International Journal of Automotive Technology (2024) 25:651–661
https://doi.org/10.1007/s12239-024-00051-5

Study on CO_2 Emission Assessment of Heavy-Duty and Ultra-Heavy-Duty Vehicles Using Machine Learning

Seokho Moon[1] · Jinhee Lee[2] · Hyung Jun Kim[3] · Jung Hwan Kim[3] · Suhan Park[4]

Received: 25 August 2023 / Revised: 29 November 2023 / Accepted: 2 January 2024 / Published online: 15 February 2024

Abstract
EU is actively moving towards the implementation of Euro-7 regulations, thus placing a strong emphasis on real-road emissions. Euro-7 introduced OBM (on-board monitoring), which is an enhancement of regulations that closely replicates real-world road conditions. Furthermore, there is a need to devise an effective application strategy for utilizing the driving monitoring data prior to the enforcement of OBM. This study addresses these challenges by conducting RDE (real-driving emission) tests on both 3.5-ton and 25-ton commercial vehicles to gather CO_2 emissions and engine control unit data accessible through an OBD (on-board diagnostics) port. To process the RDE data, an appropriate machine learning model, XGBoost, was selected and trained. The outcome of our CO_2 emission prediction for the two vehicles demonstrated that employing monitoring data yielded reliable estimates of actual road CO_2 emissions. Finally, a comparative analysis was conducted between the proposed monitoring approach and the fuel-based CO_2 monitoring method using the emission factor from EMEP/EEA air pollutant emission inventory guidebook 2019 utilizing fuel consumption data achieved through the OBFCM (on-board fuel and energy consumption monitoring) rule. Our method, which is based on predictive CO_2 emissions monitoring, exhibited significantly greater accuracy. This outcome underscores the necessity to adopt the proposed approach.

Keywords Heavy-duty vehicle · Real driving emission · Portable emission measurement system · On-board diagnostics · On-board monitoring · CO_2 emissions · Artificial intelligence prediction · Machine learning

Abbreviations

HDV	Heavy-duty vehicle
UHDV	Ultra-heavy-duty vehicle
LDV	Light-duty vehicle
PEMS	Portable emissions measurement system
OBD	On-board diagnostics
OBM	On-board monitoring
OBFCM	On-board fuel and energy consumption monitoring

✉ Suhan Park
suhanpark@konkuk.ac.kr

[1] Department of Mechanical Engineering, Graduate School of Konkuk University, Seoul 05029, Korea

[2] Advanced Powertrain R&D Center, Korea Automotive Technology Institute, 303 Pungse-ro, Cheonan 31214, Korea

[3] Transportation Pollution Research Center, National Institute of Environmental Research, Incheon 22689, Korea

[4] School of Mechanical and Aerospace Engineering, Konkuk University, Seoul 05029, Korea

1 Introduction

In general, strengthening regulations on air pollutants and greenhouse gases involves enhancing the emission limit values for regulated substances, introducing new regulatory substances, applying transient emission measurement test conditions, and adding vehicle components to the test (Proposal for a regulation of the European parliament and of the council, 2022; Tier 3 Motor Vehicle Emission and Fuel Standards (Final Rule), 2014; The California Low-Emission Vehicle Regulations, 2022; Williams & Minjares, 2016). As a result of this, the requirement for vehicle emission testing quantities for manufacturers and related institutions is increasing. In particular, heavy-duty vehicles (HDVs) and ultra-heavy-duty vehicles (UHDVs), which have considerably larger engines and chassis, imposes a relatively higher testing burden owing to the scale of the tests involved. Regarding (U) HDVs, their total production accounted for a significant proportion, ranging from 28 to 30% of the global automobile production between 2019 and 2021 (Automobile Production Statistics, 2022). Additionally, owing to the wide