Developing a High Temperature Oxidation Method for Making Real-Time Diesel Ash Emission Measurements Up and Downstream From A DPF

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ABSTRACT

Diesel ash emissions can be defined as the non-combustible fraction of Diesel particulate matter (DPM) and are mostly attributed to the consumption of metallic lube oil additives. Ash emissions are a concern when using a Diesel particulate filter (DPF) because ash is not oxidized during DPF regeneration cycles. DPFs are efficient ash filters, removing ash emissions that otherwise would be released into the atmosphere. Due to the high filtration efficiency and lack of removal during regeneration, ash loading in a DPF can over time, increase exhaust backpressure and reduce the performance of the engine while increasing fuel consumption. It is therefore useful to develop a real-time method to measure ash loading and ash filtration performance of DPFs. There are several methods to measure ash in Diesel exhaust, however most methods are not able to measure ash in real-time.

A high temperature oxidation method (HTOM) has been developed with the goal of measuring engine ash emissions in real-time. The HTOM consists of passing an exhaust sample through a high temperature oven. With a sufficient residence time and temperatures near 1100ºC, removal of the volatile and combustible fraction of DPM occurs. The remaining particles are then assumed to be the noncombustible fraction of DPM or ash. The ash is then cooled to room temperature and measured with near real-time particle instrumentation. A scanning mobility particle sizer (SMPS) was primarily used to attain the number and volume weighted size distributions of the particles exiting the high temperature oven for steady state conditions. The ash mass concentration was estimated from the volume weighted particle size distribution. TSI's Engine Exhaust Particle Sizer (EEPS) and Electrical Aerosol Detector (EAD) which reports a particle diameter concentration were used to examine ash emissions over transient engine conditions.

The HTOM was used to measure ash penetration through a non-catalyzed cordierite DPF for specific types of lube oil additives. The fuel was doped with specially blended lube oil by 0.5% in order to increase the ash emissions of specific lubricating oil additives.

Particle size distribution measurements were taken at oven temperatures of 20ºC and up to 1100ºC in order to attain the ash fraction of total DPM. This was performed up and downstream from the unloaded DPF. It was found that the HTOM was most sensitive to calcium when compared to zinc and magnesium based additives, presumably due to the stable calcium oxide which most likely forms at high temperatures within the oven. Some of the calcium results showed an ash mass penetration of 0.019 with a standard deviation of 0.001. The ash mass fraction of DPM for the calcium based lube dopant was measured to be .067 with a standard deviation of 0.003. The HTOM was also found sensitive enough to distinguish transient ash emissions.

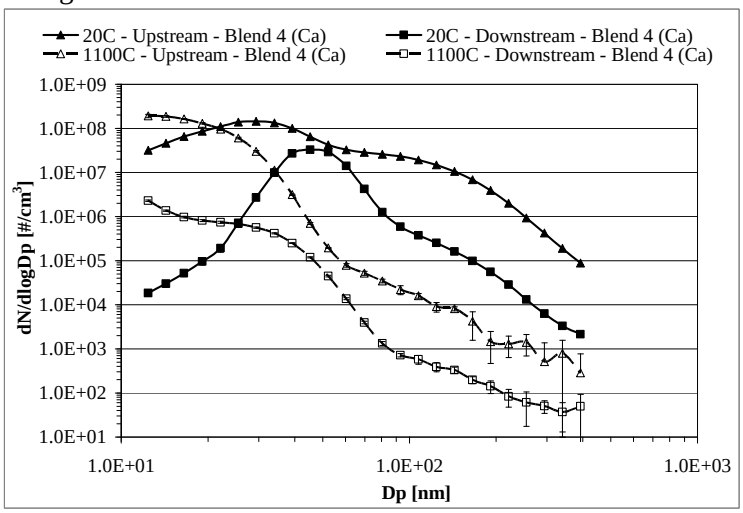

Figure 1. Particle size distributions for two oven temperatures taken upstream and downstream of a DPF. The fuel was doped (0.5% by mass) with lube oil containing a calcium based additive