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Reducing pollutant emissions from existing passenger car fleet: generic approach to personalised recommendations

René van Gijlswijk[a]*, Norbert Ligterink[a], Armando Indrajuana[a], Claus Matzer[b]

[a]*Netherlands Organisation for Applied Scientific Research TNO, Anna van Buerenplein 1, 2595 DA Den Haag, The Netherlands*
[b]*Technische Universität Graz, Institut für Verbrennungskraftmaschinen und Thermodynamik, Inffeldgasse 19, 8010 Graz, Austria*

Abstract

A new approach is proposed to decrease pollutant emissions from the existing passenger car fleet in Europe. First, vehicles are categorised by their engine block, based on fuel, engine size, power output and Euro standard. For each engine block a multi-layer emission map is calculated, using existing measurement data as an input. The engine maps will be available for new cars as well as older cars, and account for aging as well as other factors such as state of maintenance. Using the maps, drivers' trips can be analysed and used for a personalised advice to reduce emissions by changing the way they use the car as well as by changing their driving behaviour.
The work described in this paper is performed within the H2020 uCARe project.

Keywords: pollutants, emissions, fleet, passenger car, behaviour

1. Introduction

Combustion engine powered passenger cars contribute a lot to air pollution in the cities, by emitting nitrogen oxides, particulates, carbon monoxide, hydrocarbons and other components from the exhaust. Newer diesel cars (before Euro $6d_{temp}$) do not emit less than older diesel cars [Kadijk et al, 2016]. Newer petrol cars do emit less than older ones, not only as a result of technological advancement, but also because the emissions from petrol cars tend to increase over their life span due to aging. Finally, for both petrol and diesel cars malfunction or tampering can cause high emissions in individual cases. For these reasons and because of the long life span of passenger cars nowadays the actual emissions do not decrease as fast as envisaged. The factors mentioned furthermore indicate that actual emission levels from the tailpipe can vary to a large extent from vehicle to vehicle, and that the contribution of each vehicle segment (fuel, age, technology) to the emission total of the fleet is uncertain.
Actual emissions can be decreased much faster if we do not wait for new technology to be introduced in the fleet. In this paper, a novel concept is presented to reduce emissions of the existing fleet of vehicles, by establishing and quantifying the relation between tailpipe emissions on the one hand, and owner behaviour, driver behaviour, and use pattern of the vehicle on the other. This model is utilized to estimate the potential that is available to vehicle owners to reduce the emissions from their vehicle, which can serve as input to personalised feedback to owners and drivers.

* Corresponding author. Tel.: +31 88 866 2029;
E-mail address: rene.vangijlswijk@tno.nl

2. Approach

2.1. Layered emission maps

To understand the relationship between behaviour and emissions, it is crucial to first understand the relation between the use of the vehicle and emission levels. The proposed approach starts from measurement data available at TNO, TU Graz and other institutes in Europe[†], collected using chassis dynamometers, Portable Emission Measurement Systems (PEMS) and other sensor based devices such as the TNO Smart Emission Measurement System (SEMS). These measurement data are analysed to establish a base emission map, consisting of the average emission level across the engine speed range (or vehicle speed range) and engine load range. These two parameters were chosen because emission massflows generally correlate well with engine speed and load. The extent is dependent on the compound, the fuel and the emission reduction technology though.

Figure 1 shows an example of the visualisation of an emission map for nitrogen oxides (NO_x).

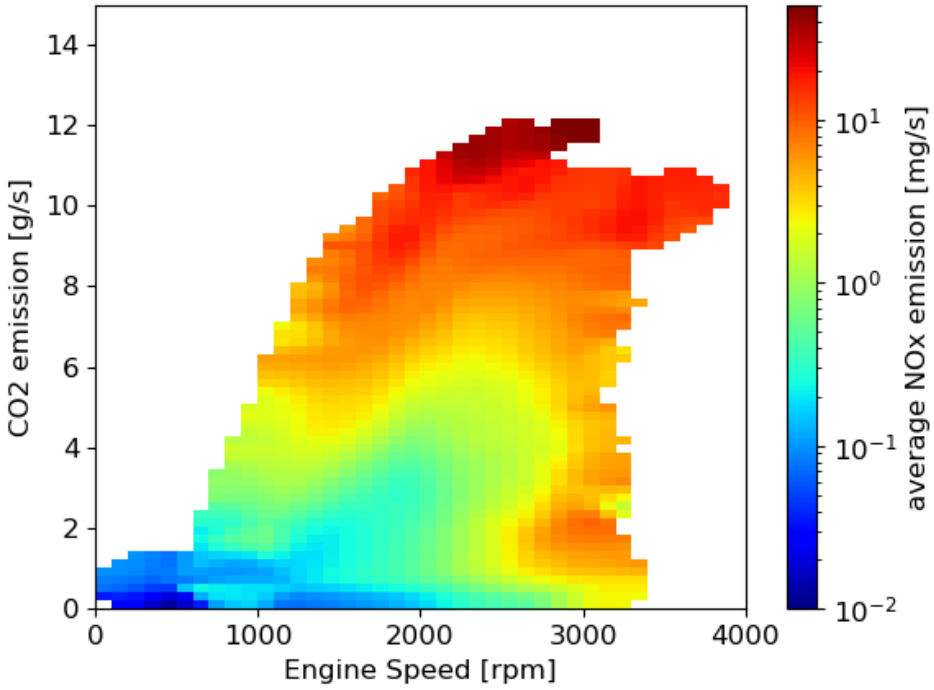

Figure 1 Example emission map of test vehicle

This base map, which is made for each pollutant, contains average emission levels at a specific engine speed and power output. Because the power output is not always available in the measurement data, the CO_2 massflow is used as an indicator for the power output, as shown in figure 1[‡].

For the base emission map, measurement data is filtered to contain only hot engine conditions.

On top of the base map, additional layers are projected. The layers represent the increase in emission levels resulting from the following factors:

- Use pattern and load:
  - Auxiliary use such as airconditioning, light, heated seats
  - Additional weight: passengers and luggage
  - Hilly surroundings
- Cold start
- Aging
- Tampering

[†] Collaboration within the European Research on Mobile Emission Sources (ERMES) network, www.ermes.eu
[‡] The CO_2 emission is dependent on the efficiency of the engine as well.

- Malfunction and maintenance

2.2. Vehicle categorisation

Since 1988, TNO has tested about 4,500 vehicles. Combined with data from other institutes, through the ERMES network, data is available for a large number of vehicle make/models. However, full coverage cannot be achieved, and should not be necessary. The emission behaviour of a vehicle is mostly related to its engine and the exhaust gas aftertreatment tailored to that engine. From monitoring data it has become apparent that vehicles with equal engines have similar emission behaviour, irrespective of its brand, model or size. Since manufacturers frequently exchange engines, and some manufacturers have several brands (e.g. VW Group), using the engine block as the distinguishing factor reduces the number of maps drastically. It is proposed to create a taxonomy of engine blocks, consisting of the following characteristics:

- Primary fuel
- Engine size in cc
- Maximum power output in kW
- Euro class
- Flag for hybrid

Considering vehicles sold in Europe over the last two decades the expected length of the engine block list is in the order of 2000 entries.

2.3. Map definition

For some vehicles, hundreds of hours of monitoring data is available, mainly for NO_x emissions. For most test vehicles and pollutants data is less complete. An interpolation tool is going to be built to translate the available data to a full emission base map. Where possible, insights of similarly designed engines is going to be used.

For the overlays for cold start and other influencing factors, it is not expected to be necessary to have a unique map for each engine block. For instance, the additional emissions from malfunction and tampering may be described sufficiently on the basis of the Euro class alone. For each of the factors the best strategy will be determined, to remain accurate but avoid unnecessary work and data requirement.

2.4. Personalised recommendations

Once the maps are available, it will be possible to analyse monitoring data from individual car drivers. Using the emission maps, behaviour can be detected that leads to high emissions, providing input for a personalised advice. The level of detail of the advice is dependent on the findings of the data analysis and mapping activities, but will encompass at least observations with respect to the use pattern (short trips, target speed on the highway) as well as event-based advice (throttle input, coasting).

2.5. Use

Present tools that give feedback on driving behaviour give generic tips to reduce emissions, and are mainly targeted to reducing fuel consumption (and CO_2 emission). The present work enables tool makers to extend to pollutant emissions, thereby making also the connection between the emission of CO_2 and the emission of pollutants. But more importantly, it can improve the level of detail of the present tools, leading to more specific instructions to owners and drivers.

3. Results

The work on the emission maps and engine block taxonomy is presently being carried out in the H2020 uCARe project. The full paper will contain results for the first set of engine blocks and an analysis of the possibilities to generate feedback to drivers and owners based on these results.

References

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