ARTICLE IN PRESS

Atmospheric Pollution Research xxx (2017) 1–8

HOSTED BY

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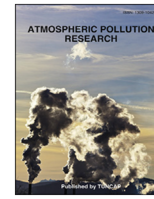
Contents lists available at ScienceDirect

Atmospheric Pollution Research

journal homepage: http://www.journals.elsevier.com/locate/apr




# Reduction of $CO_2$ emissions with automatic mooring systems. The case of the port of Santander

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A R T I C L E I N F O

*Article history:*
Received 23 January 2017
Received in revised form 29 June 2017
Accepted 1 July 2017
Available online xxx

*Keywords:*
Maritime transport
Automatic mooring system
$CO_2$ emissions
Bottom-up methodologies

A B S T R A C T

The revolutions in the maritime industry resulting from the implementation of integrated transport systems (bulk) and containerization (regular lines) at first had little effect on traditional mooring systems for ships in port. However, the research into innovation in automated mooring systems with increasingly advanced technologies carried on regardless.

The so-called "Automatic Mooring Systems" (AMS), automatic systems that allow vessels to be moored without ropes, are being increasingly implemented in numerous ports in many different countries in the world, particularly in those whose traffic volumes have allowed the threshold of profitability of these infrastructures to be reached. But besides the financial benefits, the implantation of the AMS is having positive effects on the environment by reducing $CO_2$ emissions in many commercial ports.

The present work aims to measure for the first time the reduction in the $CO_2$ emissions of merchant vessels as a consequence of the substitution of traditional mooring systems with the new automatic systems, continuing along the lines of previous works in the field of the reduction in $CO_2$ emissions in ports.

The estimation is made by applying the EPA and ENTEC "bottom-up" methodologies to the traffic in the port of Santander (Spain) in the year 2014.

The implementation of the AMS, when compared to the traditional mooring systems, leads to a reduction in $CO_2$ emissions of 76.78% calculated using the EPA method and 76.63% using the ENTEC method. Hence, the Port Authorities in their long-term planning decisions should promote the introduction of automatic mooring systems wherever the profitability thresholds of traffic allow it, as this will lead to significant environmental benefits by substantially reducing $CO_2$ emissions during the maneuvers of merchant ships in maritime commercial ports.



## 1. Introduction

Until the Second World War, the exploitation and organization of sea traffic had not changed very much. The loading and unloading operations followed a slow and laborious process. Therefore, in the post-war era, with the expansion of the market and rapidly rising labor costs, the system was placed under great stress. Congestion in ports increased and new methods had to be found through innovation, both technological and in processes, in response to these problems.

The maritime industry responded to the new challenges with two "revolutions" in the two sub-sectors of maritime transport: in non-regular traffic, through the development of integrated transport systems (bulk) (Vigarié, 1999) and in the regular lines by means of the grouping together of the general cargo (containerization) (Rodrigue and Notteboom, 2009).

These revolutions did not affect the traditional mooring systems of vessels in port. However, the research into innovation on AMS, with increasingly advanced technologies, continued to make

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Peer review under responsibility of Turkish National Committee for Air Pollution Research and Control.

http://dx.doi.org/10.1016/j.apr.2017.07.002
1309-1042/

progress (Cavotec, 2015).

The first results were obtained in 1998 with the first implantation of an AMS in the Port of Picton in New Zealand. Since then, AMS have been implanted in numerous ports in many different countries of the world (USA, Canada, UK, Denmark, Norway, Finland, the Netherlands, Australia, New Zealand, South Africa and The Lebanon), when their volumes of traffic have allowed the threshold of profitability of these infrastructures to be reached (Díaz, 2016).

As well as the financial benefits, the implantation of AMS also leads to important environmental benefits, through the reduction in $CO_2$ emissions in commercial ports, thanks to the reductions obtained in the operating times of the ship engines (in the main engines in the propulsion of the ship and in the auxiliaries in the generation of electricity). However, these benefits are not generally taken into account when analyzing the impact of these infrastructures.

The aim of this paper is to measure the reduction in $CO_2$ emissions by merchant ships as a consequence of the substitution of traditional mooring systems with the new automatic systems, by means of a comparative study.

## 2. Description of the automatic mooring system

This is an automatic system by vacuum cup direct on the hull of the vessels, whose fifth generation of 2013 (Montgomery, 2013) incorporates a remote control system with laser by telemetry that allows simultaneous visualization of the data on board and on land and the transmission of the connection commands from the control station to the AMS. It also includes a program so that the position of the vessel is maintained automatically and each mooring robot can be controlled independently from the rest.

The data received by the processor through some sensors located in the robots are the speed of the ship with respect to the terminal, the acceleration or deceleration of the vessel, the kinetic energy of the vessel and the inertia of the vessel.

It also receives another set of data from the on-board AIS and from the GPS.

This device (see Fig. 1) consists of a certain number of mooring robots, with a coupling mechanism so that the vessel remains perfectly moored in its berth and a system that detects the movements of the vessel.

A processor calculates the movement required by the coupling mechanism of each mooring robot and a controller controls the movement of the mooring robots in response to the information received from the processor.

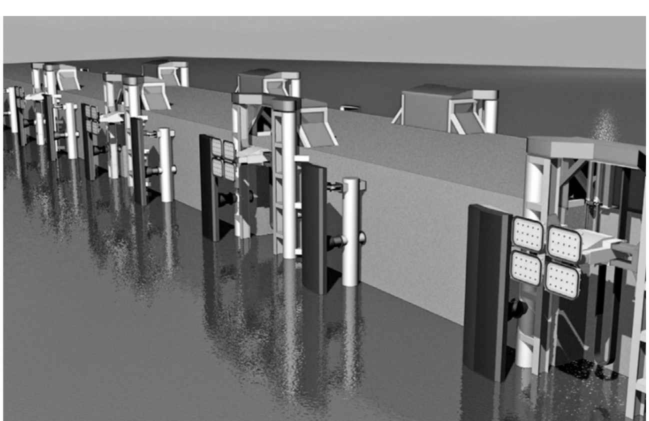

**Fig. 1.** Automatic Mooring System by vacuum cups.
Source: Cavotec

## 3. Background: $CO_2$ emissions in maritime transport

Emissions of gases by vessels in maritime transport are increasingly being subjected to more stringent restrictions at all phases of transport, both at sea and in port, so we will next address the analysis of these emissions.

Maritime transport is a growth sector in the global economy, and although it was expected that contributions to global $CO_2$ emissions would increase, thanks to the measures taken by the International Maritime Organization (IMO), these have decreased and moreover, this reduction has been achieved at a lower cost than initially expected (Eide et al., 2013).

Some of the fundamental policies of the IMO in recent years have been those aimed at improving the energy efficiency of vessels, the effects of which have led to an immediate reduction in the emissions of greenhouse gases (GHG), most notably those of $CO_2$.

According to studies by the IMO itself, the world fleet in 2006 generated 3% of the total $CO_2$ emissions to the atmosphere and 2.2% in 2015 (Oria et al., 2015). Of this amount, breaking it down by vessel type, we found that ships engaged in Ro-Ro transport (vessels designed to carry wheeled cargo), which are the subject of this study, produced by themselves an average of 29.40 Million MT. (Third IMO GHG Study, 2014).

The changes in emissions brought about by the reductions in $CO_2$ in shipping will obviously be beneficial from the perspective of long-term climate change, and in fact, positive environmental and health effects have already been identified, such as the reduction in concentrations of key short-life pollutants (Eide et al., 2011).

There already exists an extensive literature on the environmental impact of shipping and the direct effects on the contribution of greenhouse gases into the atmosphere from vessels in each of their phases of operation. In this regard, among the most interesting works are those that analyze the environmental impact of shipping in relation to other a priori less efficient means of freight transport (Belmonte and Romero, 2010).

At the same time, shipping companies have been forced to pay increasing attention to improving energy efficiency and reducing $CO_2$ emissions, which has led to the implementation in big shipping companies of integrated measures of sustainability within the global strategies of corporate social responsibility in order to mitigate the effects of climate change, in keeping with the Ship Energy Efficiency Management Plan (SEEMP): IMO mandatory measures entered into force on 1 January 2013 (Bocchetti et al., 2015).

The objective of the IMO with the inclusion of this plan in the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is to improve the energy efficiency of vessels through a set of technical operating rules that result in a reduction in the emissions of all substances coming from fuel and its combustion process. To achieve this goal, it encourages the member states to conduct studies on the chemical composition of the exhaust emissions from the engines, both main and auxiliary, of cargo ships and to calculate the Emission Factors (EFS) (Celo et al., 2015). Various methodologies have been used to accomplish this task, some of which, such as the Ship Traffic Emission Assessment Model (STEAM) (Jalkanen et al., 2014) (Johansson et al., 2013), combine information on the characteristics of individual vessels with the Automatic Identification System (AIS), enabling the tracking of vessels with a high spatial resolution.

The measures taken by the shipping industry have taken some time to begin to improve the environmental credentials (Cullinane and Cullinane, 2013), but it is expected to be able to drastically reduce the environmental impact of shipping in the near future

Please cite this article in press as: Ortega Piris, A., et al., Reduction of $CO_2$ emissions with automatic mooring systems. The case of the port of Santander, Atmospheric Pollution Research (2017), http://dx.doi.org/10.1016/j.apr.2017.07.002