Comparison of DPG and engine soot

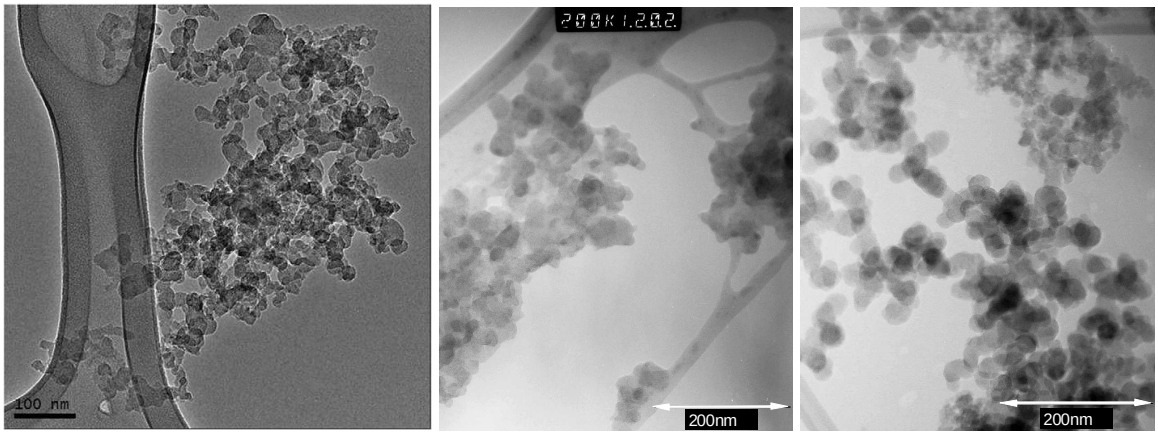
Introduction

DPF regeneration and back pressure (ΔP) measurement are core activities for the Diesel Particulate Generator (DPF testing system). However, some customers have understandable concerns about the similarity of the soot derived from the DPG compared to soot produced from an engine.

It is expected that some differences should be evident because the diesel combustion is occurring under very different conditions in both cases. There is also very little NOx produced by the DPG combustion (which is relatively cool) and in general, the DPG gas is lean compared to an engine.

Below is a summary of data which investigates potential differences in various important parameters.

Soot morphology



Light Duty Diesel engine soot

Heavy Duty Diesel engine soot

Cambustion DPG soot

Figure 1: TEM photos of soot (courtesy of Penn State Univ. and Univ. Reading).

Generally, the structure of engine and DPG soot (when viewed with an electron microscope) is similar (see *Figure 1*); the primary particle diameter being approximately 30nm.

Soot composition

Finally, various soot composition parameters have been tested between a group of 4 DPGs and an engine. The results are shown below:

	Soot %	VOF %	Water %
DPG1	91.3	7	1.7
DPG2	92	6.2	1.8
DPG3	92.1	5.9	2
DPG4	95.4	3.3	1.3
Engine	87.9	6.3	5.8

Figure 2: Soot composition of various DPGs and engine.

The main difference appears to be the increased water content of the engine soot. This was thought to be due to lower DPF inlet temperatures when loading on this engine.

DPF back pressure (ΔP) comparison

One of the aims of developing the DPG was to create a stable platform on which to test for variations in DPF fabrication. A typical application is for the acceptance/rejection of batch-produced DPFs on the basis of ΔP at a prescribed soot load. A large amount of development work has been spent on ensuring that the soot loading regime of the DPG is constant and repeatable (95% confidence for back-pressure @ 12g which is better than +/- 3%).

For soot vs ΔP testing, engines are typically run either on transient cycles or in steady state and this might be expected to affect the soot back-pressure. In addition, as the DPF becomes loaded, the back-pressure affects the engine performance and hence soot generation rate.

The standard soot load set-point of the DPG is 10g/hour and, given that the flow through the DPF is induced by downstream blowers, the soot-producing flame of the DPG is unaffected by the DPF's back pressure. Hence a more stable and repeatable soot load is achievable.

The results shown in *Figure 3* are for the same DPF loaded on the same engine but with different methods of loading. The DPG was used to determine the back-pressure at standard conditions. For this engine the ΔP vs soot load is similar for transient / steady state loading and DPG loading. The main advantages of the DPG soot remaining more rapid load rates and lower costs involved.

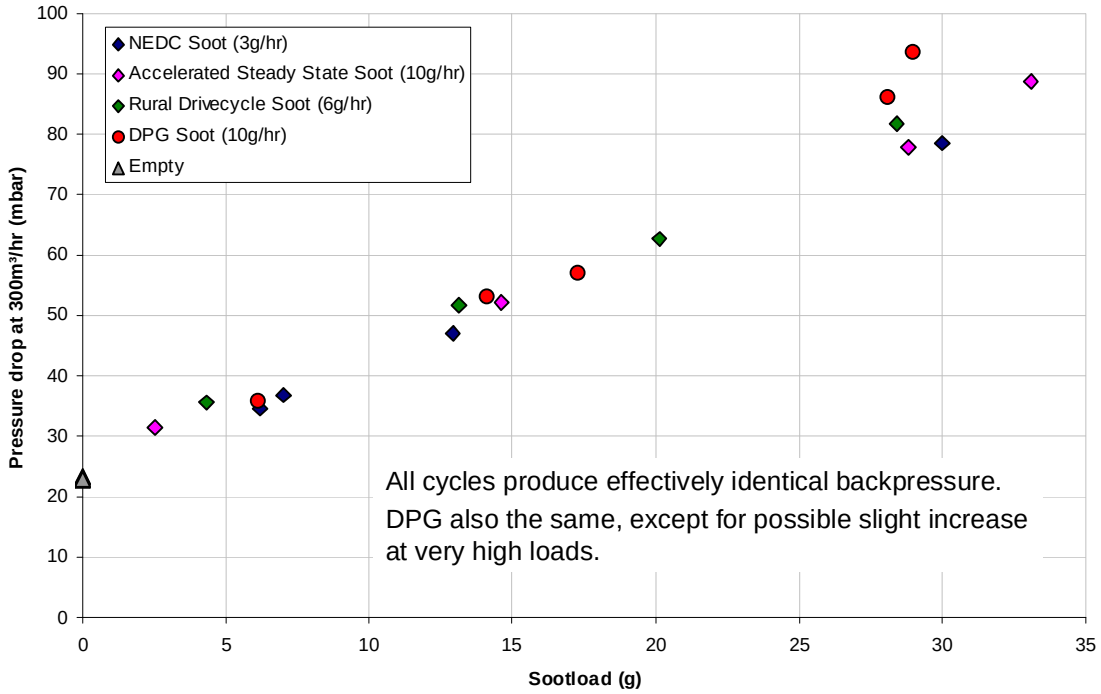


Figure 3: Comparison of DPF back pressures when loaded with various drive cycles or on DPG.

Soot size comparison

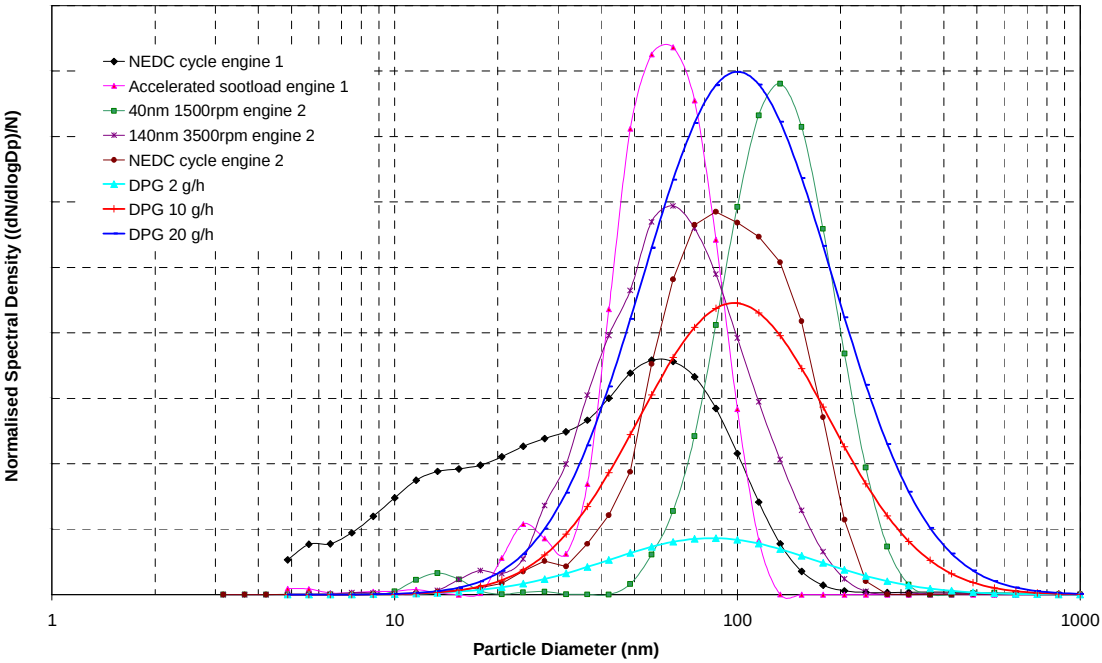


Figure 4: Engine and DPG soot sizes from various steady state and transient cycles

The data shown in *Figure 4* shows the particle size spectra measured with a Cambustion DMS500 fast particulate spectrometer from various steady state and transient engine operating conditions commonly used to load DPFs. It also shows size spectra from different DPG soot production rates. The DPG particle size and distribution vary but no more so than for the different engine running conditions.

Regeneration

A short study has been conducted in to the regeneration of a DPF on a DPG. The DPF was loaded with both engine soot and DPG soot. The results are shown in *Figure 5* below.

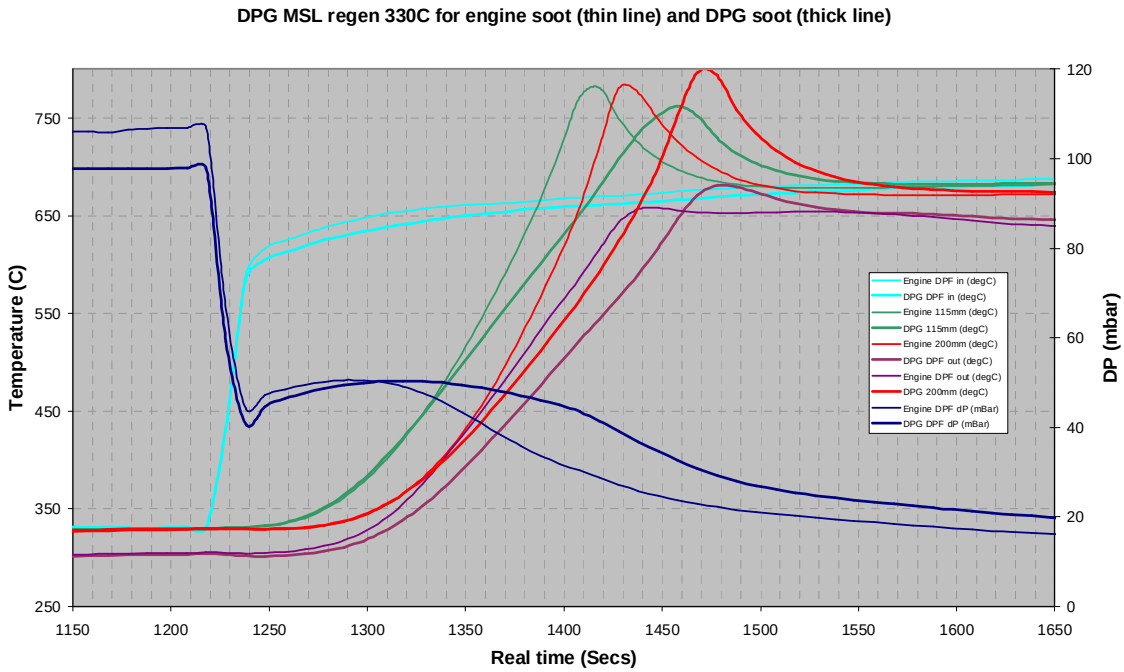


Figure 5: Thermocouple and back pressure data during regeneration of engine and DPG soot.

The thermocouple results broadly suggest that the engine soot is slightly more “reactive” than DPG soot; the exotherm occurs sooner with the engine soot. The maximum temperatures are, however, similar.

Summary

The DPG is now being widely adopted as a “standard” method of loading and regenerating DPFs. Although some slight differences exist between DPG and engine soot, these differences are small and often within the “spread” of engine results. The advantages of lower cost DPF testing combined with better repeatability from the DPG remain major considerations.