

Multifunctional Reactor for Emission Reduction of Future Diesel Engine Exhaust

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Diesel Low Temperature Combustion (LTC) technologies for passenger cars are considered to be potentially beneficial due to low soot particulate and NO_x emissions. However, it is anticipated that they will not remove the necessity of the exhaust emission control systems and especially the Diesel Particulate filters (DPFs). Moreover, LTC mode of engine operation demands tailored emission control systems that would address issues like the low NO_x to soot ratio, the elevated HC and CO concentration etc. In this work, the development of a novel Multi-Functional Reactor (MFR) for the diesel engine exhaust is presented. The aim was to build a system that would have increased catalytic direct and indirect (NO₂-assisted) soot oxidation activity taking also advantage of thermal heat recovery (Konstandopoulos & Kostoglou, 1999) to minimize, the associated to the filter regeneration, fuel penalty.

The MFR incorporates a metal mixed oxide catalyst (MOC) and barium oxide (BaO) synthesized and deposited via an aerosol route, and a noble metal (Pt) applied via a traditional wet-chemistry technique (Konstandopoulos *et al.*, 2008). MOC was used to enhance the direct soot oxidation rate, while Pt was used for the enhancement of the indirect soot oxidation rate and CO and HC conversion. BaO was included to improve the local availability of NO₂ and thus increase the soot oxidation rate.

The combination of aerosol and wet chemistry techniques enabled the optimal distribution of the different catalytic functionalities on the filter substrate wall. Evaluation of the catalysts was conducted at the small scale (catalyst coated small filter samples), with respect to their filtration efficiency, soot loading behaviour and soot oxidation activity at the engine test cell bench and was compared samples obtained from a catalyzed wall-flow Reference Diesel Particulate Filter (Reference DPF).

At the small scale the catalyzed filters demonstrated increased “initial” filtration efficiency compared to the reference DPF. The incorporation of Pt enhanced the indirect soot oxidation activity as well as the HC and CO conversion, with the type of the washcoat and the amount of Pt playing an important role. Addition of BaO has positive impact on the indirect soot oxidation, while the combination of aerosol and wet-chemistry techniques (for the Pt and the washcoat) enabled the production of multifunctional coatings with enhanced direct as well as indirect soot oxidation activity.

Based on the obtained results a full scale prototype MFR was built. The performance of this prototype was examined with respect to its heat recovery capability and to the soot loading and regeneration behaviour.

At the full-scale (prototype MFR) integration of the filtration function and heat exchange was achieved, without the use of an external heat exchanger. The MFR prototype demonstrated significant internal heat recovery capability. On the basis of soot loading and regeneration behaviour, the pressure drop of the MFR during soot loading was at comparable level with the pressure drop of the Reference DPF and even smaller after a certain soot mass load. More significantly, it demonstrated increased soot oxidation rate with respect to the Reference DPF in the temperature area between 450 and 550°C (up to 4 times, Figure 1).

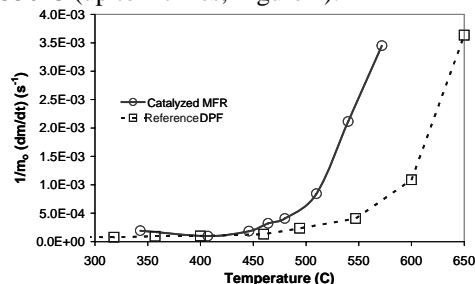


Figure 1. Soot oxidation rate as a function of filter inlet temperature for MFR and reference filters.

With respect to gaseous conversion, the MFR demonstrated significant HC and CO oxidation without notable NO₂-slip. However, the HC and CO conversion was less than the one attained by the small-scale filter sample produced initially without the incorporation of the MOC-BaO components, indicating a possible masking of the Pt activity when all catalytic components are integrated.

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