Ash loading and assessment

Background

The detrimental effects of ash on DPF (and now GPF) performance is of significant concern because the resulting permanent back pressure penalty compromises both fuel economy and soot storage capacity (leading to more frequent regeneration intervals; with further fuel economy impact).

The ash is thought to be derived primarily from oil additives but also from fuel, engine wear and other sources.

As DPFs (and now GPFs) accumulate more miles on customer vehicles, the long term effects are becoming of more concern to vehicle and filter manufacturers.

However, the time taken to accumulate a representative amount of ash (over, say 100,000km) is significant and the DPG (DPF testing system) can be used to load DPFs/GPFs with ash over a matter of hours.

DPG configuration(s) for ash accumulation

Initial tests at Cambustion involved mixing oil additive "packs" to the fuel tank of a DPG and burning the resulting fuel/additive mix in the DPG's burner. Note that the production of ash can be obtained at the same time as soot yield and regeneration events.

Back pressure results from multiple loads (from clean)

Tests using a 4 litre SiC DPF have been conducted where a yield of 1.5g/hour of ash was achieved along with 10g/hour of soot.

The results for 3 loads (interspersed with regenerations performed on the DPG) on a clean (without soot or ash) DPF are show in figure 1.

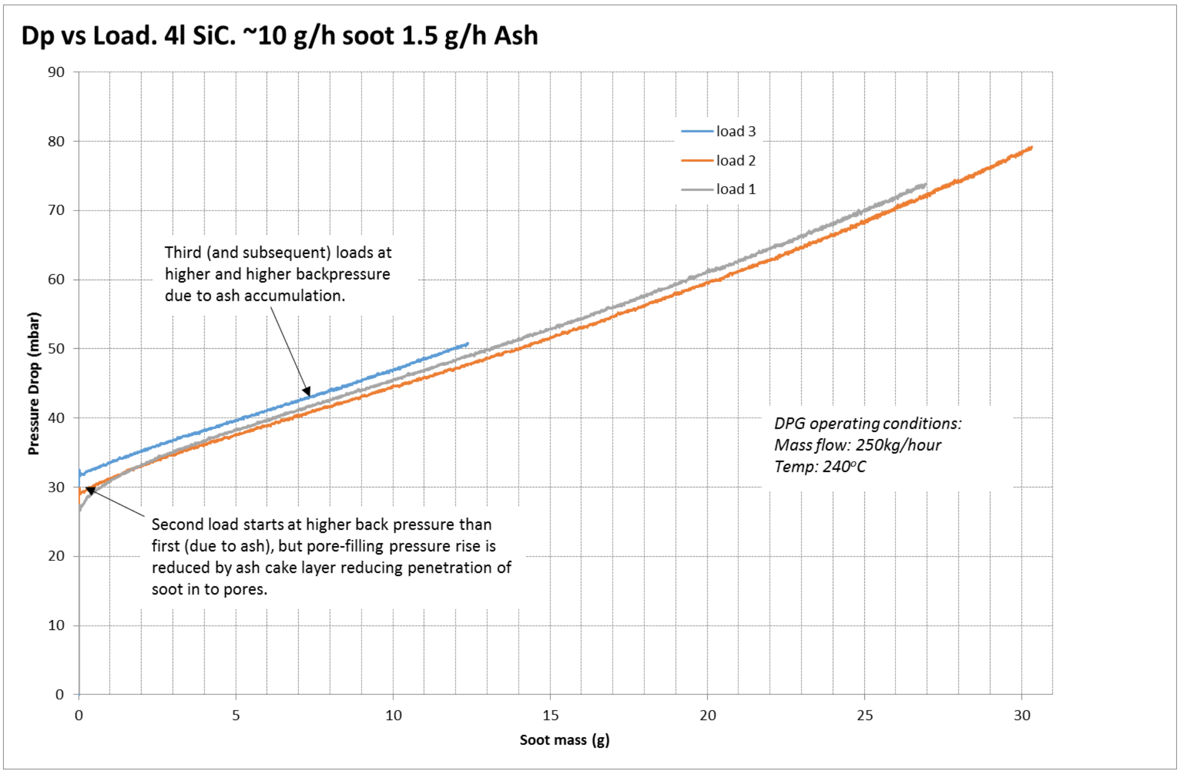

Figure 1: Three sequential soot & ash loads on the same (initially clean) DPF

Load 1 shows the classic pore-filling curve within the first gram of loading. The back pressure then continues linearly until the part is regenerated. Then load 2 begins….

The second load begins at a higher back pressure because a layer of ash has been deposited during load 1 as a "cake" layer. Note also that the pore-filling and pore bridging phase is absent from load 2 because ash is preventing as much soot entry in to the pores. Also, the *gradient* of the linear pressure increase thereafter is slightly less than for load 1. This is because the reduced soot within the pores (displaced by the ash) is unable to dominate the DP during the cake layer build up.

The third (and all subsequent) loads begin at a higher and higher initial back pressure indicating permanent ash back pressure penalty.

The deposition position and quantity have yet to be assessed for the DPG, but the back pressure characteristics and filtration efficiency changes (not shown here) appear to be similar to engine tests performed by a variety of customers.

Further tests are planned using alternative loading temperatures, flow rates, doping rates and soot rates.

Assessment of ash

Some measurements have been taken with a DMS500 particle sizing instrument to identify the ash and soot particles which are being produced by the additive-in-fuel technique, the results of which are shown in *Figure 2*

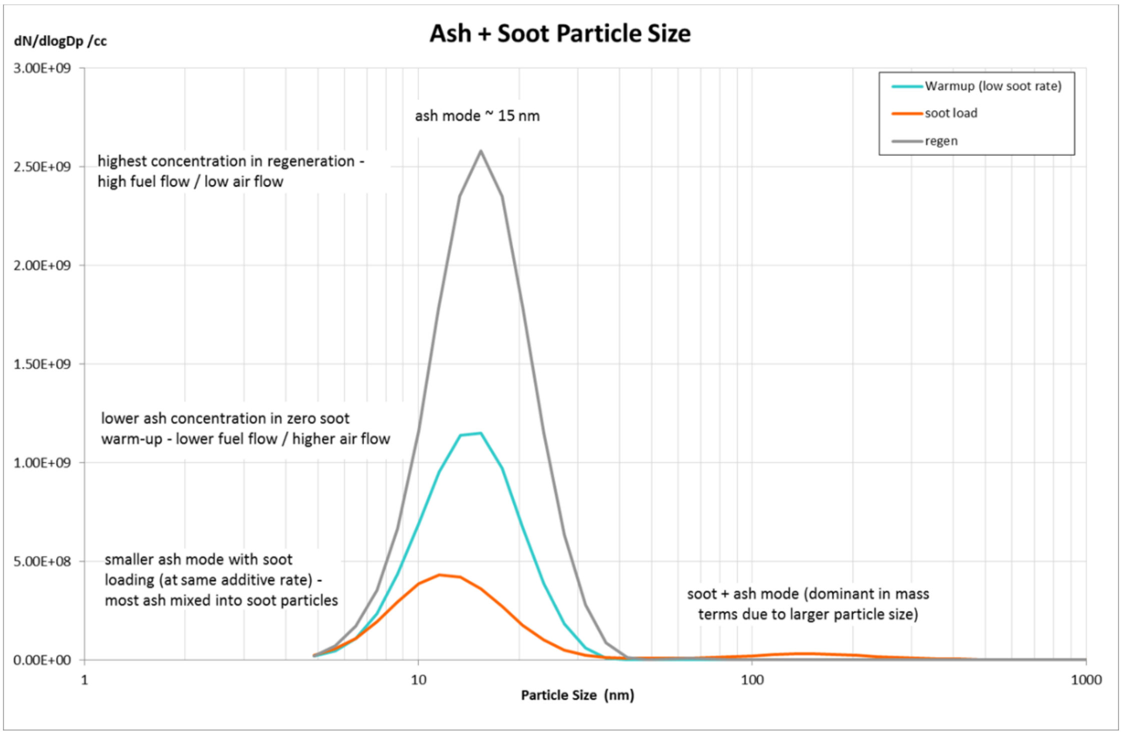

Figure 2: Ash size and number at various DPG operating points

A clear, small ash size mode was identified centred at about 15nm (compared with the DPG soot mode at approx. 100nm). The *amount* of ash being generated is basically linked to the fuel flow in to the burner and the additive dosing rate. The maximum ash yield is therefore occurring during regeneration where the burner is operating in a hot (but non-sooting) mode with high fuel input. It is interesting to note that the soot load mode and the warm-up mode actually consume very similar fuel rates but where soot is being produced, it is clear that the ash particles are being bound-up on to the surface of the soot particles.

Post ash testing requirements

Note that this technique contaminates the entire fuel system with the additive which can be problematic if the DPG is required for other conventional work. Both the fuel system and the surfaces upstream of the test part need to be cleaned of ash deposit before accurate soot-only tests can resume.