Active DPF System for Nanoparticle Filtration and NO2 Reduction in Practical Use with Low Exhaust Gas Temperatures

Hanspester Mayer, Dipl.Ing. MBA
PURItech GmbH & Co KG

Task:
Development and practical use of an active exhaust gas cleaning system for effective nanoparticle and simultaneous reduction in gaseous pollutants NO, NO2, HC and CO with low exhaust gas temperatures as with inner city vehicle applications.

Object:
PURItech diesel particle filter with combined active-passive filter regeneration, a nanoparticle reduction of 99,7%, a NO2, HC and CO reduction of over 90% in practical use with vehicles with low-load operation or in city traffic.

Summary:
Conventional catalytic coated wall-flow filters very effectively reduce particles, CO and HC emissions. So far, it has been unusual that a catalytic active particle filter could also reduce nitrogen oxides and especially NO2 with a high degree of efficiency in the range of over 90% without additional liquids such as ammonia, with low exhaust gas temperatures, e.g. engine idling.

PURitech has further developed an active, self-regenerating particle filter system with a high nanoparticle reduction of 99,7% and thereby, together with a high NO2 reduction, also achieved a reduction in the total NOx emission.

This filter system has proven itself in practical use and reduced above all, the NO2 emissions, already at exhaust gas temperatures of between 120° - 230°C.

To support the functioning and for confirmation of the results, the Technical University in Graz tested a city bus (Mercedes Benz O530 Citaro) on a roller dynamometer with a low temperature city cycle and checked the functioning (attachment: Inspection Report by the FVT TU Graz).

This report confirmed that the PURItech NO2 diesel particle filter had reduced the normal pollutants PM, HC, CO and also NOX (NO2): NOX was reduced in total by 21% and NO2 by 61% compared with the raw emissions in a measured test cycle without activation of the diesel injection (active component of the filter system). This reduction was made during a dynamic driving cycle in which the average exhaust gas temperature was only 230°C.

The filter system can be retrofitted in vehicles and machines without changes to the engine and without the addition of operating fluids. With its high reduction in the number of nanoparticles and simultaneous NOX and NO2 reducing function at low exhaust gas temperatures, the filter system presents a solution in the decreasing of inner city particulate matter and NO2 emission loads.

Compared with SCR technology that requires an exhaust gas temperature of over 230-250°C for the reduction of NO2 emissions, the reduction of NO2 using the PURItech DPF System begins at 120°C and presents a considerable advantage in the reduction of the high NO2 emissions in inner cities. Furthermore, with the PURItech DPF System, the particulate matter concentration in the ambient air is decreased due to the high nanoparticle reduction. SCR Systems cannot achieve this as they do not show significant nanoparticle reduction.

Environmental Problems:
With the introduction of the limit of 40mg/m3 from 01.01.2010 in German inner cities, the seriousness of the problem has become apparent. In 120 German cities, the NO2 concentrations are by far exeeded – the front-runner is Stuttgart with a yearly NO2 average of 120 mg/m3.
Due to its higher density, it is concentrated at ground level. Those especially affected by high NO2 loads are those whose health is already damaged by respiratory problems, such as children and

juveniles. Heart disease and even death in the population is rising with the increasing NO2 emission load.

Particulate matter emissions in the form of diesel nanoparticles are classified as carcinogenic and massively damage the health of the exposed population because of their mutagen effect. The financial evaluation of the damage to health exceeds many comparative calculations with the volume of investment for the retrofitting of particle filters.
Environmental zones have been set up throughout Europe to reduce particulate matter emissions. By 2012, the relevant EU guidelines on the limiting of particulate matter emissions limits must be implemented. Accordingly, the number of environmental zones in the EU increases until 2012. To comply with the EU guidelines, access restrictions to centres of population are being set up that prohibit entry to older vehicles that do not have a retrofitted diesel particle filter.
Unfortunately, national guidelines on the certification of retrofitted filters – in Germany „Attachment 27“ – also allow for the retrofitting of „open“ filter systems that achieve no substantial decrease in the nanoparticle emissions from diesel vehicles. An effective reduction in nanoparticle emissions can only be achieved with “closed” filter systems that have a high particle concentrate deposition rate of over 99%.

To lower the burden on health from from diesel exhaust gas, exhaust gas cleaning systems that effectively reduce the NO2 emissions as well as the number of nanoparticles are therefore to be preferred.

Technological Conflict:
A considerable portion of the NO2 emissions in cities is caused by traffic, especially by older commercial vehicles and busses. Until now, attention has been paid to the reduction of pollution components CO, HC and PM which can be reduced by platinum-containing diesel particle filters or in combination with platinum-containing oxidation catalysts. Hereby, so-called “CRT systems” are used as well as “open” filter systems that considerably increase the NO2 proportion in comparison with engine raw emissions, especially with low exhaust gas temperatures.

With new vehicles, DPF systems combined with SCR systems can be used to reduce the NO2 and nanoparticle emissions. The SCR technology requires a urea water solution in order to function. However, with exhaust gas temperatures below 230°C, the function of SCR systems is not assured, the urea dosing system mostly remains switched off.

In addition, with combined systems, the use of „open“ filter substrate is preferred which does not essentially reduce the particle proportion or the nanoparticle concentration.

With commercial vehicles and busses, the exhaust gas temperatures of 230-250°C that are required for functioning usually fall short due to stop-go operation in traffic. The use of an SCR system in traffic with reference to NO2 reduction is therefore to be viewed critically.
Which technical solution is then applicable and effective under these unfavourable conditions?

Technical Solution:
An ideal technical solution would be an exhaust gas cleaning system that:
- function at exhaust gas temperatures below 230°C in practical application
- reduces the nanoparticle concentration
- simultaneously reduces the CO, HC, NO- and NO2 emissions
- is easy and economic to retrofit.

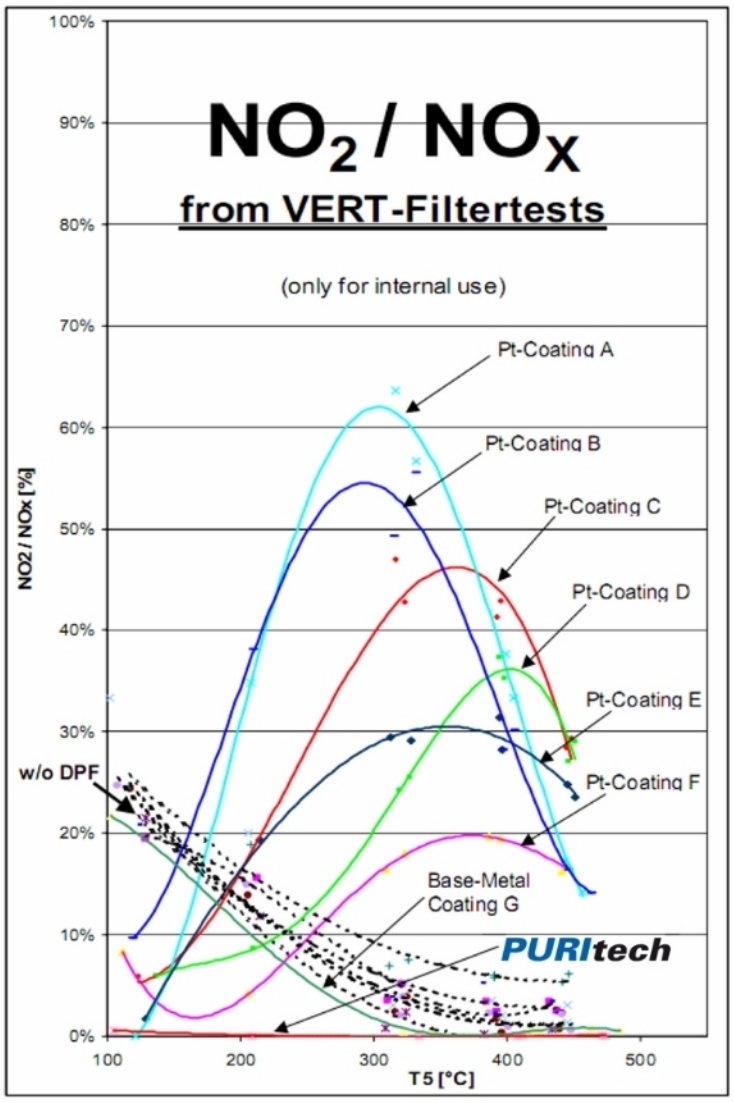
This technical solution is presented with the active PURItech filter system with high nanoparticle and NO2 reduction.

PURItech
ABGASTECHNIK – EMISSION TECHNOLOGY

Diesel particle filter with combined regeneration and NO_2-reduction

The PURItech filter system achieves an almost complete elimination of the NO2 emissions within all engine operating conditions. The test results of the Swiss VERT approval /VSET test) demonstrated this fact.

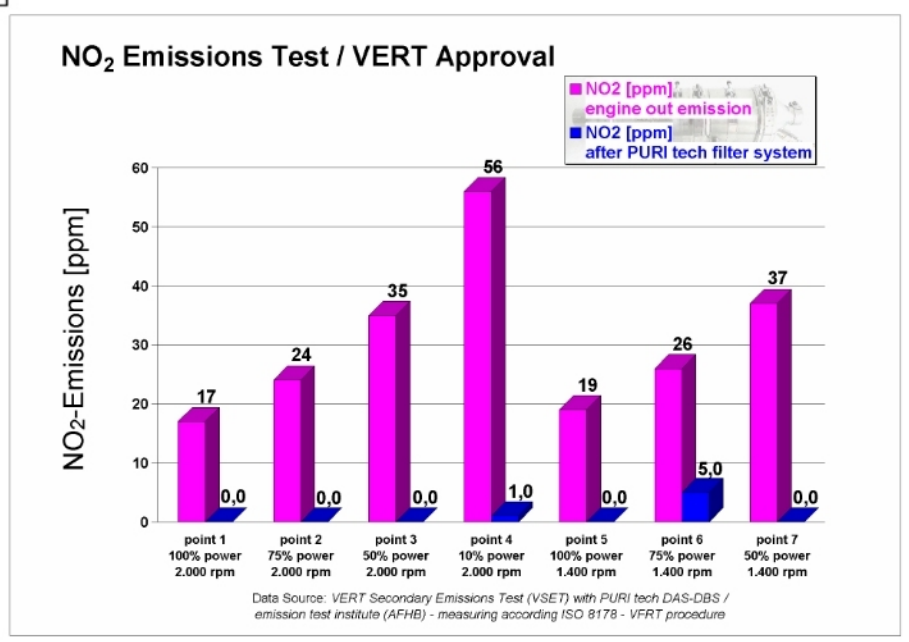
The test report of the VERT approval summarizes:



"The NO2 value was extremely low. A very impressive result with this filter system. These test results clearly demonstrate that efficient oxidation of the pollutants CO and HC in the diesel exhaust gas is in fact possible and quite effective without automatically increasing NO2 emission.
Based on these findings it can be concluded that with these excellent reduction rates of HC, CO and NO2 this filter system successfully contributes to the elimination of their harmful effects for health." Source: VSET (VERT Secondary emission Test)

PURItech filter systems allow you to be on the safe side for the future requirements for low NO2 emissions of DPF systems:

+ Reduction NO2 emissions: > 90%
+ Reduction nano-particles: > 99,7%
+ Reduction CO-emissions: > 95%
+ Reduction HC-emissions: > 99%



PURItech GmbH & Co. KG
Badstraße 26
79761 Waldshut-Tiengen
Germany