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Reducing speed and fuel transfer of the Green Flag Incentive Program in Kaohsiung Port Taiwan

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ABSTRACT

This research applied the Green Flag Program to assess the benefits of reducing speed and fuel transfer for large merchant vessels (bulk and container) entering Kaohsiung Port. This study adopts an activity-based model to calculate fuel consumption and emissions, as well as setting up two scenarios, (1) decrease vessel speed to 12 knots 20 nm away from port; and (2) decrease vessel speed to 12 knots and transfer fuel 20 nm away from port, which based on the Green Flag Program in Long Beach, in the U.S. The findings are (1) In scenario one, the container and bulk vessels saw reductions in CO_2 emissions of about 41% and 14%, respectively. In scenario two, container and bulk vessels had reductions of about 48% and 43% in SO_2 emissions, respectively. (2) Large vessels are more environmentally friendly than small vessels. (3) Using the CATCH model to assess the effectiveness of the two scenarios, it was found that container vessels benefited from both reducing speed and fuel transfer, while bulk carriers only did so from the former.

Introduction

According to the fourth assessment report from the Intergovernmental Panel on Climate Change (IPCC), the Earth's average annual temperature is rising year by year, and it is an indisputable fact that climate change is impacting the environment as a result of global warming. For example, melting ice is causing rises in sea level which result in low-lying coastal area flooding, unusual drought and storms are affecting land and water resources and taking lives, the phenomenon of desertification has expanded, causing ecological changes and affecting human survival, among other weather anomalies. Scientists believe that the main cause of global warming is greenhouse gases resulting from human use of fossil fuels and the large number of chlorofluorocarbons (CFCs) produced from this use.

The six controls on greenhouse gases as set by the Kyoto Protocol included controls on carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC_s), hydrofluorocarbons (HFC_s), and sulfur hexafluoride (SF_6). CO_2, which is the largest issue, accounts for about 70% of total greenhouse gases with the main emission sources resulting from the use of fossil fuels. Since the industrial revolution, the concentration of carbon dioxide in the atmosphere has increased by 28%, and scientists have pointed out that without any preventative measures, the surface temperature of the Earth will increase from 1 °C to 3.5 °C by 2100 (IPCC AR4, 2007). Therefore, reducing CO_2 emissions has become the subject of many studies and developmental projects.

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A review of marine transport (2011) pointed out that in recent years, marine transport and ship emissions have increased because of economic growth. According to the Second IMO GHG Study 2009, CO_2 emissions of all ships were 1046 million metric tons (Mt) in 2007, accounting for 3.3% of global CO_2 emissions; CO_2 emissions from international ships were 870 million tons, accounting for 2.7% of global CO_2 emissions. Additionally, the International Maritime Organization (IMO) estimated that global CO_2 emissions will increase 150–250% in 2050 as compared to 2007.

In the past, greenhouse gas emissions from the transport sector grew 45% from 1990 to 2007, with the transport sector emissions rate increasing faster than that of other sectors (OECD, 2010). In 2004, 75% of total emissions in the transport sector came from trucks (IPCC, 2007), and although three-quarters of the emissions came from road transport, marine transport emissions rose dramatically, moving from 955 Mt to 1054 Mt between 2005 and 2007 (IMO, 2009).

Decreasing vessel speed has not only explored by previous studies (Endresen et al., 2007), but has been adopted by marine corporations, such as Wan Hai Lines LTD of Taiwan. Wan Hai Lines LTD has participated in the Green Flag Incentive Program at Long Beach Port in the U.S. since 2007. The Green Flag Incentive Program involves reducing speed to 12 knots when vessels are away from port 20 nm. In 2009, Wan Hai Lines LTD participated in the plan requiring vessels to reduce speed to 12 knots when away from port 40 nm (Wan Hai Lines LTD, 2010).

There is currently no implementation of fuel transfer in the maritime industry. The advantage of fuel transfer in vessels is a reduction in GHG emissions from vessels, especially SO_x emissions. There is a difference in sulfur ratio between heavy fuel oil (HFO) (2.7%) and MDO (0.5%) ((IMO, 2009); therefore reducing SO_x emissions from vessels can reduce the impact of acidic substances (such as acid rain) on environmental of human habitation and reduce building erosion (Tzannatos, 2010). However, if the operator of vessel is poor in operational technique, engine component failure may result from the fuel transfer process and accidents may even be a result.

Taiwan is an island, and this it relies heavily on marine transport. Kaohsiung Port is the biggest international port in Taiwan, with a large cargo throughput. The port's own statistics show that in 2012, 18,869 vessels entered the port. This high level of activity means that Kaohsiung Port has the highest CO_2 and SO_2 emissions of any port in Taiwan, and this motivates the current discussion of how to emissions these.

This study thus applies the Green Flag Program to examine whether decreasing vessel speed and fuel transfer can reduce ship emissions when vessels enter the port. First, this work establishes a fuel consumption and CO_2 calculation model and explores the relationship between ship speed and fuel consumption. This study considers all large merchant vessels (container and bulk) that enter Kaohsiung Port, and the following two scenarios are examined: (1) decrease vessel speed to 12 knots 20 nm away from port; and (2) decrease vessel speed to 12 knots and transfer fuel 20 nm away from port. These two scenarios are which based on the Green Flag Program in Long Beach, in the U.S.

The rest of this study is organized as follows: Section 'Introduction' explains the research background, motivation and purpose. Section 'Literature review' reviews the literature on ship emissions, as well as measures for reducing these and decreasing vessel speed. Next, Section 'Methodology' refers to the Second IMO GHG Study 2009 and the related literature in order to establish the model and scenarios used in this work. This model is then applied in Section 'Empirical analysis' to calculate the fuel consumption and CO_2 and SO_2 emissions from vessels. Finally, the conclusions of this work are presented in Section 'Conclusions'.

Literature review

Corbett and Koehler (2003) used an activity-based model to calculate global vessel emissions in 2001, and their results indicated that, at that time, NO_x accounted for 6.87 million Mt of these, SO_x for 6.49 million Mt, and CO_x for 249 million Mt. Their study concluded that the level of seaborne trade is directly proportional to fuel sales, and that while fuel use on land had decreased in the years of 1983–2003, but it had been rising with regard to marine use.

Endresen et al. (2007) used an activity-based model to calculate the fuel consumption of global vessels from 1970 to 2000, and they found that it rose from 1520 thousand tons to 2010 thousand tons over this period. They also noted that, starting in 1973, improvements related to building vessels and operational changes have meant that fuel consumption and emissions did not increase at the same rate as vessel growth. In addition, they concluded that the main factors affecting annual fuel consumption are vessel size, engine effects, and fleet effects.

Hulskotte and Gon (2010) investigated data from 89 ocean-going vessels calling at Rotterdam Port. This data included vessel type, engine type, and fuel type for auxiliary engines, and also used the Emission Registration and Monitoring of Ships (EMS) as well as an activity-based model to calculate vessel emissions. According to their results, emissions from tankers (30%), containers (25%), ferries and ro–ro (20%) accounted for 75% of emissions at Rotterdam Port. The main reason for this was the use of heavy fuel oil when these ships called at port.

Yau et al. (2012) used the Automatic Identification System (AIS) and vessel data to estimate NO_x, SO_2 and PM_{10} emissions from 37,150 ocean-going vessels (OGVs) in Hong Kong in 2009. According to their results, the emissions generated by OGVs were composed of 17,097 tons of NO_x, 8190 tons of SO_2, and 1035 tons of PM_{10}, which accounted for 0.07%, 0.05%, and 0.06% of global vessel emissions, respectively, in 2009.

McArthur and Osland (2013) examined the emissions from ships at berth in the Port of Bergen in Norway, and calculated external costs generated by these. The cost of these emissions was estimated at between €10 million and €21.5 million per year, with containers found to be the biggest emitters.