Empirical in-port tugboats emissions assessment based on operational modes

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Pollution emitted from ports comes from merchant ships constantly docking and undocking but also from other auxiliary port vessels working continuously throughout the year, like pilotage vessels, bunkering barges, vessel-generated waste collection services, mooring and unmooring services and port tugs. Ship emissions are deeply bound with ship engines operational modes. The estimation of fuel consumption and the consequent emissions, is commonly based on the cubic speed–power relation as a bottom-up approach (Kristensen 2017). The need to emission-control policies and regulations at ports is widely acknowledged as an active policy issued by maritime port authorities. It is also considered an answer of international and European regulations and depends on an accurate estimation of emission inventory in close-to-land and in-port (Yu et al. 2021). Current emissions estimation methods fail to reach accuracy when vessels are not sailing under design conditions, that being the case for port tugboats in most of their performance range. Port tugboats have powerful engines but they are not prepared for speeding and in most ports, between 40% and 70% of all light-sailing is done at speeds where the fuel consumption is higher. The traditional propeller-law-based method is not applicable to estimate the emissions during pushing and pulling operations, even during light-sailing phases in tug speeds due to the characteristic engines these vessels are designed with (Chen et al. 2021). The empirical rules are based on the experiences of tug captains and operational guidelines, thereby providing a more accurate estimation of main engine load than the propeller-based method. However, these empirical rules face the emissions assessment considering real data of main engine load during operations. The limited availability of fuel consumption data and the changeability of engine orders under maneuvering conditions hamper the emissions assessment.

This contribution aims to stablish the adequacy of empirical rules to override the discrepancies on the outcomes of port tugboats emissions when calculated though the propeller law based method in the different operational phases and compare them with data gathered during a field campaigns. The scenario selected for analysis is the Barcelona Port, where an in-port tug has been monitored over 40 maneuvers during the month of April 2023. The field campaigns have enabled the characterization of port tug manoeuvers by collecting realtime engine orders and their duration.

Results identify in which operational phases the existing formulae yields higher errors and if they can be easily corrected within the formulae adjustment or new expressions are needed. The results point out the adequacy of applying low load adjustment factors (Chen et al. 2021) when the vessel is sailing slow ahead condition (showing a discrepancy below 5% when compared to real values), and they also state that most penalizing operational mode for the case study vessel is during half ahead engine order.

The findings suggest that port operators can reduce emissions by requiring tugs to perform pushing and pulling operations with an optimal engine load depending on the maneuvering requirements. This approach will help to reduce the impact of in-port ship emissions on human health, the environment, and the climate of the coastal community.

References

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