Integration of Vehicle Activity into Emissions Estimation based on On-Board Measurements for Diesel Light-Duty Vehicles

Margarida C. Coelho1*, H. Christopher Frey2, Nagui M. Rouphail3, Haibo Zhai4 & Luc Pelkmans5

1 University of Aveiro, Dept. Mechanical Eng., Aveiro, Portugal
2 North Carolina State University (NCSU), Dept. Civil & Environmental Eng., Raleigh NC, USA
3 Institute for Transportation Research and Education, NCSU, Raleigh NC, USA
4 Carnegie Mellon University, Dept. Eng. and Public Policy, Pittsburgh PA, USA
5 VITO – Flemish Institute for Technological Research – Belgium

ABSTRACT

Diesel vehicles market is expanding globally, since these vehicles are attractive in terms of improved fuel economy.

Portable Emission Monitoring Systems (PEMS) indicate that emissions are not directly proportional to vehicle miles traveled, but are episodic in nature, with high emissions events coinciding with periods of high acceleration and speed.

But... can current methodologies that correlate vehicle activities with emission estimation for light-duty gasoline vehicles (LDGVs) be extended to diesel vehicles (LDDVs)?

Focus: Assess whether current methodologies (namely, Vehicle Specific Power – VSP – approach) that integrate vehicle activities with emission estimation for LDGVs can be extended to LDDVs.

Secondary objective: Compare fuel use and emissions between LDDVs and LDGVs.

METHODOLOGY

Portable Emission Measurement System (PEMS) in LDDVs & LDGVs (Second-by-second data)

Speed profiles & Emission rates (g/s)

Vehicle Specific Power (VSP) approach

VSP = v [1.1 a + 9.81 sin(α) tan(grade)] + 0.000302 v^3

ANOVA

RESULTS

- ANOVA ⇒ Evaluation of statistical significance of the explanatory variables on emission rates
  - Strong correlation between speed and facility type, independent of the vehicle.
  - Generally speed and VSP are significant factors for emissions rates, and the significance is not as high for facility type.
- Average emission rates for EURO II light commercial diesel vehicle Citroen Jumper 2.5D & EURO III family-size diesel car Skoda Octavia TDI 90 HP:
  a) CO
  b) CO
  c) NOx
  d) HC
  e) PM

CONCLUSIONS

1. VSP is highly correlated with variability in second-by-second emissions of pollutants from diesel vehicles.
2. The VSP method that was previously developed for LDGVs was found to be applicable to LDDVs as well.
3. Modal diesel CO, NOx, HC, and PM mission rates increase for positive VSP for the tested diesel vehicles.
4. Modal CO emission rates for the tested diesel vehicles increase for the Jumper but the trend is less clear for the Octavia. CO emissions appear to be more affected by speed changes and high accelerations compared to other pollutants.
5. CO2 emission rates are higher for the gasoline Polo compared to the diesel Octavia, even though the gasoline vehicle is newer and smaller ⇒ this is consistent with the expectation that LDDVs are generally more fuel efficient than LDGVs.
6. NOx emission rates are higher for the diesel Octavia than for the gasoline Polo, but the Polo vehicles generate higher CO emission rates ⇒ this is consistent with the expectation that LDDVs produce higher NOx and lower CO emissions than LDGVs.

MAIN CONCLUSION:

VSP approach can be used to aggregate micro-scale data from LDDVs to produce driving cycle-based emission estimates.