Unregulated Gaseous and Particulate Emissions During Active Regeneration of Diesel Particulate Filters

M.Leblanc (1), L.Noël (2), B.D'Anna (3), A.Boreave (3), B.R'Mili (3), S.Raux (1), Ph.Vernoux (3)

(1) IFP Energies nouvelles, Rond-point de l'échangeur de Solaize, BP 3, 69360 Solaize, France
(2) IFP Energies nouvelles, 1 & 4 avenue de Bois-Préau, 92852 Rueil-Malmaison Cedex, France
(3) Institut de Recherches sur la Catalyse et l'Environnement de Lyon, UMR 5256, CNRS, Université Claude Bernard Lyon 1, 2 avenue A. Einstein, 69626 Villeurbanne, France

Context and Objectives

- Diesel Particulate Filter is an efficient solution to drastically reduce particulate emissions
- Diesel soot accumulated inside the DPF must be burnt in average every 600 to 800 kms
- This process named «active regeneration» leads to an increase in pollutant emissions

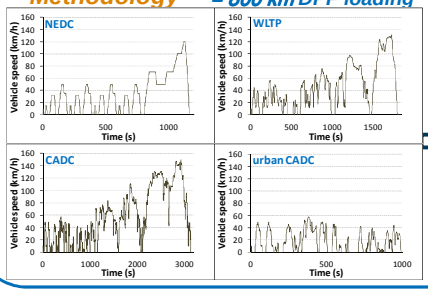
⇨ These gaseous and particulate emissions need to be better defined

Vehicles description

Engine	€5 1.5 Diesel	€5 1.6 Diesel
After-treatment	DOC + cDPF	DOC + FBC
Location	underfloor	close-coupled
Mileage *[km]*	13 000	27 000

Methodology

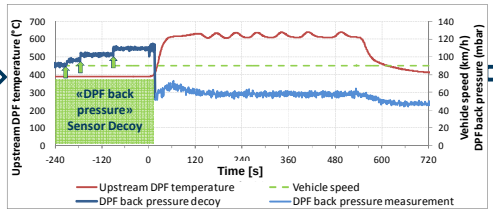
≃ 800 km DPF loading



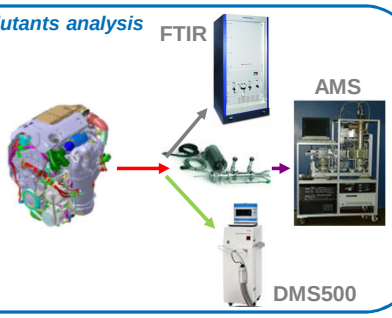
Active Regeneration triggering

Vehicle speed = 90 km/h

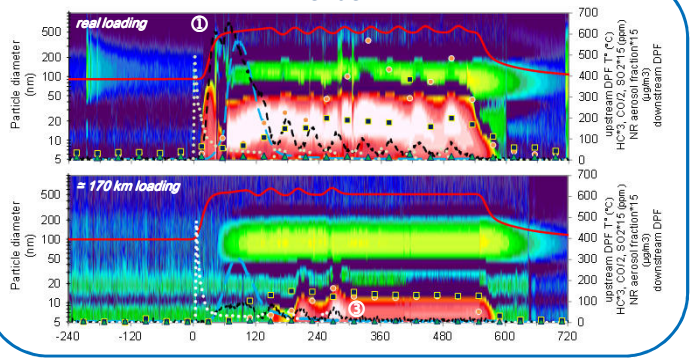
upstream DPF Temperature ≃ 390 °C before regeneration



Pollutants analysis



Vehicle A



Results – Control strategies

- The active regeneration's progress of the two vehicles is similar but their control strategies present different accuracies.
- Regeneration's durations are comparable with length ranging from 8 (vehicle B) to 9 minutes (vehicle A). Moreover, they are more variable with vehicle A.
- Targeted temperatures are close with average upstream DPF temperature of 610 ºC during the whole regeneration.
- The emissions are widely variable, whether it is between the vehicles or between different regenerations with the same vehicle.
- The vehicles characteristics are different (engine, catalysts technologies volumes and locations, actuators,…) with noticeably different mileages and in use lubricants, the observed emissions should not be related to the after-treatment technology only.

Particulate Number
1,E+3 1,6E+4 2,5E+5 4,E+6 6,3E+7 1,E+9
dN/dlogdp/cc

Non refractory aerosol fraction
⇨ Sulfates
⇨ Organic
⇨ Nitrates

DPF temperatures and exhaust gases
Unburnt hydrocarbons
CO ; Upstream DPF T
SO2 ; Downstream DPF T°

Results – Emissions

➢ *Gaseous emissions*

① ⇨ SO_2 is more emitted and variable with vehicle A due to successive desulfations of the DOC, linked to the temperature over/undershoots.

➢ *Nucleation mode*

② ⇨ For the two vehicles, the combined effect of DPF soot load, catalyst poisoning and control strategies contribute to its appearance (presence or delay) and importance (quantity and width).

③ ⇨ The post-injection control can promote the nucleation particles release because of unburnt hydrocarbons, saturation index and after-treatment device temperature increase.

➢ *Accumulation mode*

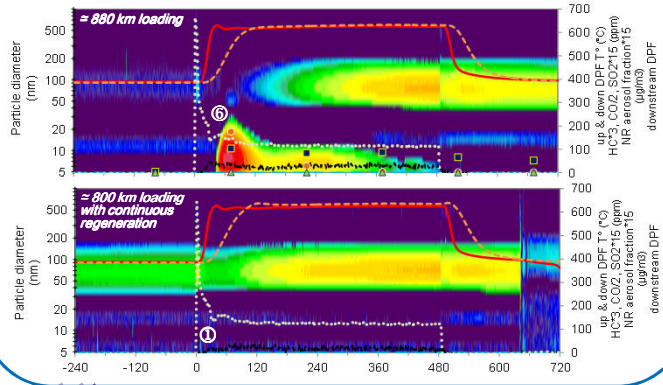
④ ⇨ The accumulation mode is increased during the active regeneration, due to the soot cake removal and the associated filtration efficiency decrease.

➢ *Composition*

⑤ ⇨ The volatile fraction of PM mainly consists in sulfates and various organic species.

⑥ ⇨ These compounds coexist on the two modes. Sulfates further seem associated to the nucleation particles during the active regeneration events.

Vehicle B



Acknowledgements

This study has been performed in the framework of the CAPPNOR project funded by the French Environment and Energy Management Agency (ADEME) in collaboration with IRCELYON

Ongoing work

- Emissions comparison of the two €5 Diesel vehicles with a €5 Gasoline Direct Injection (GDI) vehicle during different driving cycles including particles morphology (TEM) and Polycyclic Aromatic Hydrocarbons (PAHs) composition of the particles
- Pursue the work on €6 Diesel vehicles (SCR and NOx trap technologies) and Secondary Organic Aerosols (SOA) precursors

INSTITUT CARNOT IFPEN Transports Energie

The IFPEN Transports Energie Carnot Institute develops efficient, clean and sustainable technological innovations in the fields of powertrain and propulsion systems, energy sectors and industrial thermal processes with CO_2 capture.

Contact

Mickaël LEBLANC

Tel : +33 4 37 70 27 44

mickael.leblanc@ifpen.fr

IFP Energies nouvelles