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"Emergency Regeneration" of DPF

André Pfiffner, Niklaus Bergamin, Raffael Büeler, Rainer Bunge
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Abstract

Diesel particulate filters (DPF), such as "Continuously Regenerating Technology" systems (CRT), must be regenerated by burning off the accumulated soot particles. This requires a minimum threshold temperature around 230°C. At UMTEC a system for the "emergency regeneration" of CRT at temperatures below 230°C has been developed, whereby the exhaust gases are artificially heated through the catalytic combustion of glycol. Glycol is oxidized on conventional Pt oxidation catalysts at temperatures approximately 50°C below those necessary for burning diesel. While regular regeneration takes place on a CRT system with NO_2, catalytic combustion of glycol ensures "emergency regeneration" at low exhaust gas temperatures resulting from abnormal operating conditions.

Problem

Diesel particulate filters (DPF), such as "Continuously Regenerating Technology" (CRT) systems, retain even the smallest of particles. To avoid clogging, they must be regenerated by burning off the accumulated soot particles. In CRT this mechanism only works above a threshold temperature, which is usually around 230°C. Although the temperatures of exhaust gases generally exceed 230°C, particularly in the case of commercial vehicles, there are occasions when the operating conditions are such that exhaust gas temperatures are simply too low to regenerate the filters. For such cases GLYCOCAT has been developed.

Solution

GLYCOCAT is a system for injecting fuel into exhaust gases that pass over an oxidizing catalyst, such as the ones used in CRT systems. The glycol is oxidized in an exothermal reaction thereby heating up the exhaust gas. Compared to diesel fuel, glycol has the advantage of being combustible on oxidation catalysts at temperatures well below 200°C.

While regular regeneration takes place with NO_2, glycol injection ensures "emergency regeneration" at abnormally low exhaust gas temperatures, which can occur, for example, as a result of extended idling periods of the engine.

Experimental

In initial trials on an engine test rig, the light-off temperatures of various oxidation catalysts were determined for various combustible liquids. This trial showed that glycol oxidizes on a conventional CRT at temperatures approximately 50°C below those necessary for diesel, e.g. at 180°C instead of 230°C. Fig 2 shows the result on a conventional CRT with glycol and diesel injections. The advantage of glycol with the lower light-off temperature compared with diesel is obvious.

In contrast to diesel, glycol decomposes into gaseous products at temperatures of around 170°C. This does away with the need for an atomizing nozzle or pre-evaporator which, in the case of diesel injection, are also prone to clogging through the formation of coking residues.

GLYCOCAT was installed on an IVECO Daily (light truck, *Fig. 3*). First trials were carried out on different test courses. These trials showed that a regeneration can only be accomplished on rural roads and motorways because in inner city traffic the exhaust gas temperatures were mostly below 180°C (*Fig. 4*), which was, on the installed catalyst, the minimum temperature necessary for the complete combustion of the injected glycol. Our control strategy ensured that the minimum

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combustion-temperature was 180°C before DOC before glycol injection started. The glycol injection is then controlled to maintain a regeneration temperature of the filter of an average 550 °C even during dynamic driving conditions. This control strategy was initially tested during operation of the vehicle on a motorway. Fig 5 shows the increase in temperature with an automatically controlled injection.

On a second set of tests, on the rural road, the exhaust gas temperature before DOC occasionally dropped below 180°C, for example due to stops at traffic lights. In this case the control stopped the injection until 180°C was exceeded again (*Fig. 6*).

Fig 7 shows another regeneration on a motorway. During the injection the backpressure continuously dropped indicating the successful regeneration of the filter.

System

Our GLYCOCAT system is entirely autonomous, encompassing two temperature sensors, a backpressure sensor and a small glycol tank plus a pump. It can therefore be used for retrofitting CRT-equipped engines that occasionally run into regeneration problems due to low exhaust gas temperatures. We are now in the process of licensing this technology to producers.

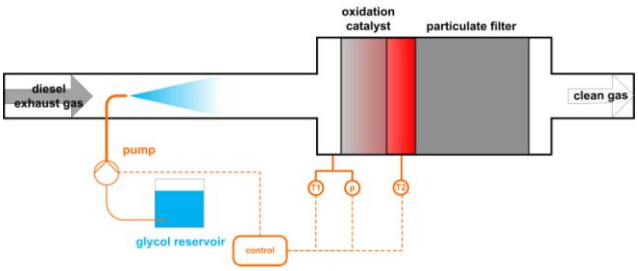

Fig. 1: Active regeneration of a CRT filter with glycol injection

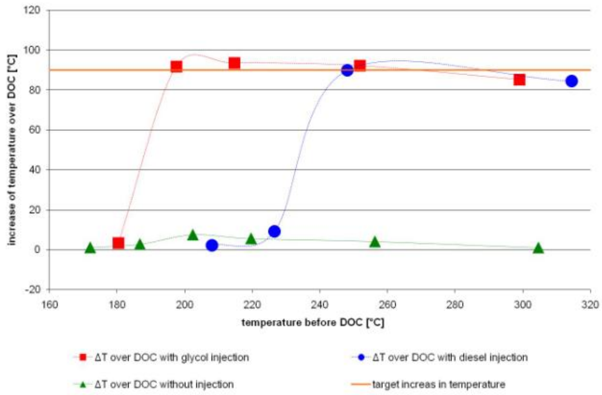

Fig. 2: Increases in temperature over DOC on a conventional CRT using glycol and diesel.

Fig. 3 The test vehicle, an IVECO Daily (light truck)

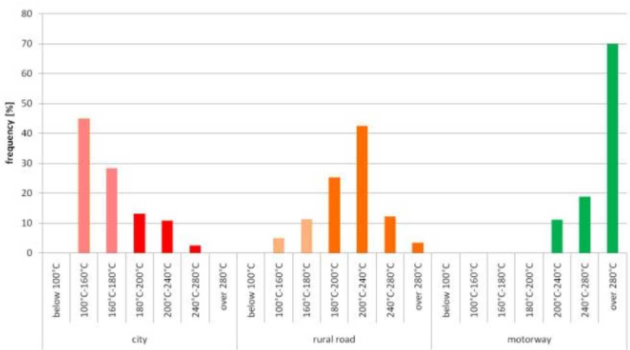

Fig. 4: Temperature profiles in different applications: city, rural road, motorway

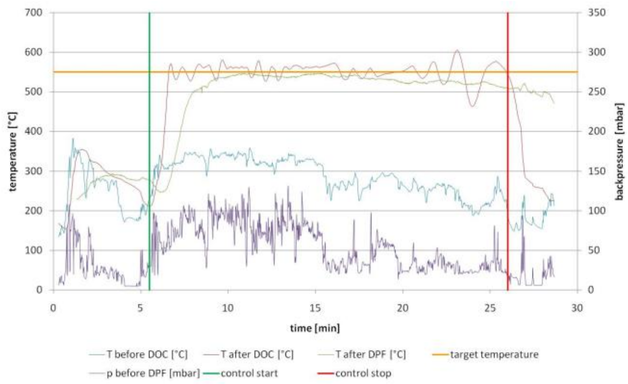

Fig 5. Temperature and backpressure during a controlled glycol injection on a motorway

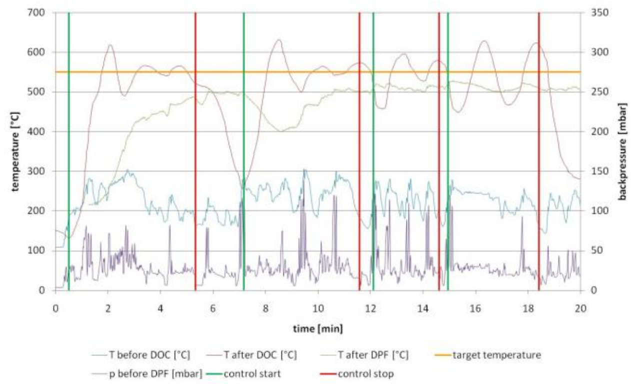

Fig. 6: Temperature and backpressure during a controlled glycol injection on a rural road

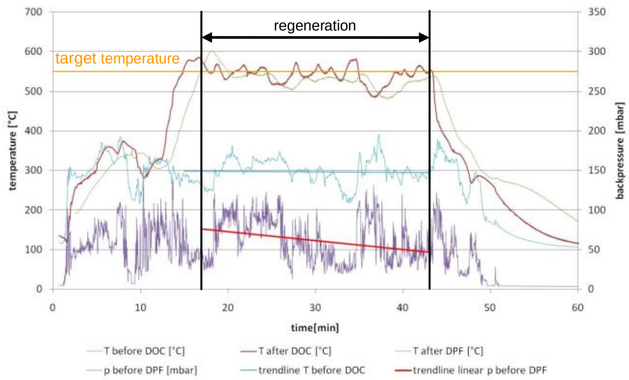

Fig. 7: Temperature and backpressure during a controlled regeneration on a motorway

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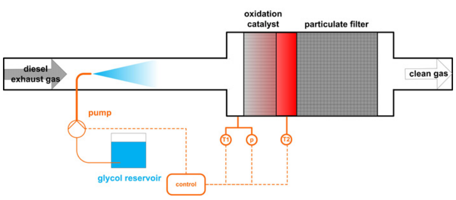

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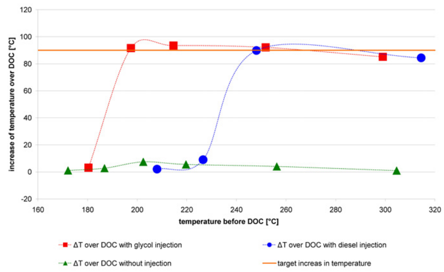

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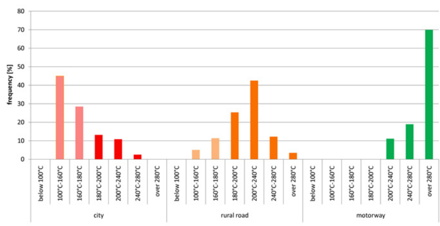

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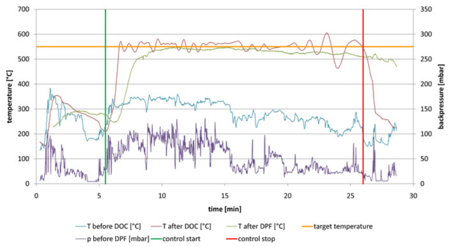

Fig 5. Temperature and backpressure during a controlled glycol injection on a motorway

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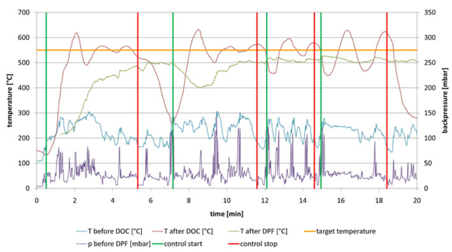

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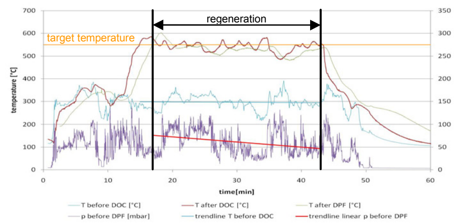

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