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Reduction in CO_2 emissions in RoRo/Pax ports equipped with automatic mooring systems☆

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ABSTRACT

Faced with the unavoidable reality of the emission of pollutant gases by vessels both while sailing and when performing in-port manoeuvres, the international community has devised an extensive set of rules to limit greenhouse gas emissions and the emission of other pollutants which are bad for our health. In order to make these reductions in the emissions, the areas addressed are the engine regime or speed control, the quality of the fuel used, the state of conservation of the vessel and its hull or the time taken to perform the manoeuvres of mooring and unmooring. One factor which is having a strong influence on this last aspect is the installation in commercial ports of Automatic Mooring Systems using suction cups (AMS). These devices, which help to reduce considerably the time required to perform the mooring and unmooring manoeuvres, allow the times taken in operations for making steady a vessel to land and of releasing it to sail away to be reduced from some tens of minutes to a few seconds. The aim of this work is to verify the effect of the AMS on the emission of pollutant gases in the surroundings of the installations devoted to Ro-Ro/Pax vessel traffic. In particular, will focus on the CO_2 emissions produced by vessels during mooring operations using two different calculation methodologies (EPA and ENTEC), first when using traditional mooring methods as a means of securing the vessel to the dock and second when using only the AMS, to finally carry out a comparison of the results. Will conclude with a discussion on the values of the reduction in emissions obtained and the advantages of installing AMS in commercial ports. In the RoRo/Pax terminals in which the AMS is installed and operating, a reduction in CO2 emissions of 97% has been estimated.

1. Introduction

At present, there are new European and International regulations (Cullinane and Cullinane, 2013; Kalli et al., 2013) to limit the emissions of greenhouse gases (CO_2) and the emission of pollutants harmful to health produced by vessels. Vessels emit pollutant gases both during navigation and during mooring and unmooring operations while berthing and unberthing manoeuvres, these emissions depending on different factors such as the machine regime or the speed control (Chang and Chang, 2013; Eide et al., 2013, 2011), the quality of the fuel used, the state of conservation of the ship and the hull (Bocchetti et al., 2015; Celo et al., 2015) or the times used in carrying out the manoeuvres. (see Fig. 1)

Today there are automatic mooring systems using vacuum cups (AMS) installed in many commercial ports all over the world that considerably reduce the time required to carry out the manoeuvres of mooring and unmooring vessels. With these systems, the time spent on operations to secure a vessel to land and to release it to sail is reduced to a time interval of around 30 s, while the same operations take around 30 min with the traditional rope systems.

During the preparation of the initial studies in which the reduction of CO2 emissions in the port of Santander was quantified in a Ro-Ro dock in which this AMS was to be installed, some research was carried out into which ports the system was already installed in and what types of vessels were using it. One of the most surprising findings was that most of the AMS systems installed in the world were located in Ro-Ro/Pax vessel traffic facilities (vessels

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

designed to transport ro-ro cargo, mainly automobiles and trucks, and passengers) (Ortega Piris et al., 2017). There are studies on this type of vessels that focus on analysing the CO_2 emissions they produce during navigation (Baird and Pedersen, 2013; Psaraftis and Kontovas, 2009), or during their stay at the dock, which is when they carry out supply activities or loading and unloading (Cooper, 2003), but none of these studies referred to the time allocated to the maneuvers. It is estimated that the average emissions of a RoRo/Pax vessel during mooring operations over a year could be around 833 tonnes. Hence our study, in which the traffic in these terminals with AMS is studied and the emissions of the vessels that use the facilities are calculated when mooring with the AMS and with ropes.

The objective of this work is to quantify the effect on the CO2 emissions registered in the surroundings of the facilities destined to the traffic of Ro-Ro/Pax vessels of the ports, as these are usually the closest to the population centres and are those which held the most traffic (Tichavska and Tovar, 2015). To do this, we initially performed the calculation using two different "bottom-up" methods, the EPA and the ENTEC (Entec, 2002; Hildreth and Torbitt, 2010; Moreno-Gutiérrez et al., 2015), first when using traditional mooring methods as a means of securing the vessel to the dock and second when using only the AMS, to finally carry out a comparison between the results obtained by the two methods.

1.1. List of abbreviations and acronyms

AE Auxiliary Engine AMS Automatic Mooring System with suction cups C Fuel Consumption CF A dimensionless Conversion Factor CO2 Carbon dioxide. E Ship Emissions EEDI Energy Efficiency Design Index EEZ Exclusive Economic Zone EF Emission Factor EFME [g/kWh]: Emission Factor for the Main Engine for the pollutant of interest varies by engine type and fuel consumed rather than by activity mode] (g/kWh grams of pollutant emitted per energy unit produced) EFAE [g/kWh]: Emission factor for an auxiliary engine for the pollutant of interest. ENTEC Environmental Engineering Consultancy environmental and engineering consultancy in UK EPA Environmental Protection Agency FERRY Ship used to carry passengers, and sometimes vehicles and cargo GT Gross Tonnage IMO International Maritime Organization LF Load Factor MCR Is the engine regime used during the undertaking of the manoeuvres, and also denominated LF. MDO Marine Diesel Oil MEPC Marine Environment Protection Committee ME Main Engine MGO Marine Gas Oil PAX Passenger cruise service vessels Ro-Ro ships similar to the automobile carrier but can accommodate larger wheeled equipment Ro-Ro, Roll-on Roll-off: denoting a passenger ferry or other method of transportation in which vehicles are driven directly on at the start of the voyage or journey and driven off at the end of it. Ro-Ro/Pax Ships built for freight vehicle transport along with passenger accommodation SFC Is the certified Specific Fuel Consumption of the engines, measured in g/kWh.

2. Background

The changes in emissions caused by the reductions in CO_2 in maritime transport will obviously be beneficial when seen from the perspective of long-term climate change. In fact, positive environmental and health effects have already been identified, such as the reduction in concentrations of some key short-lived pollutants (Eide et al., 2011). There is an extensive literature available on the environmental impact of maritime transport and its direct effects on greenhouse gas emissions into the atmosphere from ships in each of their modes of operation. Some study the effects of the environmental impact (Belmonte and Romero, 2010) and the socioeconomic impact (Eide et al., 2013; Johnson et al., 2013; Lun et al., 2015).

In other cases, the effect of reducing the speed of ships due to poor sea conditions on greenhouse gas emissions has been studied (Prpic-Orsic and Faltinsen, 2012). Other options studied to reduce emissions into the atmosphere are the use of alternative fuels (Hsu et al., 2015) or the modification of the design of ship routes in certain areas of the world (Song and Xu, 2012) while other authors sustain that reduction of CO_2 emissions depends in part on the Incoterms used in international freight rates (McKinnon, 2014), and others focus on the analysis of the technical improvements required to reduce emissions from maritime transport (Chang and Wang, 2014; Cullinane and Cullinane, 2013).

Other studies analyse the methodology of calculation of the emissions (Johansson et al., 2013; Kalli et al., 2013; Oria Chaveli, 2016; Pirjola et al., 2014). Several methodologies have been used up to the present, from full bottom-up model for the elaboration of emissions maps which are useful for confirming the locations of the hotspots inside the ports (Tichavska and Tovar, 2015), to the use of the inventory of contaminating atmospheric emissions EMEP/EEA 1, with which the emissions can be estimated with different levels of complexity and separately, according to the activity of the vessel, sailing mode, manoeuvre or stay in port (Trozzi, 2010).

3. Description of the automatic mooring system

The AMS consists in an automatic mooring technology based on a vacuum which secures all kinds of vessels safely to the dock, eliminating the need for conventional mooring lines (ropes and cables).

The system consists of some mooring robots equipped with vacuum pads, remote-controlled, which can be installed on the edge of the dock or on it and which are fitted on arms which are hydraulically activated and which stretch out, thus connecting the vacuum pads with the ship's hull in a matter of seconds.

In reality, the reduction in CO_2 occurs when the vessels use these new mooring systems; the difference is in the time required to carry out the mooring maneuvers or to secure the vessels to the dock. Mooring with the traditional system takes about 15 min while with the AMS only 15 s are needed; this is the saving, in the almost 15 min that the machine is no longer used and thus no longer emits CO_2 into the atmosphere, for each vessel that uses the AMS per manoeuvre.

Using this mooring system, the vessels are made fast to the dock safely in less time than using conventional mooring techniques. This allows the engine running time to be reduced, thus lowering the emissions and improving the operative efficiency. By means of