Gasoline Particulate Filter (GPF) testing

The DPG can be used to load soot on to GPFs much faster than the rate obtainable from a gasoline engine. The GPF's back pressure and filtration efficiency can be evaluated during the load and then the loaded GPF can be fitted and tested on a gasoline vehicle.

The need for testing soot-filled GPFs

The introduction of particle number limits (in Europe and elsewhere) for gasoline engines has stimulated interest in GPFs and their ability to limit the tailpipe solid particle number over the lifetime of a vehicle.

Many modern GDI vehicles can meet the PN limit without after-treatment when new, but ageing effects on engine hardware and the associated degradation in fuel vaporisation and combustion quality has led to concerns that GPFs might be required to maintain the vehicles' PN emissions below the permitted limits (currently 6x10E11 per km for Euro 6b).

The relatively low engine-out PN compared to diesel engines means that the filtration efficiency of a GPF doesn't need to be as high as for a DPF of equivalent size and a more porous substrate is generally employed for this application. However, if a catalytic surface is applied to the GPF (resulting in what is sometimes termed a "4-way catalyst"), this can dramatically affect the back pressure and filtration efficiency and the performance of GPFs with different amounts of soot load is important to characterise.

The effect of ash deposition on the GPF is generally more evident than on an equivalent sized DPF because it has a strong effect on back pressure and filtration efficiency (and thereby on the vehicle's fuel economy and performance).

Furthermore, similar to the concerns about over-filling with soot of DPFs, the exotherm produced by regeneration of GPFs on which large amounts of soot have been deposited (perhaps in cold climates and/or where only light engine operating conditions have been experienced for prolonged periods) can cause damage and hence is worth investigating.

Potential problems with loading GPFs with soot (and ash)

As mentioned above, gasoline engines (even GDI) produce relatively little soot compared to Diesels. Also, the higher exhaust temperatures tend to produce passive regeneration of any soot which has been loaded on to the GPF. This poses a problem in producing the larger soot loadings which are required for fully characterising back pressure, filtration efficiency and exotherms generated during regeneration events.

Some OEMs try to increase the engine-out soot rate by reducing the fuel rail pressure to produce less effective fuel vaporisation. They might also increase external EGR. But soot accumulation with an engine still remains slow and expensive.

The deposition of ash along with the soot is also a very long duration project when performed on a gasoline engine.

Loading a GPF with DPG soot

The DPG can be used to load GPFs with soot derived from burning diesel fuel at rates typically of 1–2g/hour. Although this soot is not produced from burning gasoline, it is soot of a repeatable form and "gasoline soot" varies in morphology and composition depending on the engine's running conditions – especially if the engine has been modified to increase the soot rate.

On the DPG, the soot deposition rate, flow and loading temperature are controlled giving consistent soot loading with no possibility of spontaneous combustion.

Some OEMs have already adopted DPG schedules with a view to systematic GPF testing using this technique and such schedules consist of the following steps:

1. Precondition in an oven by ramping temperature to 700°C, hold for 2 hours (8 hours following any soot load)
2. Fit GPF to DPG and stabilize for 5 minutes at flow = 250kg/h, 50°C, no burner
3. Warmup for 5 minutes at 250kg/h, 240°C, (target <0.1mg/m3)
4. Weigh the GPF (to measure the "hot empty weight")
5. Warmup for 5 minutes at 250kg/h, 240°C, (target <0.1mg/m3)
6. Load soot at 250kg/h, 240°C, ~2g/h

7. Monitor filtration efficiency
8. Target 3.5g/litre using AVL415 to monitor upstream soot
9. Confirm final weight of soot deposited on GPF by another “hot weighing”

Some typical GPF data

Repeat tests of two coated GPFs is shown in figure 1.

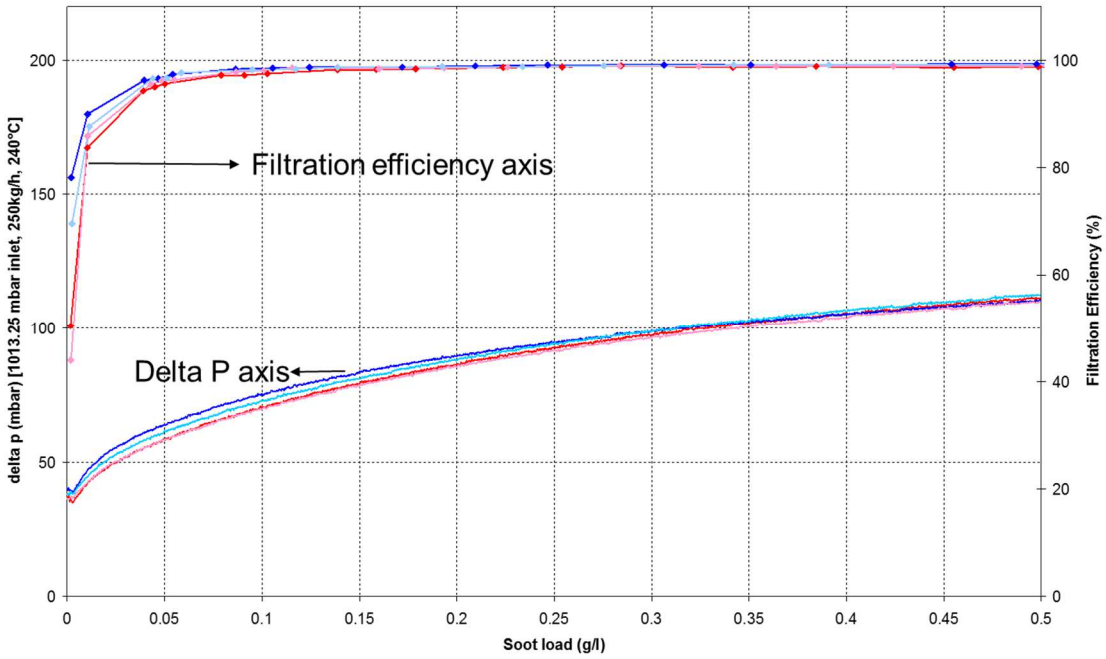

Figure 1: The back pressure and filtration efficiency results from two coated GPFs showing repeats as light colours.

It can be seen that the filtration efficiency of a clean GPF can be as low as 40%, but this rapidly increases as pore filling occurs.

The loaded GPF is then fitted to a gasoline vehicle to undergo further testing including the monitoring of any exotherms or other features which may compromise the vehicle’s performance.