SAE 2009-01-1087

Properties of Partial-Flow and Coarse Pore Deep Bed Filters proposed to reduce Particle Emission of Vehicle Engines

A. Mayer[1], J. Czerwinski[2], P.Comte[2], F.Jaussi [3]
[1]TTM, [2] AFHB, [3]Tecmot, Switzerland

ABSTRACT

Four of these Particulate Reduction Systems (PMS) were tested on a passenger car and one of them on a HDV. Expectation of the research team was that they would reach at least a PM-reduction of 30% under all realistic operating conditions. The standard German filter test procedure for PMS was performed but moreover, the response to various operating conditions was tested including worst case situations. Besides the legislated CO, NOx and PM exhaust-gas emissions, also the particle count and NO_2 were measured. The best filtration efficiency with one PMS was indeed 63%. However, under critical but realistic conditions filtration of 3 of 4 PMS was measured substantially lower than the expected 30 %, depending on operating conditions and prior history, and could even completely fail. Scatter between repeated cycles was very large and results were not reproducible. Even worse, with all 4 PMS deposited soot, stored in these systems during light load operation was intermittently blown-off. Due to these stochastic phenomena the behavior of these systems is hardly predictable. Furthermore the provision of NO_2, through catalysis ahead of the filter or in the filter matrix, is inherent in these systems. Some of this secondary NO_2 is emitted. Cost/benefit ratio is high compared to full-flow filters and Diesel engines equipped with partial-flow filters are inferior to SI engines regarding global warming potential. Based on these findings it is concluded that the sustainable performance of partial-flow filters is not yet determined.

INTRODUCTION

Full-flow filters (FFF) have become a standard. Wall flow honeycomb filter media, used in this concept are reaching filtration efficiencies exceeding 99.9% [1]. These are fitted ex-factory to European passenger cars and USA trucks [2,3]. Retrofitting onroad heavy-duty (HD) vehicles and offroad construction machines is also very successful [4]. Retrofit filter systems with active regeneration, a prerequisite for dependable operation, are however still rather complex, bulky and costly and therefore prohibitive for retrofitting in-use passenger cars. Nevertheless to diminish emissions, in countries with a high Diesel car population, environmental policy requires simpler and less costly retrofit systems. These shall enable at least 30% curtailment of the particle mass (PM) emission, and correspondingly benefit air quality in the Low Emission Zones. The German [5] specification, which the Netherlands and other countries have adopted, is based on a weighted average PM emission reduction measured over 3 New European Driving Cycles (NEDC) in the as new state, after 2000 km, and after 4000 km operation.
This paper describes the investigation of 4 commercially available partial-flow filters. These were tested according to the German NEDC based criteria. Moreover, since the NEDC is regarded as not reflecting real world city driving conditions [6], tests were performed in various other driving cycles and at other realistic operating conditions. In addition to PM, the investigation also measured the emission of solid nano-particles in the size range 10 nm – 400 nm, and of the systems inherent NO_2 emissions.

BASIC PROPERTIES OF FULL-FLOW (FFF) AND PARTIAL FLOW FILTERS (PFF)

The filtration response of the full-flow [7,11,21] filter and the partial-flow filter [8,9,10] is very extensively published. Fig. 1 shows schematically the basis concept of the full-flow filter and the partial-flow filter.

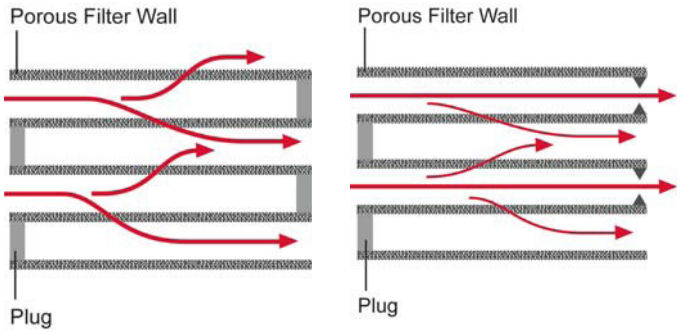

Fig. 1: Schematic of full-flow Filters FFF (left) and partial flow filters PFF (right).

Whereas in FFF [11] all exhaust gas has to pass through the fine porous walls of the filter, in the PFF [10] some flow is allowed to pass unfiltered. The ratio of the two