"Emergency Regeneration" of DPF

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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 minimal threshold temperature, which is usually around 220°C. At UMTEC a system for "emergency regeneration" of CRT at temperatures below 220°C has been developed, whereby the exhaust gases are artificially heated through the catalytic combustion of glycol. Glycol is used instead of diesel because it is oxidized on conventional Pt oxidation catalysts (which are used in CRT systems) at temperatures approximately 50°C below those necessary for burning diesel. While regular regeneration takes place on a CRT system with NO2, catalytic combustion of glycol ensures "emergency regeneration" at low 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 220°C. Although the temperatures of exhaust gases generally exceed 220°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 NO2, 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.

While the simultaneous oxidation of fuel (such as glycol) and the oxidation of NO to NO2 compete on a given catalyst, we have found ways to ensure that neither of these processes interfere with each other. However, for proprietary reasons we cannot publish the details at this stage.

Trials

In initial trials on a block heat and power plant, as well as 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.

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.

For emergency regeneration, engine cooling water may be tapped and the additional glycol tank completely dispensed with. Cooling water for diesel engines contains 30%-50% glycol, which has such a high calorific value that it not only vaporizes the water injected together with the glycol but generates enough excess heat to heat the exhaust gases. This has been confirmed by the trials we conducted using various aqueous glycol solutions.

Trials with various combustible glycols on a conventional CRT showed that some glycols generated greater increases in temperature than diesel (Fig. 2). Some of the combustibles were better than diesel. However, a few of the combustibles were equal to or worse than diesel.

The comparison of NO2-concentrations after DOC between the various combustibles demonstrated astonishing values (Fig. 3). While diesel caused a severe reduction in the conversion from NO to NO2, the glycol combustibles led to much higher conversion ratios. Some of the glycols even led to higher conversion ratios than the standard conversion ratio of the DOC without injection.

The same trial using different glycol combustibles was conducted on another system containing a DOC and a DPF. This system showed a much lower light-off temperature than the previously tested CRT (Fig. 4). One of the tested combustibles already lit-off at a temperature of 150°C before the DOC. The conversion ratios from NO to NO2 with the tested combustibles showed equal behaviour to those shown in Fig 3. The only difference was the earlier starting point of the conversion along with an earlier increase of temperature.

Fig. 5 shows the results of a trial regeneration of a loaded DPF. The first six hours show the loading of the DOC with soot particles. During this period the exhaust backpressure mounted to 145mbar. This process happened at a temperature after DOC of approximately 200°C. By injecting glycol the temperature after the DOC increased to 350°C. This rise in temperature also caused an increase in the exhaust backpressure. After a few minutes, the combustion of soot began. This was identified by a decrease in the exhaust backpressure. After 1.5 hours, as the exhaust backpressure reached a level of 95mbar, the injection of glycol was stopped.

System

Our GLYCOCAT system is entirely autonomous, encompassing a temperature sensor, 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.

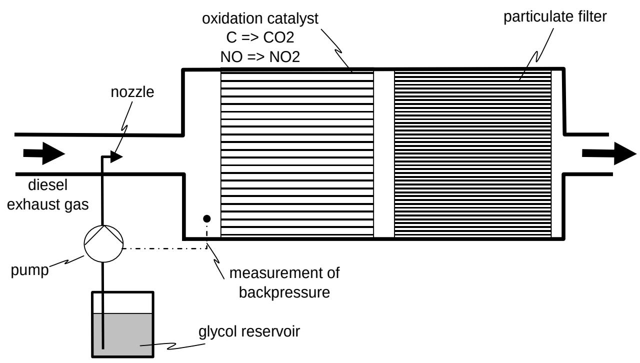

Fig. 1: Active regeneration of a CRT filter with glycol injection

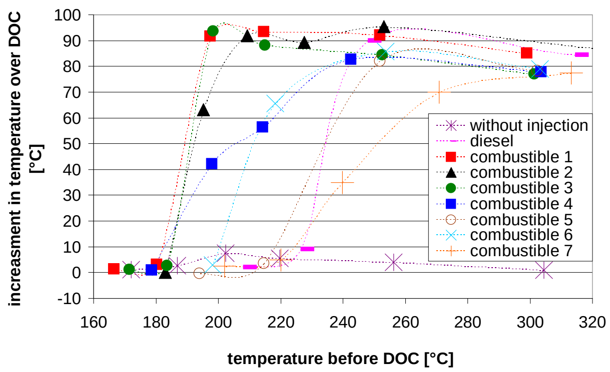

Fig. 2: Increases in temperature over DOC on a conventional CRT using various combustibles.

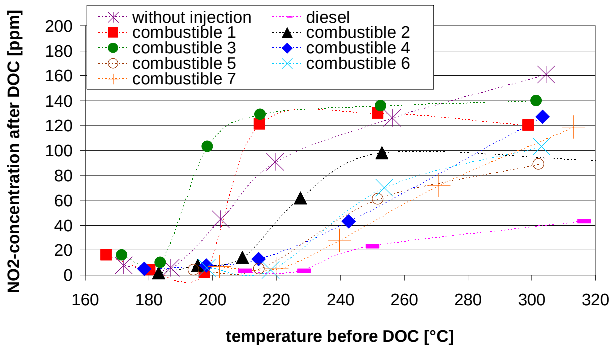

Fig. 3: Various NO2-concentrations during injection of combustibles on a conventional CRT

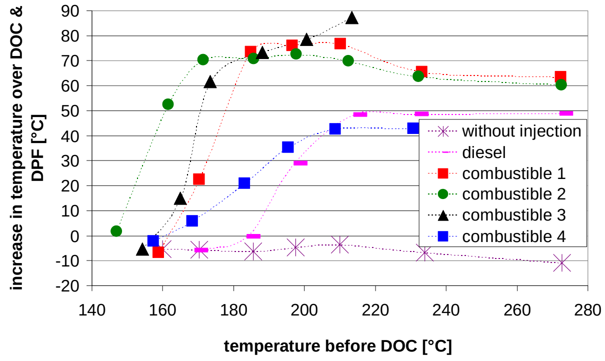

Fig. 4: Increase in temperature over DOC & DPF during injection of different glycol combustibles

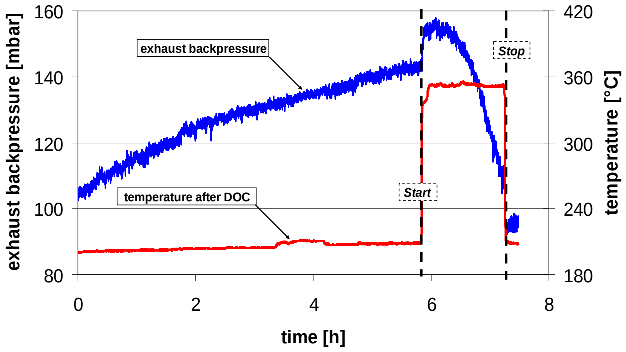

Fig. 5: Characteristics of a regeneration process on a conventional CRT with injection of glycol combustibles

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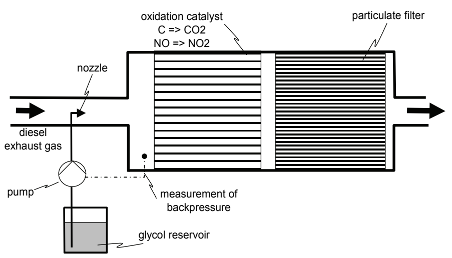

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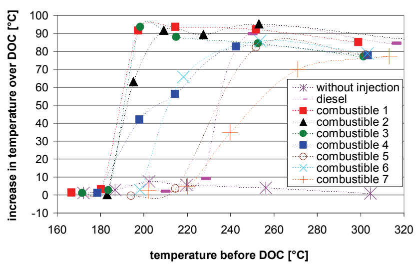

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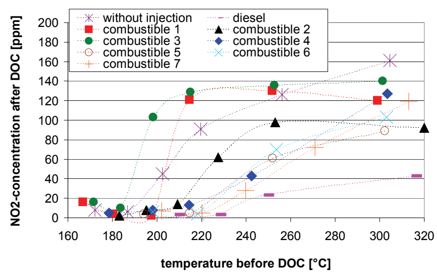

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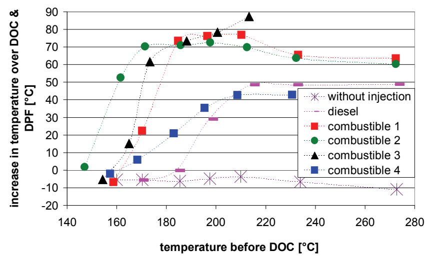

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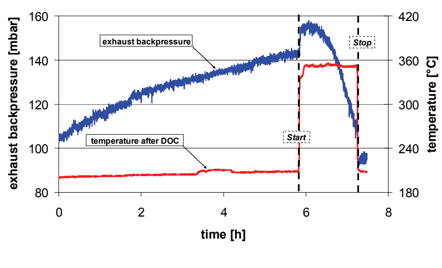

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