

# Exhaust Gas Aftertreatment

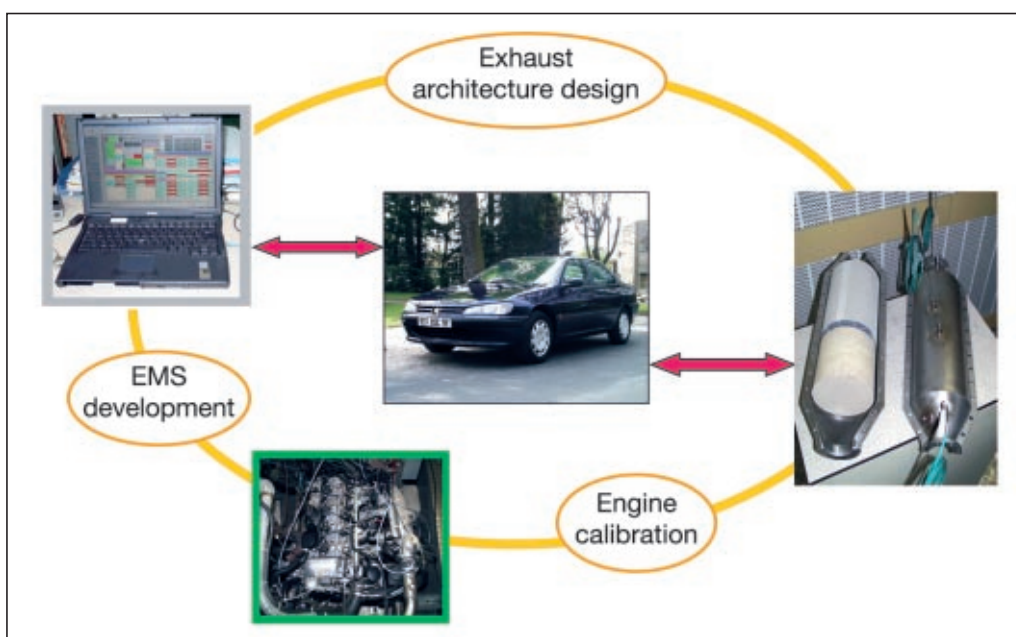
## IFP Offer

### INTRODUCTION

IFP capabilities offer a wide range of expertise and services in the field of exhaust gas aftertreatment, from complete systems optimization to fine analysis, including EMS strategy design.

Applications include passenger car, LD, HD vehicle, new vehicles and retrofit.

The area benefits from the great variety of IFP's competences: chemical kinetics, catalysis, materials, electronics, automation, fuels, lubricants and engine technology.

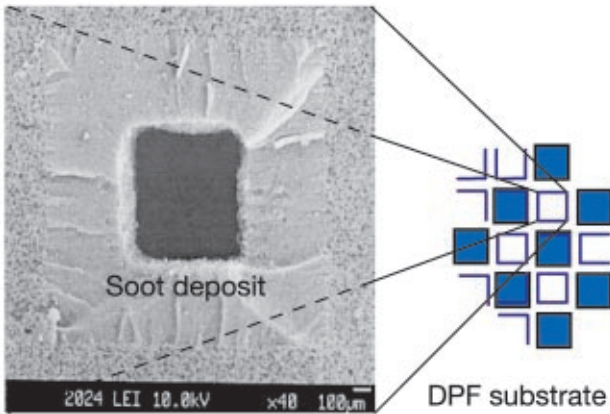


*DPF, NOx adsorber, 4-way catalyst Diesel vehicle demonstrator from exhaust line to engine control design*

In various exhaust gas aftertreatment working areas (DPF, urea SCR, NOx adsorber, Diesel 4-way catalysis, systems for retrofit), IFP is leading advanced developments in:

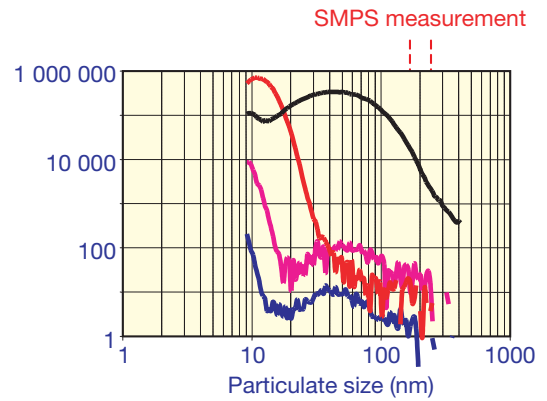
- aftertreatment control strategy design,

- DPF + NOx adsorber system development,
- reliability and durability evaluation of aftertreatment systems.



Soot deposit visualization

Electron microscope



Particulate number SMPS measurement

## AFTERTREATMENT CONTROL STRATEGY DESIGN

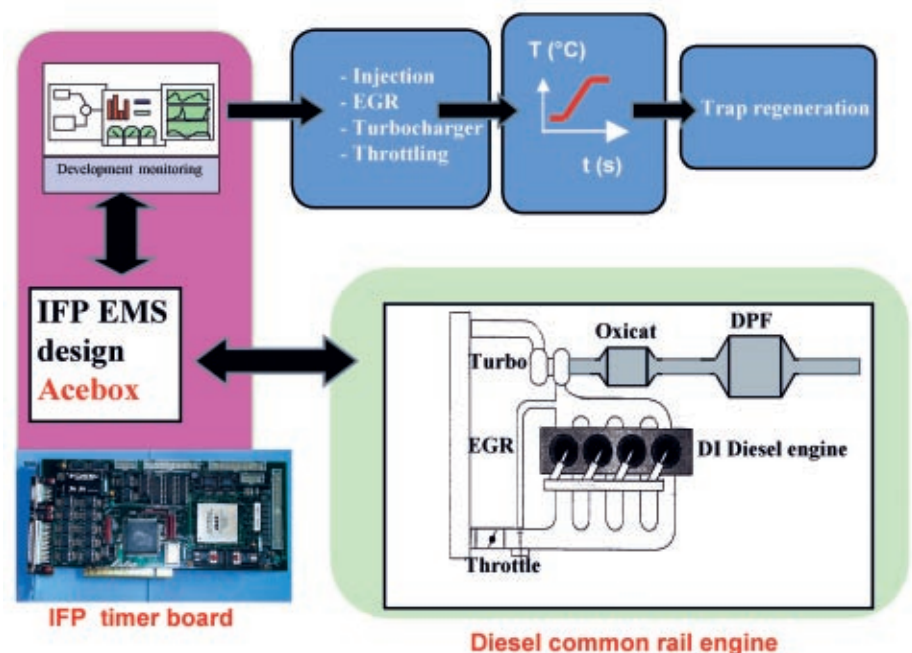
### Example: DPF regeneration control

IFP has designed its own tool for EMS strategy design: the ACEbox, particularly convenient for adapting aftertreatment solutions.

The advanced aftertreatment devices imply sophisticated control strategies.

IFP can develop control algorithms dedicated to:

- fuel-borne additive DPF regeneration,
- catalysed filter regeneration,
- NOx adsorber destorage and deSOx,
- 4-way catalyst control.



## DPF + NO<sub>x</sub> ADSORBER SYSTEM DEVELOPMENT

*Example: heavy duty application*

Technological solutions for heavy duty vehicle depollution are mainly:

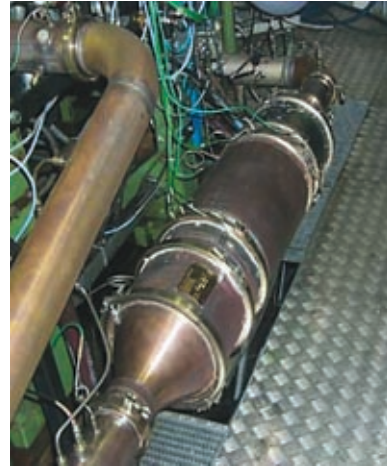
- urea SCR + DPF,
- NO<sub>x</sub> adsorber + DPF

IFP has developed a consistent approach to optimize strategies for accurate NO<sub>x</sub> adsorber regeneration management.

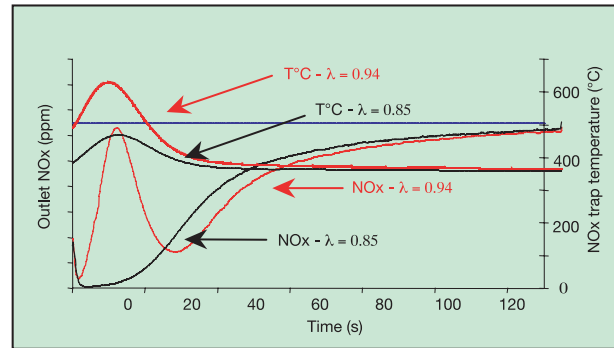
A key parameter is the regeneration A/F ratio during regeneration which influences destorage kinetic.

This approach has demonstrated the following potential performance:

- EURO IV NO<sub>x</sub> = 2 g/kWh,
- fuel penalty < 2%.



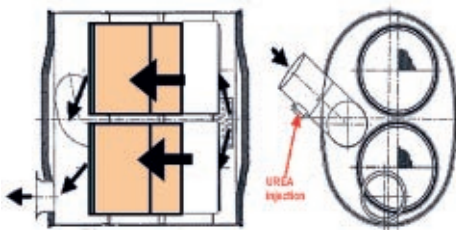
*Exhaust line*



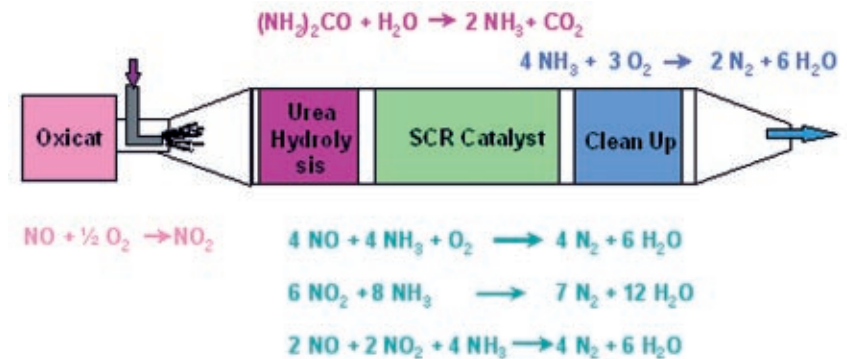
*The best NO<sub>x</sub>/fuel penalty treatment compromise is obtained at lower λ.*

## SCR DENO<sub>x</sub> CATALYSIS WITH UREA

IFP is conducting research and development programs on SCR deNO<sub>x</sub> catalysis, from performance evaluation to exhaust integration, control strategy design, and study of SCR + DPF coupling.



*Example of catalyst implementation in SCR muffler (Volvo Powertrain source)*



*Reductant injection: ammonia (urea)*

## AFTERTREATMENT SYSTEM RELIABILITY AND DURABILITY TESTING

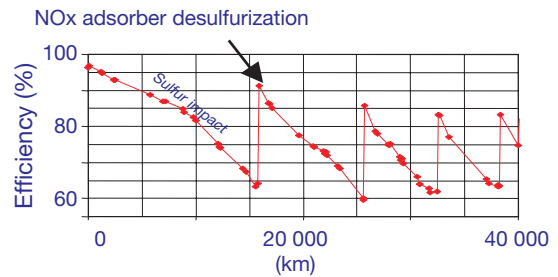
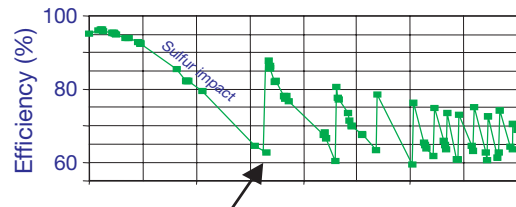
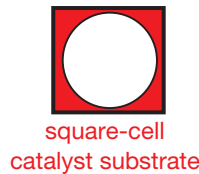
*Example: sulfur storage in NOx adsorbers*

IFP handles all types of long-term durability testing for aftertreatment systems evaluation.

The durability cycles applied incorporate realistic control strategies, such as A/F ratio tuning for NOx adsorber control.

The main tracked phenomena are:

- catalyst poisoning (sulfur, metal, etc),
- thermal aging,
- fuel dilution in oil, etc.



The example shown here illustrates the better durability of hexagonal-cell NOx adsorber substrates.

IFP has developed advanced aging

cycles including representative control strategies to test aftertreatment durability.

## IFP POWERTRAIN ENGINEERING FACILITIES AND TOOLS DEDICATED TO EXHAUST AFTERTREATMENT

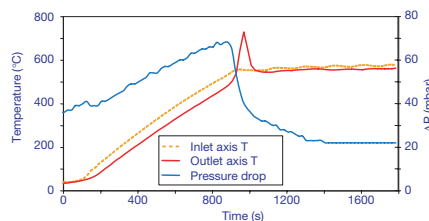
*Aftertreatment models*

*Example: DPF regeneration model*

IFP has developed various models:

- 3-way catalyst/Oxicat,
- SCR deNOx catalysis,
- DPF,
- NOx adsorber.

Those models are used to support both exhaust line design and control strategy development.

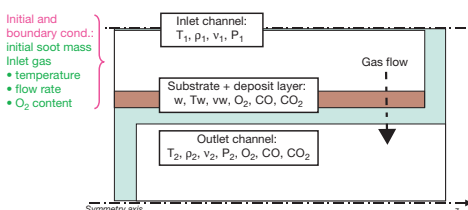


**A typical regeneration pattern**

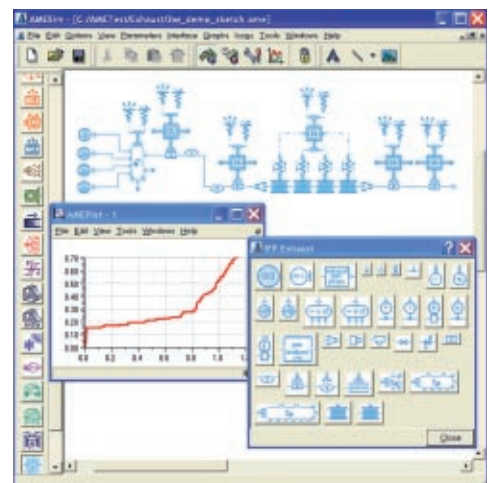
Those models developed by IFP are fully integrated in the AMESim simulation platform, marketed by IMAGINE as the IFP-Exhaust module.

Key features:

- easy GUI,
- re-usable models,
- strong simulation algorithms for stiff kinetic mechanism.



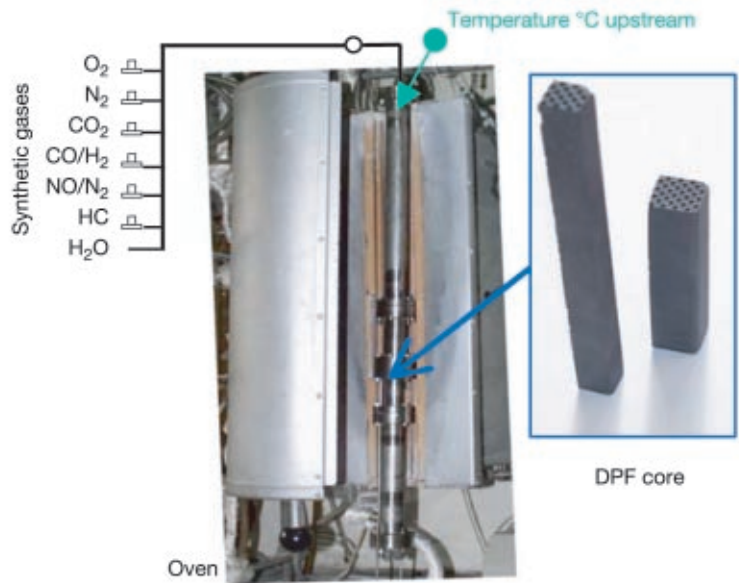
**Example of IFP model: DPF regeneration**



**Synthetic gas installation for catalyst evaluation**

Based on fundamental studies on synthetic gas installations or engine test rigs, IFP can establish fundamental kinetic laws.

This installation is operated for catalyst benchmarking as well as for catalyst or DPF model development.



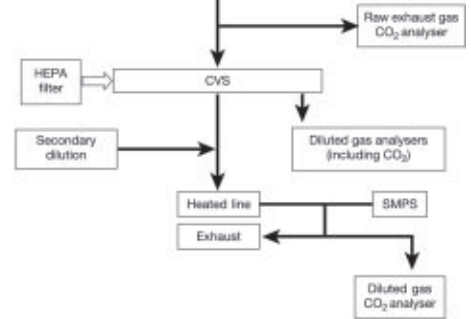
**Synthetic gas rig**

**Vehicle testing for regulated and unregulated pollutants**

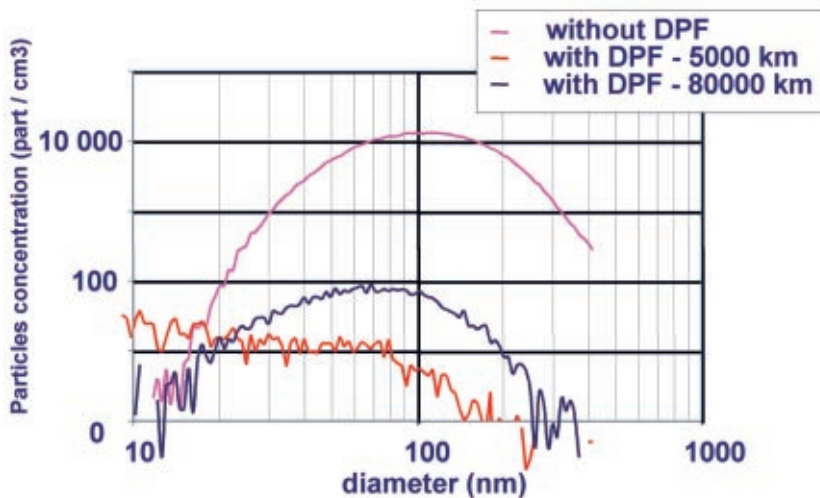
IFP has the capability to handle regulated and unregulated pollutant evaluations, including fine particulate analysis, thanks to 3 chassis dynamometers.

The equipment available at IFP for fine particulate evaluations includes:

- IFP microtunnel,
- SMPS,
- ELPI,
- PM10 and PM2.5 impactors,
- thermodenuder,
- diffusion charger.



**Sampling device for fine and accurate particulate sizing**





ISO 9001: 2000 certification for  
all IFP Powertrain Engineering activities.

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