

To use or not to use a Fuel-Born Catalyst ? (FBC)

A new fairy tale ???

by

Jacques LEMAIRE

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Is it a fairy tale ?

Once upon a time there was somewhere in Europe a passenger car powered by a diesel engine which produced so little particulates that some people said that it was cleaning the ambient air when cruising through it...

The initial small family increased up to 133,000 commercial vehicles by the end of 2001, just a little more than one year after the real introduction on the European market (the very first 607 was launched in May 2000).

All the jealous competitors were expecting a resounding collapse : the air was full of acrimonious remarks "It could not work !" " Can you imagine that a French car maker can do it ? "The recall is for tomorrow" ...

More than one year is now behind us and not a single return was reported.

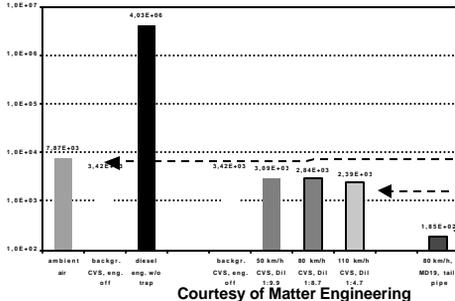
It is not a fairy tale but real life

So sorry for this disillusion !

The Peugeot 607 and its family

The family of a cars currently equipped is regularly expending:

- Peugeot 607, 406 and now 307
- Citroën C5 and soon Xantia
- future models to come ... about 250,000 expected in 2002



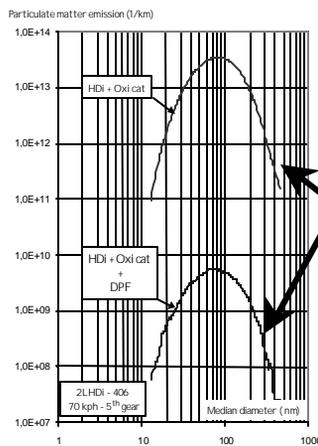
the performances :

Yes one can say that the exhaust contains a lower number of PM than the ambient and dilution airs

- ambient
- dilution air in the CVS tunnel
- exhaust of the 607

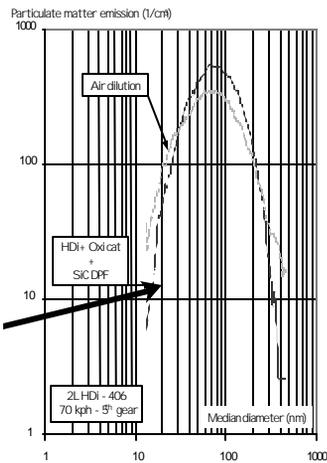
Performances ... more →

Peugeot cars : performances ...



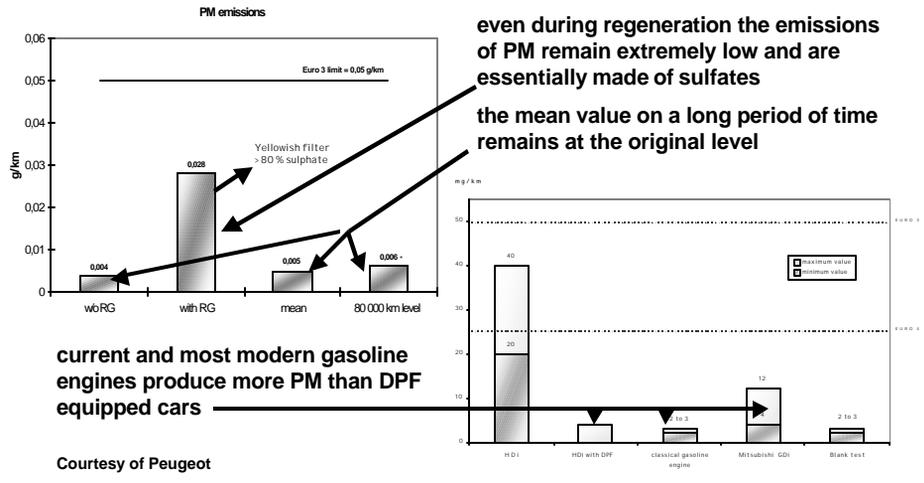
number of PM reduced by 99.99%

less ultra fine PM than in ambient air

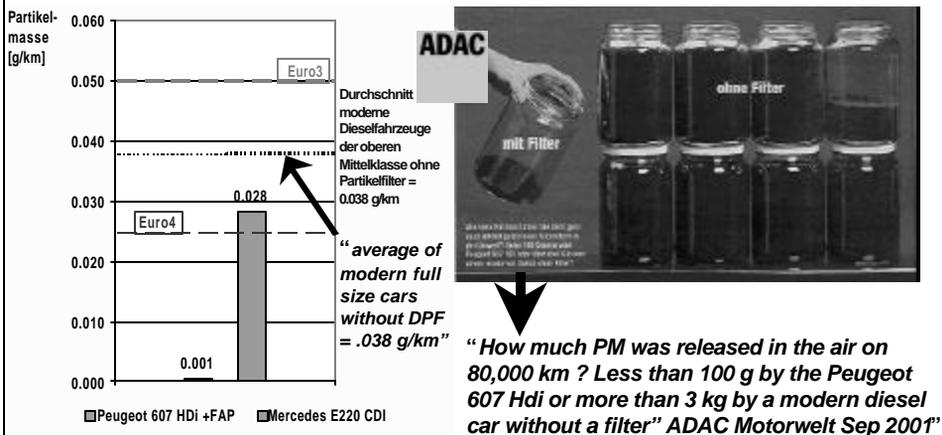


Courtesy of Peugeot

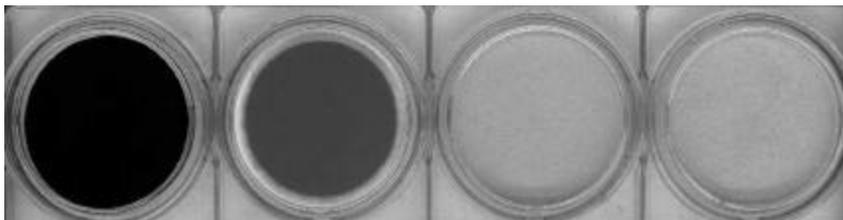
Peugeot cars : performances ...



Peugeot cars : performances ... something visual



Something visual (continued)



powertrain 605 - DK5
PM : 0.1 g/km

605 - HDi
PM : 0.035 g/km

605 -HDi + DPF
PM : 0.004 g/km

Dilution air
PM :0.004 g/km

Particulate Matters over the MVEG (full European driving cycle)

Courtesy of Peugeot

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How much of these performances are related with the FBC ?

- **the retention of soot is the result of a good selection of the filter media**
 - it exists different excellent filter media able to do it
 - they exist for many years
- **so far, the only unresolved issue was to design a reliable regeneration of the filter applicable on a passenger car**
 - the FBC is a key part of the solution
 - solution implies a system approach in which exhaust control is integrated with engine management

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Why an FBC (*) is unique ? (1)

- **At one and the same time a FBC is**
 - a combustion improver which can reduce PM out of the engine up to 50%(average of 20/25%) which means less work for the filter
 - an active oxidation catalyst for burning the carbon being accumulated in the filter
 - this catalyst is finely dispersed in the soot, by this dispersion surface of contact between carbon and catalyst increases
 - this catalyst is less active than precious metal, but the increased surface of contact compensate this deficit of activity
 - as a consequence of lower activity, the catalyst is more selective and avoids the formation of SO₃ and NO₂ and related compounds
 - being generated at each combustion, catalyst is not deactivated by aging : FBC has low sensitivity to sulfur in fuel or lubricants

(*) FBC means cerium, iron and mixtures based on these elements, copper is no considered appropriate

Why an FBC (*) is unique ? (2)

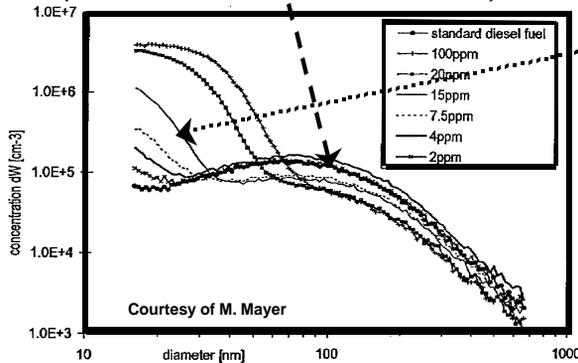
- **FBC have also positive catalytic activity on non regulated emissions**
 - FBC contribute to reduce PAH
 - FBC reduce formation of sulfates when sulfur is in fuel
 - appropriate FBC do not contribute to formation of dioxins, furanes, and nitro-PAH (copper to be avoided for dioxins)

Even if no scientific explanation was found so far , it should be noted, among the numerous data of the VERT program, that some FBC improves the filtration capacity of commercial wall flow filters by about one extra order of magnitude (99 -> 99.9%of the numbers of PM).

A FBC can be a combustion improver which reduces soot

Reduction of soot mass can be as high as 50 %

(this test is made with a thermodenuder)



BUT

at the expenses of creating a large number of ultra fine PM

these ultra fine PM are not volatile (as usually made at high temperature in a filter), but solid residues which were identified by chemical analysis as metal oxides

the mass of this ultra fines is very low, but their number is very high

which health impact ???

overall benefit ???

Why FBC were not well accepted ?

- it creates residues containing metals, a potential health risk if residues in the air
- these residues contribute to plug filters
- its activity is too low to achieve totally passive regeneration
- its addition to the fuel requires special devices

All these issues can be overcome and somewhat transformed in advantages

Residues emitted in the air ?

- **Case I : no filter, all residues are going to atmosphere as ultra fine metal containing PM or as deposits on larger carbon PM.
*Better to avoid***
- **Case II : FBC is associated with efficient filters, all PM (including the finest) trapped
Health risk associated to metals residues is eliminated ()***

(*) In addition filters capture also ashes from lube oils (Zn, Ca, P, Mg, ...) and wear residues (FE, Cr, V, Ni, Cu, ...)

Residues are plugging filters

- **could look strange BUT FBC's residues are not the main cause of plugging : filters without FBC also requires cleaning from ashes**
- **the main contributors to plugging are Ca and Mg sulfates which, combined with water, produce clogging cements**
- **cleaning by hot water easy to proceed at intervals of 50,000 to 75,000 miles (current and future intervals for the Peugeot)**
- **the most problematic residues to be disposed after washing are heavy metals**

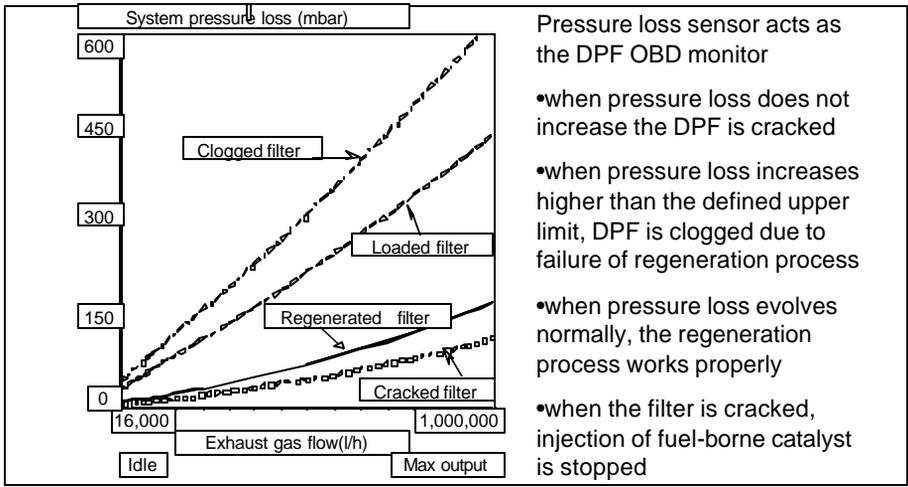
FBC's Activity too low for passive regeneration of filters

- today (at last !) passive regeneration is no more a prerequisite
- lower activity increases selectivity and avoid formation in excess of SO₃ and NO₂
- level of activity good enough for system approach (passive regeneration secured in critical cases) without too high penalty
- system approaches (passive - active) limit risks of filter destruction and include OBD

Addition of FBC to fuel requires special devices

- on-board dosing preferred, to be sure that only vehicles equipped with filters will receive FBC
 - on-board dosing systems are fully automatic (no need of human care)
 - with concentrated FBC, intervals of maintenance (refill) are large, could be identical to interval between cleaning
 - on-board dosing gives the right amount of active catalytic phase to each engine
 - an OBD based on pressure sensors can be coupled to the system to stop addition of FBC when filter not properly working (see following slide)

OBD coupled with filter system



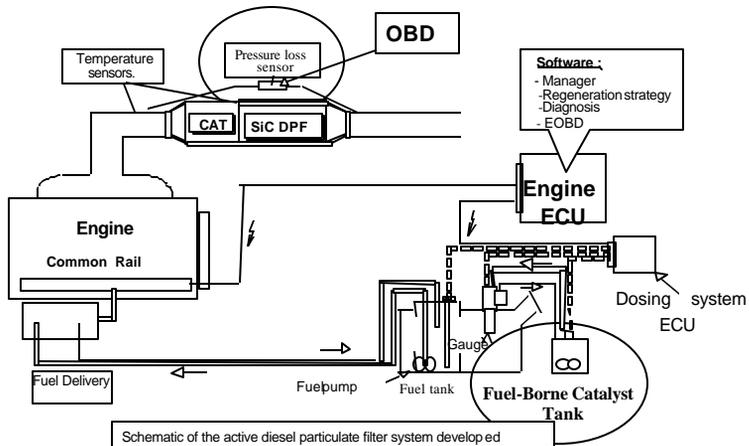
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Courtesy of PSA / SAE 2000-01-0473

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PSA PM Filter System for LDV



Courtesy of PSA / SAE 2000-01-0473

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Other dosing systems

- **For fleet operators having a large number of identical engines an outside dosing at the curb side is possible**
 - it requires a special nozzle including an identification device in order to deliver the right dose to the right vehicle
 - it does not have OBD, and then require regular checking of the filter

Are FBC applicable to retrofit ?

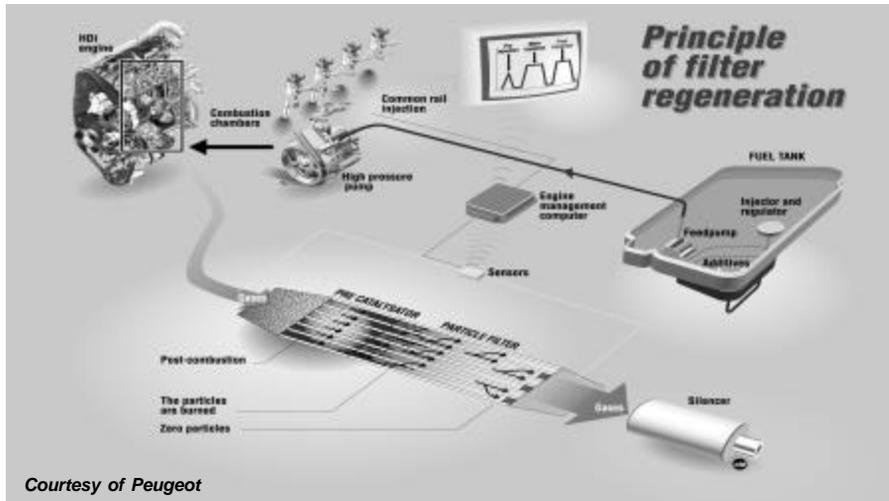
- **the technical answer is certainly YES !**
 - through a system approach securing the regeneration during critical phases, necessary energy being brought by electricity, fuel injection or engine rebuilt
 - in combination with other technologies to secure their operation in their own critical phases

BUT

**the critical question remains cost effectiveness :
are so costly added exhaust controls justified on
very old vehicles ?**

when compared with engines early retirement ?

Peugeot system at a glance



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Conclusions (1)

- FBC shall be part of integrated systems
- FBC are well adapted to series production
- FBC have to be used in combination with efficient filters
- when used in appropriate surroundings FBC improve the control of regulated and unregulated emissions
- commercial cars with systems based on FBC have demonstrated both outstanding efficiency and exceptional reliability

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Conclusions (2)

- **FBC not to be confused with additive with functional activities including combustion improvers : additives residues are emitted in air while residues of FBC are trapped**
- **systems based on FBC can be applied to retrofit**
- **FBC can help other retrofit technologies to overcome their critical phases**
- **FBC have a lower sensitivity to sulfur in fuels and/or lubricating oils than precious metal catalysts**