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Comparison Study on Emission Measurement with MOVES and Emission Factor Methods

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Abstract

NOx emission from diesel vehicles in real-time driving can be significant discrepancy from the values measures with in-laboratory method. NIER developed NIER driving mode in order to evaluate emission factor for Korean domestic vehicles. The emission factor for vehicles is a function of average vehicle speed. The driving mode for each average speed reflects acceleration and driving pattern, however, it is difficult to reflect the emission factor method since in real driving on road pattern of acceleration or deceleration and driving characteristics are appeared variously even in same vehicle speeds. This research aims to investigate NOx emission of real-time driving vehicle by applying MOVES method and compared the results with current vehicle emission factor. There are large deviations depending on road types of urban, rural and motorway. In urban, the emission factor based on average speed is computed 20~40% lower than real-time NOx emission and the amount of NOx emission in motorway and rural road is estimated 17~33% and 6~25% lower than real-time NOx respectively.

Keywords: NIER (National Institute of Environmental Research), Light-duty Vehicle, MOVES, NOx, PEMS

1 Introduction

The emissions from automobiles were evaluated and certified by using mainly a chassis dynamometer or an engine dynamometer in laboratory. According to some report [1][2][3][4] of recent research and for examples, it was confirmed that there are significant discrepancy between amounts of air-pollutants which is evaluated in a laboratory and in actual driving condition. In particular, the amount of nitrogen oxides in diesel vehicles certified in a laboratory have been reported considerable differences compared to emissions which are emitted from actual driving conditions. Furthermore, the amount of NOx emission increased up to maximum 10 times in extreme conditions of air-conditioning or sudden acceleration driving. NOx emission has exceeded significantly environmental emission standard from heavy-duty diesel vehicle and light–duty diesel vehicle even in actual driving test by using PEMS.[5][6] Similar results have been reported by research papers of European and USA as well. This is due to the fundamental limit in reflecting actual road driving condition fully. In this regard, NIER developed NIER driving mode in order to evaluate emission factor for Korean domestic vehicles. The emission factor for vehicles is the function of average vehicle velocity. The driving mode for each average speed reflects acceleration and driving pattern, however, it is difficult to reflect the emission factor method since in real driving on road pattern of acceleration or deceleration characteristics of vehicle driving are different even in the same vehicle velocity. EPA made an effort to reflect emission characteristics in various real road driving conditions by improving emission evaluating system from MOBILE to MOVES.[7][8] The purpose being, EPA provides VSP (Vehicle Specific Power) and emission rate (mg/s). By doing these, there is an effect which can provide reconsidering flexibility in modelling emission prediction for vehicles. European Commission Joint Research Centre (EC-JRC) has conducted some research on the revision of COPERTS emission coefficient by using PEMS.[9][10] EC-JRC pointed out diversified data analysis was necessary in order to develop a standard actual driving method. This research aims to investigate NOx emission of real-time driving vehicle by applying MOVES method and compared the results with current vehicle emission factor.[11]

2 Experimental Approach

MOVES method is applied in order to reflect emission characteristics of actual driving for light-duty diesel vehicles. Emission rate maps are computed by MOVES OP (Operating Mode) of EPA after analyzing emission data obtained by a chassis dynamometer. OP-Mode is determined by vehicle speed and vehicle specific power (VSP). The VSP is defined by engine power per vehicle specific power can be represented by multiplication of total tractive forces and vehicle velocity. Vehicle power is required by the consideration of aerodynamics, rolling resistance, climbing resistance and initial resistance. VSP is considered as the most important factor which can affect emission characteristics in operation variables. Vehicle velocity is classified into three sectors, for example less than 40km/h, 40~80km/h and more than 80km/h. VSP is classified into 12 sections and reconstructed according to the characteristics of each acceleration section. OP-Mode consisted of 23 sections including idle and brake conditions. The total amount of emission is estimated by the multiplication of emission rate mapping computed from Op-Mode and activity in driving areas. In Table 1, specifications of 8 test vehicles are shown. In order to compare and total emission computed by applying MOVES method and total emissions computed by NIER emission factor, average speed and amount of emission per distance (g/km) are calculated after average distance was set up by 1 km for the computation of real driving emission. Average speeds are divided into every 10 km/h and average emission and emission factor are compared in the corresponding vehicle speed section.

Table 1: Main specifications of vehicles

Vehicle ID	Fuel	Type	Engine Volume(L)	Emission Level
VO1	Diesel	SUV	2.2	EURO-5
VO2	Diesel	SUV	2.0	EURO-5
VO3	Diesel	SUV	2.2	EURO-5
VO4	Diesel	SUV	2.0	EURO-5
VO5	Diesel	SUV	2.0	EURO-5
VO6	Diesel	SUV	2.0	EURO-5
VO7	Diesel	Sedan	1.7	EURO-5
VO8	Diesel	Sedan	1.6	EURO-5

3 Results and Discussion

Emission rate maps are computed after analyzing real-time data obtained by the various driving modes from a chassis dynamometer. Fig. 1 depicts NOx emission rates (mg/s) with respect to operation modes for 8 test vehicles out of 12 vehicles, which are 6 SUV vehicles and 2 sedan vehicles. NOx emission rate increases with the increase of VSP in a same speed area. In general, VSP plays a role as an important driving factor having a significant relationship with NOx emission. By applying MOVES method emissions in real-time driving are classified by vehicle average velocity and amount of average emissions per driving distance are computed. Currently applying NIER emission factor based on a vehicle average speed is constant regardless road types, however, the amount of emissions can be computed according to various driving characteristics even in the same average vehicle speed by applying MOVES method.

In Fig. 2, the amount of NOx emission in an real-time average speed classified by road types for SUV and sedan vehicles are compared with NOx emission secured by applying emission factor method based on average velocity. The emission factor based on average speed is estimated 6~40% lower than real-time driving NOx emission. In urban, the emission factor based on average speed is computed 20~40% lower than real-time NOx emission and thus there are large deviation in urban area. The amount of NOx emission in motorway and rural road is estimated 17~33% and 6~25% lower than real-time NOx emission respectively.

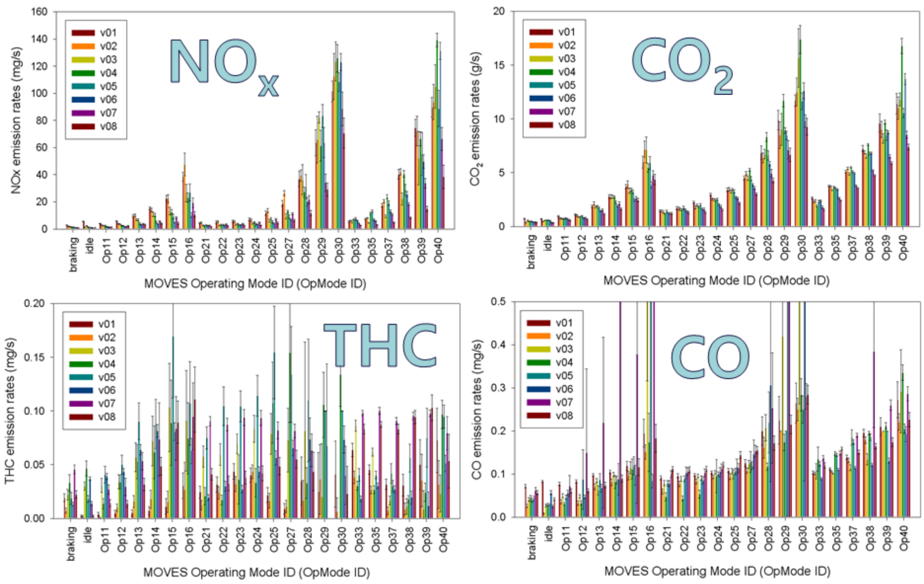

Fig 1. Emission rate maps in OP-modes of MOVES for SUV vehicles

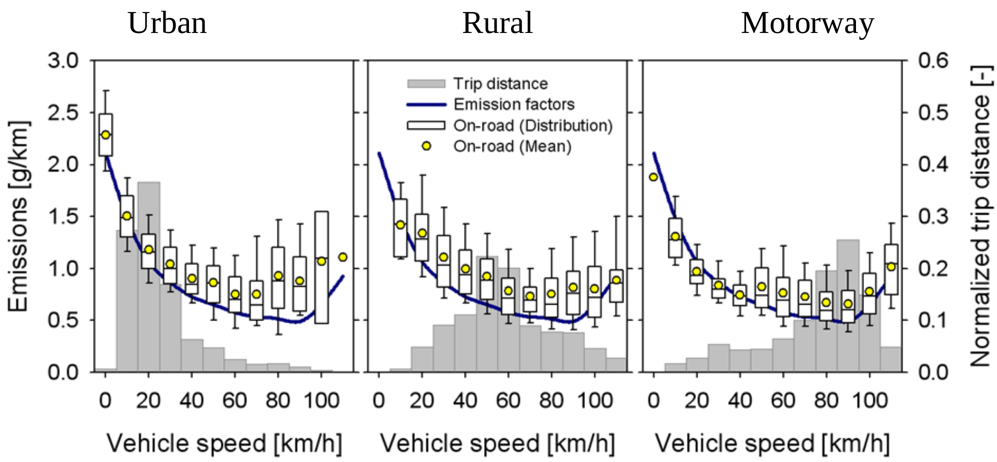

Fig 2. Comparison of NOx Emission estimated with MOVES and emission factor for SUV vehicles

Fig. 3 represents comparison study between real-time driving NOx emission and NOx emission calculated by emission factor method based on an average speed for a van and a light-duty truck (LTD). NOx emission factor in a van and a light-duty truck is overestimated real-time driving NOx emission. The NOx emission from a van and a light-duty truck are overestimated up to 17~30% and 4~12% respectively.

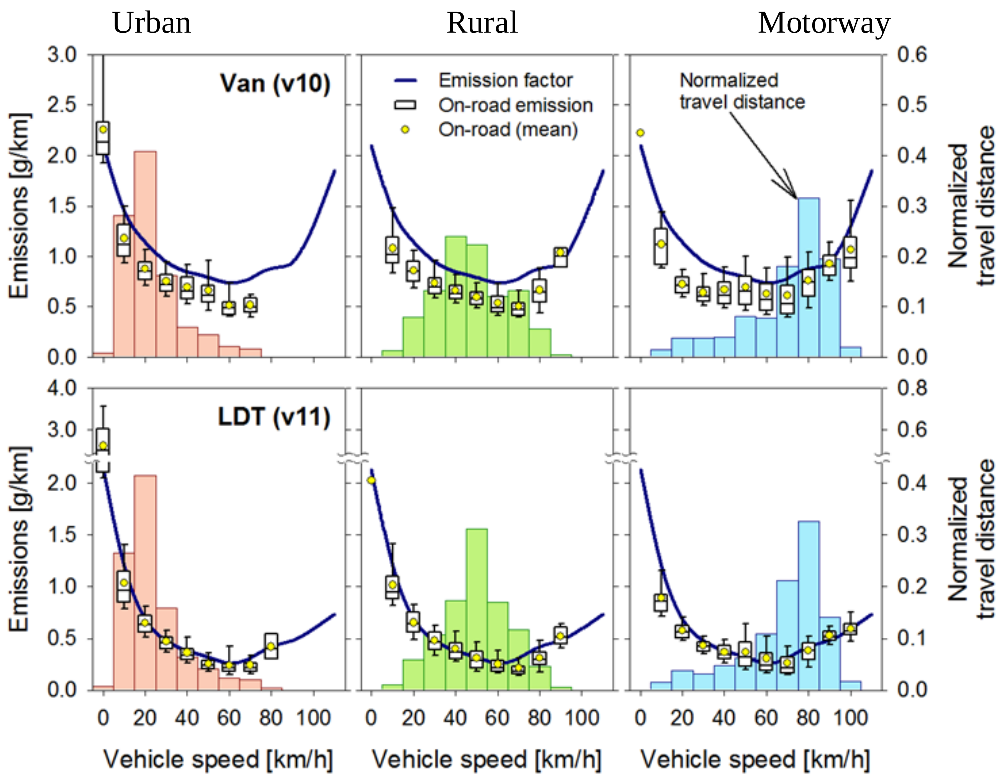

Fig 3. Comparison of NOx Emission estimated with MOVES and emission factor for van and light-duty vehicles

4 Conclusion

EPA MOVES method was applied in order to evaluate real-time driving NOx emissions, and then their amount of average NOx emissions were compared with average NOx emissions obtained from emission factor of NIER based on an average vehicle speed. In the method of NIER emission factor, there were some difficulties in reflecting various activity characteristics when it was applied to local area since current emission factor was evaluated by constant activity based on an average vehicle speed.

The difference of real-time driving NOx emission and emission factor according to the kind of vehicles was owing to the vehicle activities which were reflected for their computation. Weighted factor for each road type was applied for the computation of real-time driving NOx emission and current emission factor method based on a constant activity of an average vehicle speed. On the result of their comparison, NOx emission factor method for SUV vehicle was underestimated real-time NOx emission and the NOx emission was 19% less than real-time driving NOx emission. However, NOx emission factor method for a van and a light-duty truck was overestimated real-time NOx emission and the NOx emission was 23% and 9% higher than real-time driving NOx emission.

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