HC emissions from a diesel-engined passenger vehicle

Introduction

Diesel vehicles are increasing in popularity due to their fuel efficiency and recent improvements in performance. Concerns over the particulate matter (PM) produced by diesel engines has lead to the development of diesel oxidation catalysts (DOC) and diesel particulate filters (DPF). Control of these aftertreatment systems requires the engine to run under conditions that are not necessarily optimal for engine out emissions. For instance, regeneration of a DPF requires high temperature engine-out gas. Delayed injection coupled with post injection is a commonly implemented scheme to achieve this elevated exhaust gas temperature, but can have undesirable consequences for [HC] emissions.

Experiment

In this experiment a HFR500 Fast FID was used to examine [HC] output from a 2.2litre HDi engine. The aftertreatment system consisted of a DOC and DPF. Engine-out and tailpipe gasses were sampled simultaneously by using both channels of the HFR500. A standard bench analyser is also used to accumulate total emissions.

Engine-out gas can have very high concentrations of PM. This can cause contamination in the sample head which can lead to output drift. In this experiment the engine-out sample head was protected by a sintered metal filter. As an alternative to a filter a change of temperature set-points for the sample head can discourage deposition of soot. The tailpipe gas was clean enough to permit unmodified operation of the sample head.

The first 400 seconds of a New European Drive Cycle and two DPF regenerations are examined.

Results

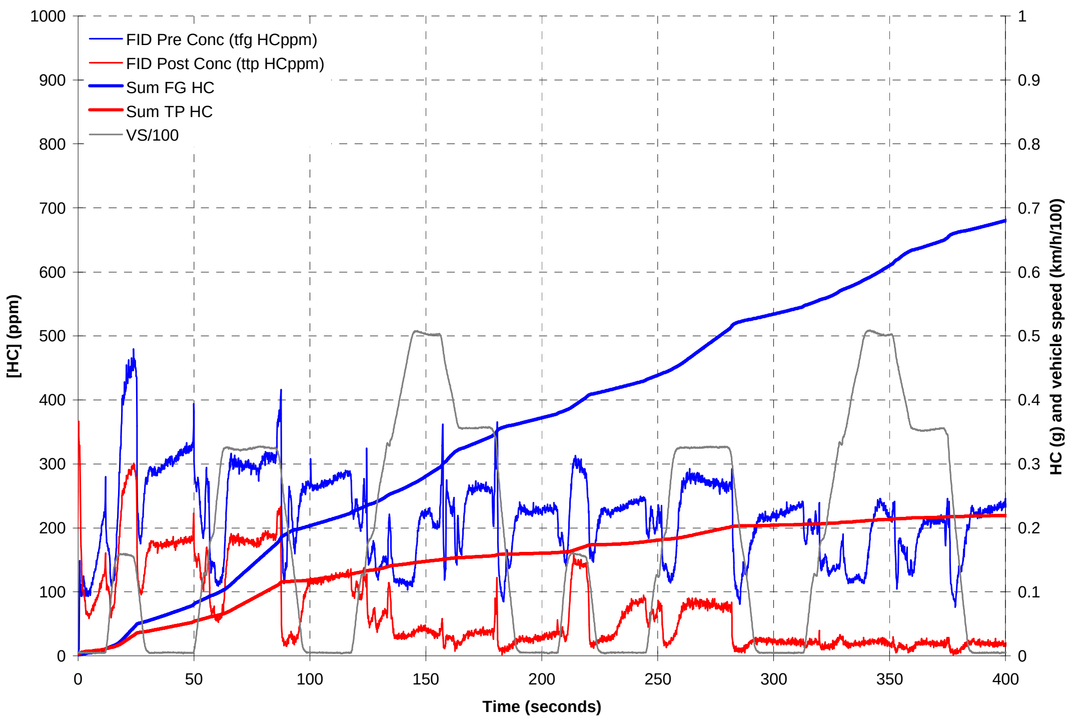

Chart 1. Diesel cold start.

There is a spike of emissions at the start (probably from a limited amount of white smoke – unburned fuel) but there is an apparent initial 50% ‘conversion’ from cold due to HC trapping. This is caused by

HC being adsorbed onto the zeolite wash coat on the DOC and slowly releasing the HCs later once the DOC has reached light-off temperature. There are large spikes on each of the throttle transients for the first 180 seconds. It is likely that the strategy at this point is to burn late in order to get the DOC up to temperature quickly. The spikes are no longer present once the DOC is operating efficiently. Conversions >50% suggest catalytic oxidation and these occur at about the same times that CO conversion occurs. After around 280 seconds the catalyst efficiency is showing around a 90% conversion.

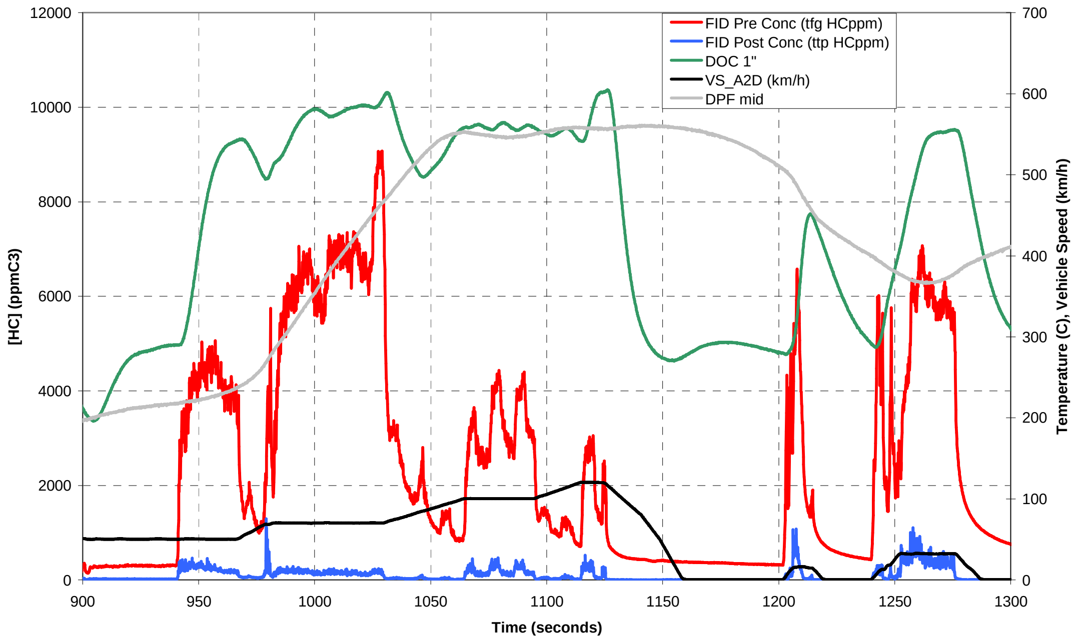

Chart 2. DPF Regeneration.

Regeneration Event.

Chart 2 shows a DPF regeneration event. The DPF temperature stays below 300°C for much of the cycle until the regeneration occurs. Post injection is responsible for raising the temperature of the feed-gas to the DOC. The oxidation process raises the gas temperature further. When the gas reaches the DPF it is at a hot enough temperature to burn off the loaded soot. It is possible to see on Chart 2 the DOC temperature rise in advance of the DPF temperature. A significant exotherm continues in the DPF after 1150s caused by the burning of soot.

The fast HC data clearly indicates the start of the regeneration process as the post-injection fuel produces a sharp increase in engine-out HC with some associated breakthrough in to the tailpipe HC emissions. The [HC] is high under low load conditions but drops as the engine load increases during the acceleration phases of the cycle. In general, the DOC provides effective and near complete conversion of the HCs but the period from 1070s to 1100s appears to exhibit some unstable points during what should be a steady state part of the cycle. These transients, possibly caused by instability of the engine control system in conjunction with slight accelerator pedal instability introduced by the robot driver, do break through and appear in the tailpipe HC emissions.