Cambustion

CLD500

Fast Response NOx Analyzer

Application Note: CLD 10v02

Transient NOx measurements from motorcycle real world driving

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A joint project between Cambustion and The Dr. Jekill and Mr. Hyde Company was undertaken using a port-fuel-injected two-cylinder Harley-Davidson Sport glide 107 motorcycle. This was with a view to measuring the transient emissions performance of the factory-delivered bike before the substitution of a Jekill & Hyde aftermarket exhaust system.

The bike was instrumented with fast NO sample probes fitted immediately upstream and downstream of its catalytic converter and the Cambustion CLD500 fast NOx analyzer (in mobile configuration) was supported on the rear passenger seat, weighing approximately 65kg. The analyzer was powered by a LiFePo supplying sufficient power for two hours of sampling.

Figure 1: Two-channel fast NOx analyzer sampling engine-out and tailpipe [NO]

The bike was then driven on a “condensed RDE” route around Cambridge involving urban, rural and motorway sections of total duration approximately 1 hour.

GPS was used to measure the precise location of each tailpipe NOx event and dashcam also recorded the driving conditions and audio of the event. Additionally, CAN data was available at rate of 2Hz which allowed analysis of engine lambda (from HEGO), rpm etc.

An example of a mapped tailpipe NOx "event" is shown in **Figure 2** and was from a gear downshift and acceleration towards a motorway on-ramp.

Figure 2: Precise location of tailpipe NOx "spike" during acceleration following gear downshift

The results from the fast NOx analyzer and the engine data is shown in **Figure 3**

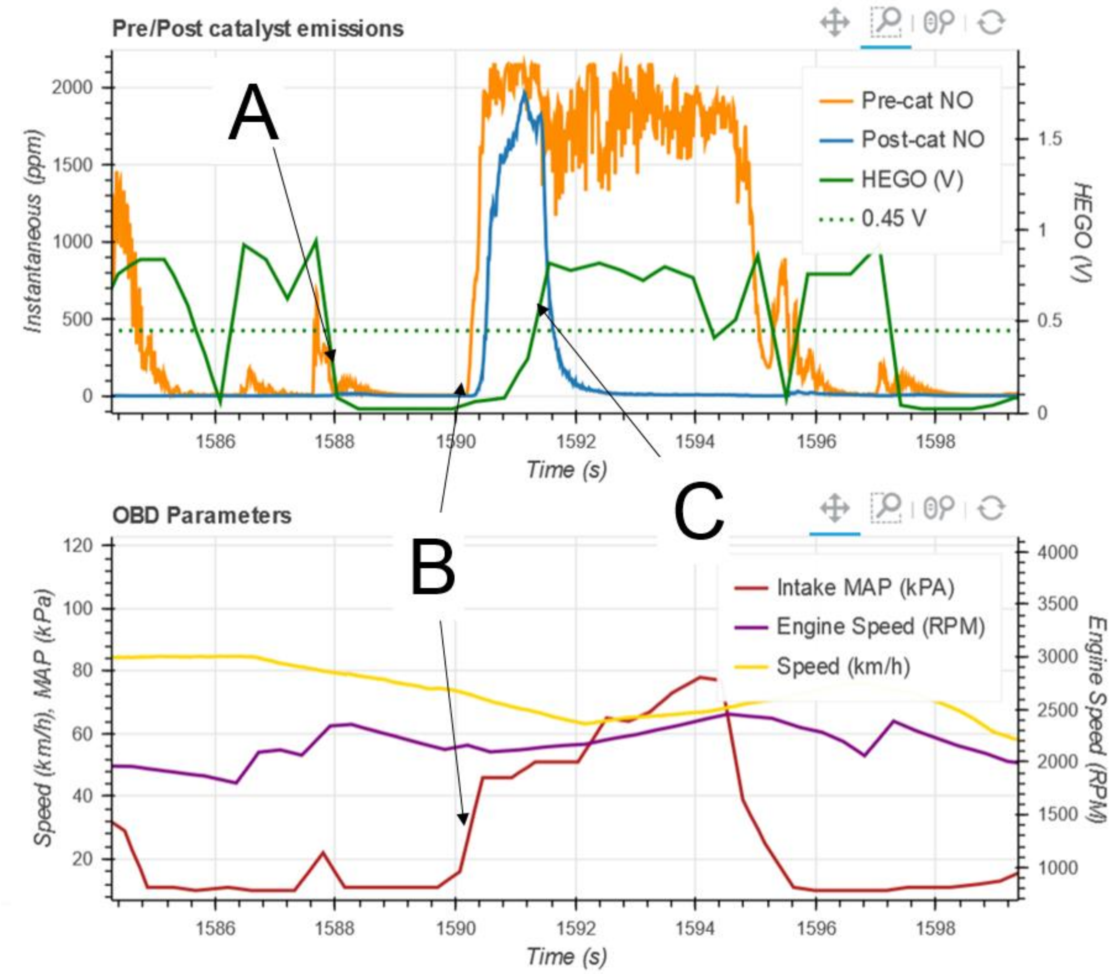

Figure 3: Fast [NO] and ECU data recorded during the transient shown in Figure 2

Decel fuel shut-off restart under load

The decel fuel shut-off is indicated at "A" where the engine-out NOx decays as burned gas is purged from the cylinders and exhaust and the HEGO voltage is low. Note that a value of 045V from the HEGO would denote lambda 1 combustion. The engine then restarts at "B" under sustained load with engine-out [NO] at 2,200ppm and, after a very short delay, similar levels of tailpipe NO. However, immediately after the PFI fuelling has enabled rich combustion at "C", then the 3-way catalyst can convert the engine-out NO and the tailpipe levels drop to near zero. The transient fuelling calibration of PFI engines has been the subject of multiple technical papers and the dynamics of the fuel puddle under various engine running conditions has been carefully modelled previously. One of the significant benefits of GDI is the more accurate and controllable fuelling control which it enables.

Summary

Transient NO emissions were measured on-board a 4-stroke motorcycle during real world driving. Many engine-out and tailpipe transients were measured (including the cold start and catalyst light-off period) but once fully warm, the main tailpipe NO "events" were associated with the well-established problems of PFI fuelling control; lean combustion causing the catalyst to pass NO to the tailpipe during very short periods. The rapidity of the event required fast response emissions analyzers to detect them and the engine-out [NO] readings allowed real-time assessment of catalyst conversion efficiency and time-alignment of other ECU parameters.

https://www.youtube.com/watch?v=7R3E_IZi8Aw