

Media communiqué

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On the test bed: How efficient are retrofitted exhaust gas particle filters on diesel motors?

Not all particle filters are equal

A study conducted by Empa shows that diesel engines with particle filters fitted after manufacture emit about 40 per cent less particulate matter than those without filters. This is, however, significantly less efficient than the performance of production series filters fitted during engine manufacture, which remove more than 95 per cent of the minute particles from the diesel exhaust gas. Furthermore, despite claims by the manufacturers to the contrary, retrofitted filters can increase fuel consumption by up to 3 per cent, depending on the driving cycle.

The problem of fine particulate matter in the atmosphere is, as always at this time of year, on everyone's lips. In the Magadino valley in Tessin concentration values of double the legal limit have been measured over the past few days. One source of these particulates is motor vehicles, in particular those with diesel engines which emit significantly higher quantities of soot than their petrol-fuelled counterparts. Particle filters, fitted to the engines during manufacturer and available for some years now, can help solve the problem. These series production or so-called OEM particle filters (for "Original Equipment Manufacturer") are "closed" types, where the diesel exhaust gas must pass through the wall of a ceramic filter. The pore size of the ceramic used is typically about 20 micrometers, and earlier measurements made by Empa showed that these kinds of OEM filters remove over 95 per cent of the smallest particles from the exhaust. The price which has to be paid for cleaner exhaust gas is, however, a slight increase in fuel consumption, because the motor has to work a little harder to overcome the resistance created by the filter in the exhaust gas' path.

But what is to be done with all those diesel vehicles which do not have a particle filters? Retrofitting is the watchword; various manufacturers offer retrofit filter kits or "soot catalysers". These so-called "open" filters have pore or channel diameters of about a millimetre, and their filtering capability derives from the fact that the particulate matter adheres to the walls of the pores and remains attached to the filter surface. Even so the manufacturers claim a removal efficiency of up to 70 per cent, and that too without any increase in fuel consumption.

Working together with the Touring Club of Switzerland (TCS), Claudio Ruedy und Silke Weimer of Empa's Internal Combustion Engines Laboratory wanted to find out whether these retrofitted particle filters actually fulfill the promised made by their manufacturers. They measured the exhaust emissions of a 2004 VW Touran vehicle in various driving situations simulated on the Empa dynamometer. Among other parameters they collected data on the mass and number of particles in the exhaust gas and with the help of a "Scanning Mobility Particle Sizer System" they determined their sizes as well. "We wanted to see if the retrofitted filter also removed the smallest particles with diameters under 20 nanometers, which are believed to be particularly harmful for to health," explains Ruedy.

The good news is that the retrofitted filter which they tested did actually work. Both the total mass and number of particles in the exhaust gas were reduced by about 40 per cent during the “New European Driving Cycle” (defined by the legislature to be used for emissions measurement) as well as during a driving cycle which more closely simulates actual driving behavior. When the vehicle was traveling at simulated constant speeds of 50, 80 and 120 kmph the retrofitted filter removed between 20 and 50 per cent of the particles from the exhaust gas, independently of the particle of size. “We were rather astonished that the filter also removed particles as small as 10 nanometers,” commented Ruedy. He had expected that above all the larger particles would be removed.

On the other hand, emissions of nitrogen oxides – the very pollutants which are already produced by diesel engines in relatively large quantities – increased by between one to eleven per cent. And at constant speed and under motorway conditions simulated in the “real” driving cycle the filter caused an increase in fuel consumption of up to 3 per cent. At 120 kmph this represents a not insignificant 0.2 litres of diesel per 100 kilometres. “Retrofitted filters are therefore not quite CO₂ neutral,” observes Ruedy.

That the OEM particle filters performed so much better did not really surprise the Empa scientist. With these series production filters the engine control systems are tuned to deliver maximum filter performance, and in addition the filters are cleaned or “regenerated” at regular intervals, when the trapped soot particles are burned off at high temperatures. “None of this is possible when using retrofitted filters, which merely replace a length of the exhaust pipe,” explains Ruedy. “At least, not without making considerable changes to the vehicle, for example by replacing the engine management system.”

So all particle filters are not equal. And although the marketing brochures talk about “series production particle filters”, they are frequently referring to retrofit equipment. Claudio Ruedy therefore recommends that when buying a new diesel vehicle, you should ask the dealer precisely which exhaust gas particle filter technology it uses.

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The “innards” of the tested retrofit particle filter: the exhaust gas flows through the metal filter element. In comparison to the OEM ceramic filter the metal filter is coarser, more porous and therefore much more permeable. (Image source: HJS Fahrzeugtechnik)



An OEM series production diesel particle filter fitted to the engine during manufacture. The filter has been cut open to demonstrate more clearly how it functions. The end of each individual channel is closed off, so the exhaust gas is forced to flow through the ceramic wall of the filter. During this process more than 95 per cent of the particulates are removed.



The VW Touran vehicle, retrofitted with a diesel exhaust gas filter and tested by the Empa, on the dynamometer shortly before measurements began.

Filterpapiere der gravimetrischen Partikelmessanlage			
original	mit Nachrüst-Partikelfilter	FZ mit Werkspartikelfilter	leere Filter
			

Filter papers visibly demonstrate the results of the gravimetric measurement: the exhaust gas flows through the filter paper, which holds back the soot particles. The paper is weighed before and after the test, giving a measure of the total particle mass in the diesel exhaust. With the naked eye alone one can see that the series production or OEM filter is significantly more efficient than the retrofitted device.

Text and image data-files available from sabine.voser@empa.ch