shown in Fig. 1.

2.1. Electrolysis type BWTS

In electrolysis of sea water, hypochlorite is generated and used to disinfect the ballast water. The process can use seawater directly, which is not practical for vessels that operate in fresh or brackish water and so an alternative source of chlorine (brine) is required.

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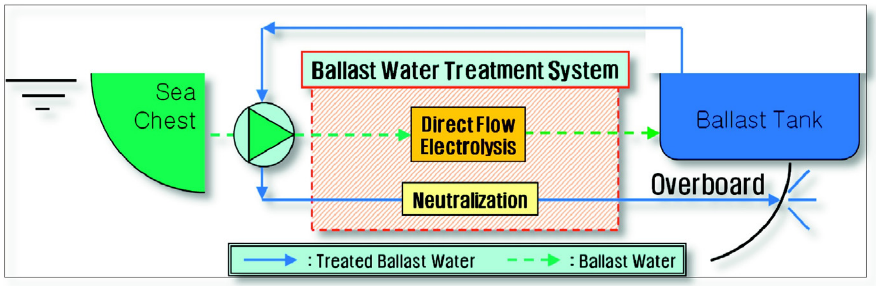
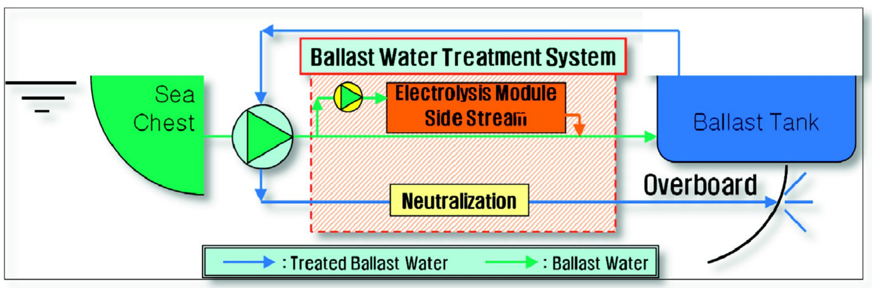
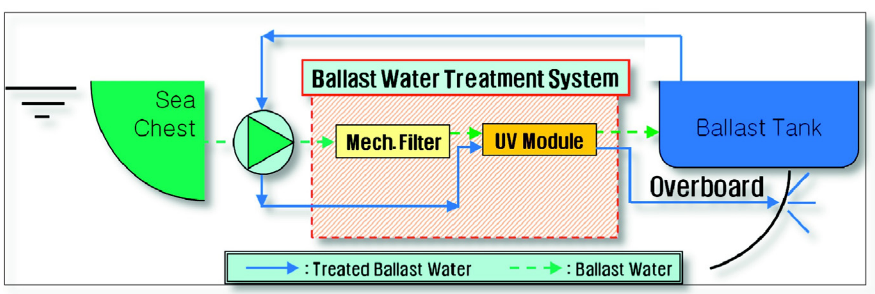


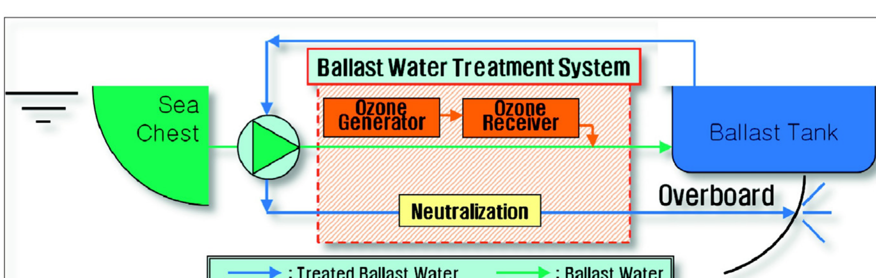
(a) Direct flow electrolysis type



(b) Side stream electrolysis type



(c) UV type



(d) Ozone type

Fig. 1. Principal concept for each type of BWTS.

Direct flow electrolysis type requires the entire flow of ballast water to pass through the hypochlorite generator and can be used when ballasting with seawater. Side stream electrolysis takes a small percentage of water from the main ballast water and uses this to produce a concentrated disinfectant stream that is then injected back into the main ballast water.

Electrolysis relies on the length of exposure to ensure effective treatment. The chemicals themselves are considered pollutants and cannot be discharged into the sea unless they have sufficiently decomposed or been neutralized by another chemical agent. Electrolysis systems use a neutralizing agent injected into the treated ballast water prior to discharge overboard. Total residual oxidants (TRO) levels are monitored

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