Ash loading and assessment

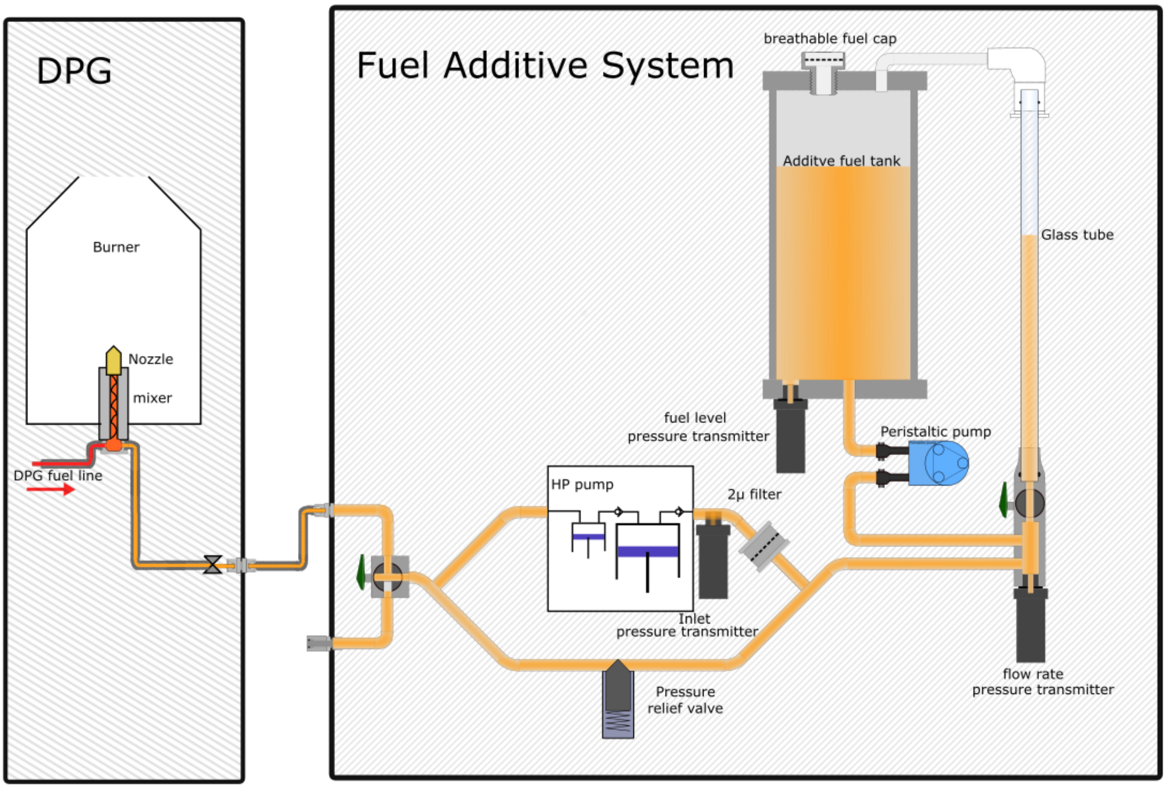
Background

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.

The growing number of ash loading requests have motived Cambustion to produce an online fuel additive system, as an add-on to the DPG package. The main advantage this gives over burning doped fuel is allowing the DPG to run the flame with or without generating ash. Another benefit is there is no contamination of the entire fuel system. Allowing the DPG to switch between applications without any cross contamination.

DPG – Fuel Additive System



The Fuel Additive system is a DPG add-on which allows additive to be metered into the fuel system (immediately before the nozzle base) from a separate source other than the DPG's own diesel supply. The desired additive (often an engine oil additive agent) is mixed with diesel to lower its viscosity which is more readily pumped and mixed. This doped fuel mix is stored and metered in the Additive unit itself. The additive flow rate is configurable, along with the ration between oil additive and diesel injected. This gives the DPG a wide range of ash loading rates which need to be calculated experimentally.

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.

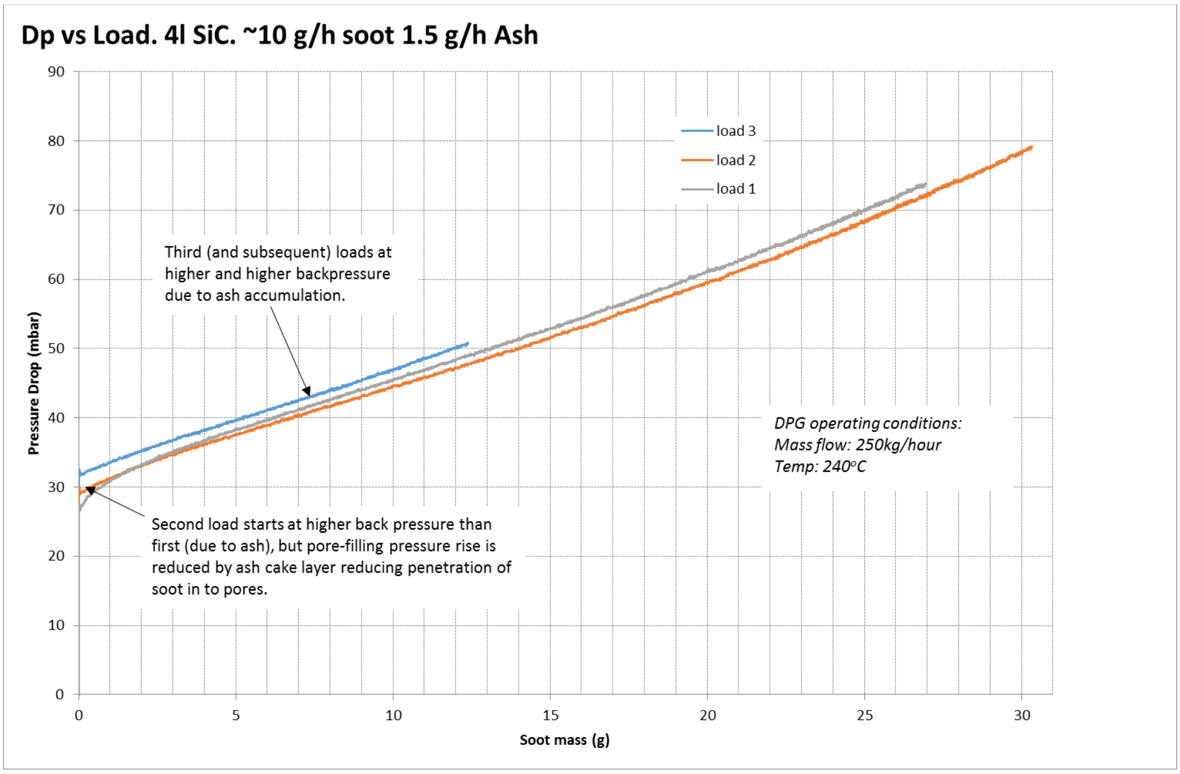


Figure 1: Three sequential soot & ash loads on the same (initially clean) DPF

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 into 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 backpressure 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*

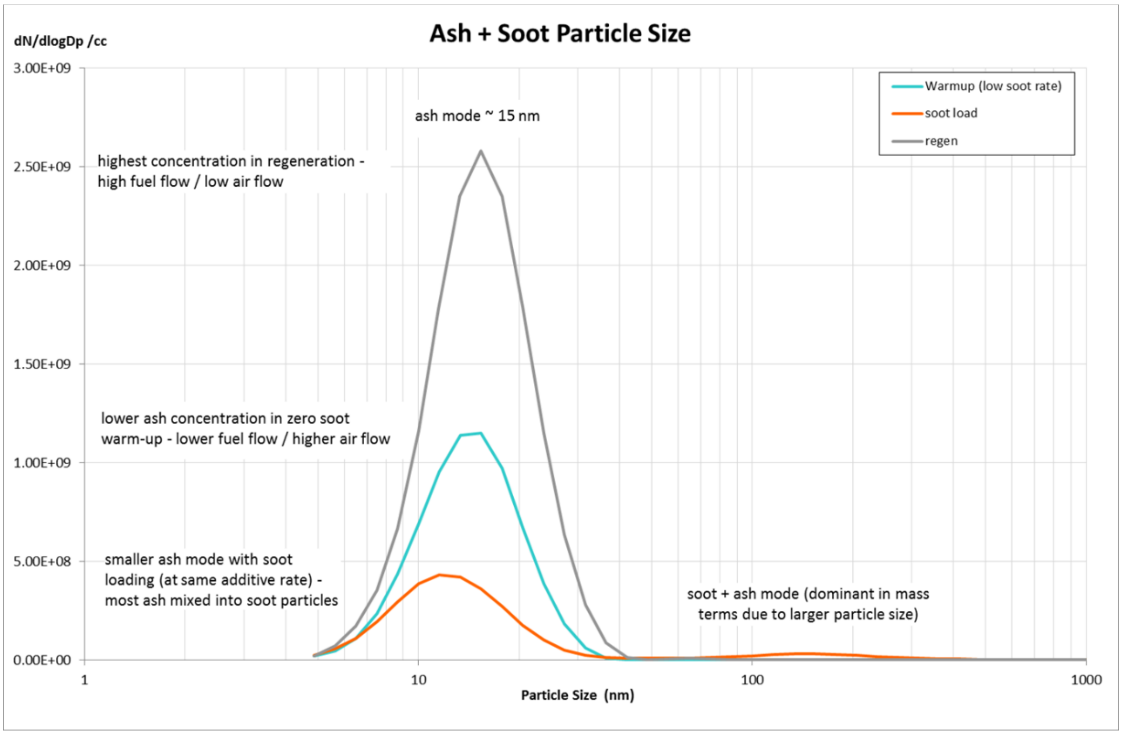


Figure 2: Ash size and number at various DPG operating points

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.