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Partial Flow Diesel Particulate Filters – Practical Experiences

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Abstract

The use of exhaust aftertreatment devices in the mining industry has been prevalent for well over 2 decades. One of the major pollutants is diesel particulate matter (DPM). Applications once left untouched for the filtering of diesel particulate matter are currently using hybrid type devices to assist with its reduction. The MINE-X® Flow-Through Filter is a product that has gained acceptance in the marketplace as an excellent alternative and achieves between 50% to 75% reduction in DPM with minimal backpressure increase. This paper will discuss the technology and show testing relative to the MINE-X® Flow-Through Filter.

Introduction

The reduction of harmful exhaust pollutants through the use of emission control technologies in underground mining has been prevalent for some time. A device currently available to the mining industry is the partial flow diesel particulate filter. These devices provide DPM reduction that are between diesel oxidation catalysts (DOC) and conventional diesel particulate filters (DPF) allowing on a wide range of applications. The reduction of pollutants by DOCs and DPFs have been well documented [1,2,3]. The partial flow DPF devices, also known as partial DPFs, flow-through filters, or partial filters, are also capable of significant reductions of harmful pollutants such as carbon monoxide (CO), hydrocarbons (HC), and DPM [4,5,6]. One such device commercially available is the MINE-X® Flow-Through Filter.

In this paper two areas will be discussed. First, a description of the product will detail the features and benefits that make the device unique. Second, the MINE-X® Flow-Through Filter has undergone extensive evaluations. Test results will show the effectiveness of the product in different applications – for example CANMET certification testing – and the practical application of the product in the mining and other off-road industries.

System Description

The MINE-X® Flow-Through Filter (FTF) utilizes substrates of alternating layers of corrugated metal foil and flat layers of metal fibre fleece brazed together to produce a flow-through honeycomb structure (see figure 1). The corrugations in the metal foil form alternating trapezoidal ducts with a varying cross sectional area. The device can be packaged into designs similar to those used with DOCs.

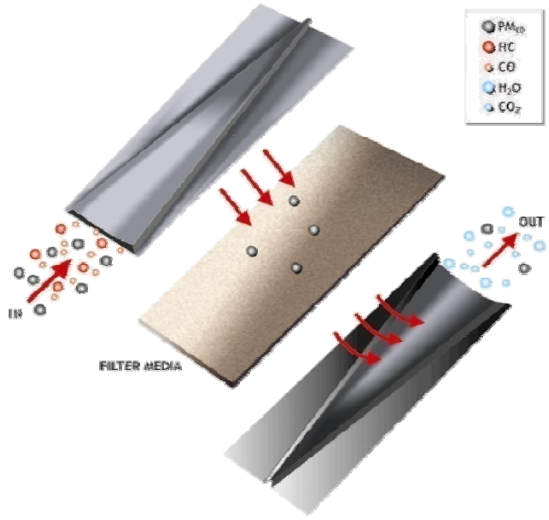

figure 1 – MINE-X® Flow-Through Filter device

When this device is installed into the exhaust stream, the design of the alternating trapezoidal ducts creates a pressure differential across the filtration media causing some of the exhaust to pass through the filter media. As the exhaust passes through the filter media DPM is trapped.

A precious metal catalyst coating is used to assist with regeneration of the collected DPM and oxidize the CO and HC constituents. This coating is also designed to minimize the production of NO_2. However, in situations where the operating conditions are not ideal for regeneration and the filtration media becomes saturated with DPM, the MINE-X® FTF, by design, allows the exhaust to by-pass the filtration media and maintain a designed backpressure. This prevents potential adverse effects, such as, increases in backpressure that could lead to engine shutdown or damage. This operation differs from a wall- flow DPF where under a similar situation increasing backpressure would be the result.

Evaluation

The MINE-X® FTF has undergone extensive testing to determine the effectiveness of the device and to validate its commercial applicability. The information shown in figure 2 is a sampling of some performance testing conducted on different variations of the device. All of these devices were evaluated on an ISO 8178 C1 test cycle. This data shows that the device is capable of achieving over 60% PM efficiency.

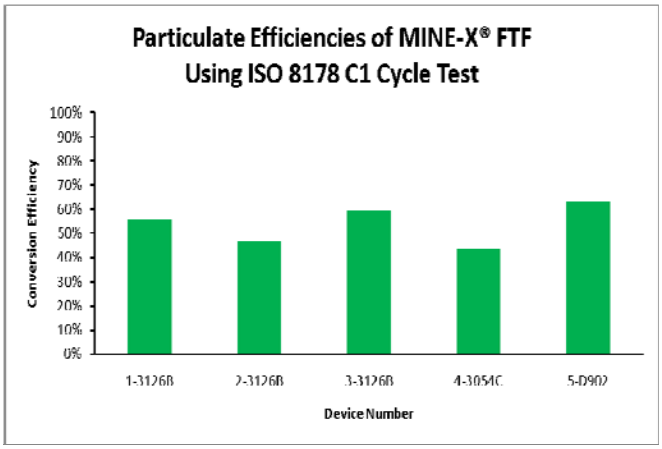

figure 2 – Sample of DPM conversion efficiency over a MINE-X® FTF

The backpressure created by the device was also evaluated and is shown in figure 3. The MINE-X® FTF is compared to a DOC coated to a metallic substrate and a cordierite DPF. All three units are sized for an identical application. The data presented demonstrates that the device generates slightly higher backpressure than the DOC and significantly less backpressure than the DPF.

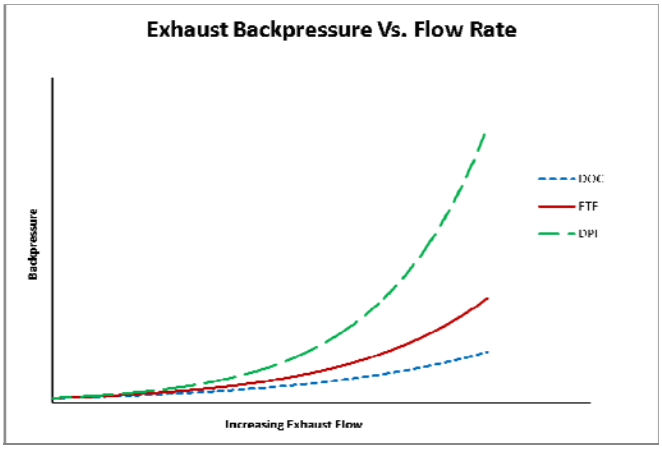

figure 3 - MINE-X® FTF backpressure is low

Case Study 1

A need for a device that could reduce the DPM concentrations by at least 20% for a mining application was presented. Since it would be difficult to achieve this result with a DOC, a MINE-X® FTF was selected. The device was evaluated on a Kubota D902-E2-UV (tier II) diesel engine, rated power of 21.6hp@3200rpm, and rated torque of 41.4ft-lb@2600rpm. The testing was performed at the CANMET-MMSL facilities and a 22-mode test (CSA Standard M424.2-90) was used.

The information presented in figure 4 demonstrates that the device was capable of reducing the DPM emissions to acceptable levels under the standard (PM(B) engine out emissions, PM(A) device out emissions); the standard has a "do not exceed" requirement for DPM emissions of 150 mg/m^3. Based on the results of this test, the Kubota D902-E2-UV with a MINE-X® FTF and using ultra low sulphur diesel fuel were granted certification and listed on the CANMET-MMSL approved diesel engine list [7].

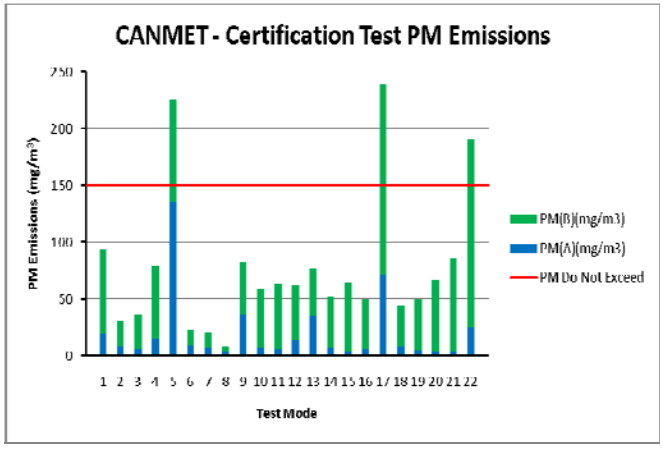

figure 4 – PM emissions from the MINE-X® FTF meets 22mode tests not-to-exceed limit (courtesy of EBC Neilson)

Case Study 2

A reduction of greater than 50% DPM and a requirement to not increase the NO_2 to baseline NO_x emission ratio by more than 20% was the target set out during this study. In this study 4 different commercially available design variations were evaluated.
The devices were all evaluated on a Caterpillar 3126B (tier II) diesel engine, rated power of 183hp@2200rpm, and rated torque of 728ft-lb@1400rpm. The testing was performed at a 3rd party laboratory and an 8 -mode test (ISO 8178 C1) was used.
The results from the testing for CO, HC, NO_2 / NO_x, and DPM emissions performance are shown in figure 5. All 4 devices were able to meet the NO_2 / NO_x target. The CO and HC efficiencies for all of the devices were also high but were not targeted in this study. Only device 4 was able to meet both targets for DPM and NO_2 / NO_x.

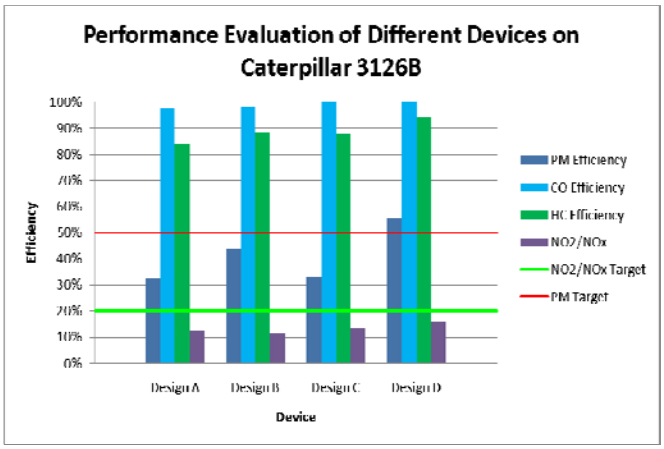

figure 5 – Design evaluation to meet PM and NO_2 / NO_x limit

Applications

Conclusions

In this paper the MINE-X® Flow-Through Filter technology was described. Evaluations on the product were discussed along with examples of practical applications for the product in the mining and off-road industries. The testing showed that the product is capable of significant reductions of harmful pollutants.

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