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Motorcycle Development Case Study-

Using a fresh aftertreatment system to clone a vehicle aged catalyst

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Executive Summary

Being able to age catalysts repeatably in both a costly and timely manner is a long-standing issue for light-duty vehicle OEMs worldwide. The importance of this work continues to grow as emissions standards for light-duty vehicles continue to tighten.

The aim of this project was to age a fresh aftertreatment system to the level of a vehicle aged aftertreatment system, by ageing the fresh hardware in a CATAGEN OMEGA test reactor. Characterisation tests were completed on both sets of hardware, to establish their performance levels and understand the requirements to clone the vehicle aged system, while allowing the performance degradation of the CATAGEN aged aftertreatment system to be tracked.

The project concluded that good correlation could be established between the CATAGEN aged catalyst and the vehicle aged system, as measured by the OEM's measurements, and that CATAGEN could successfully age and degrade performance of the hardware at a fraction of the time and cost, relative to the existing procedures.

Challenges

The challenge that exists for today's vehicle manufacturers is to repeatably age catalysts to levels known as 'Full Useful Life' (FUL) and 'On Board Diagnostic' (OBD). For example, motorcycle OEMs under the current EURO 5 legislation must age catalysts to 35,000km for FUL and demonstrate the tailpipe emissions are still below the required limits. Vehicle ageing methods can take months and incur large costs.

Solution

In order to clone the vehicle aged catalyst system, a characterisation target was required. CATAGEN completed a full characterisation suite on the vehicle aged aftertreatment system to analyse it's performance levels. A full characterisation suite was then completed on the fresh aftertreatment system to assess its performance levels. A full characterisation suite includes:

Oxygen Storage Capacity Test (OSC) – Oxygen is stored in the catalyst to ensure conversion of pollutants in both lean and rich conditions. The OSC will degrade with catalyst ageing.

Fast and Slow Light-Off Tests – Catalyst activity will improve as the temperature of the catalyst is increased. Conversion of pollutants can be tracked as the temperature is ramped at 10°C/second (fast) and 10°C/minute (slow). The light-off temperature is when conversion of each gas species reaches 50% and will increase with catalyst ageing.

Lambda Sweep – Three-way catalysts have an optimum lambda range for full conversion of harmful gas species to occur. This test provides performance analysis over a wide lambda range. The optimum lambda range will reduce with thermal ageing.

The degradation of the catalyst performance for each of the characterisation tests was analysed throughout the project and used to predict ageing times required. The process is outlined below in table 1 :

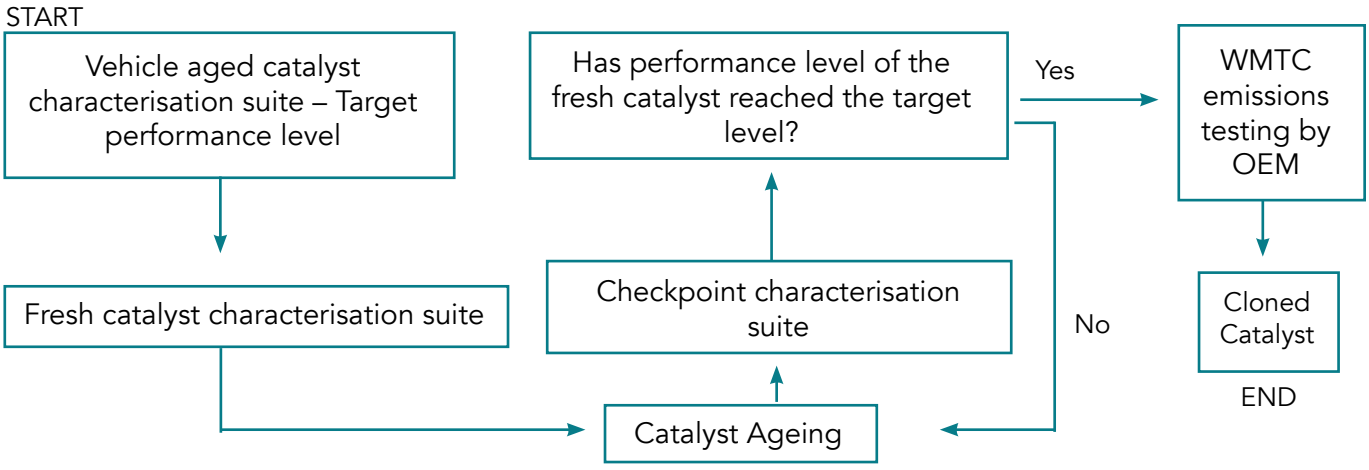

Table 1 – CATAGEN Process to clone a vehicle aged aftertreament system

Results

As described previously, characterisation checkpoints were used to track the degradation of the CATAGEN aged aftertreatment system. Figure 1 details the deterioration of the catalyst's performance levels, measured by fast light-off characterisation tests.

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Figure 1- Fast Light-Off Degradation

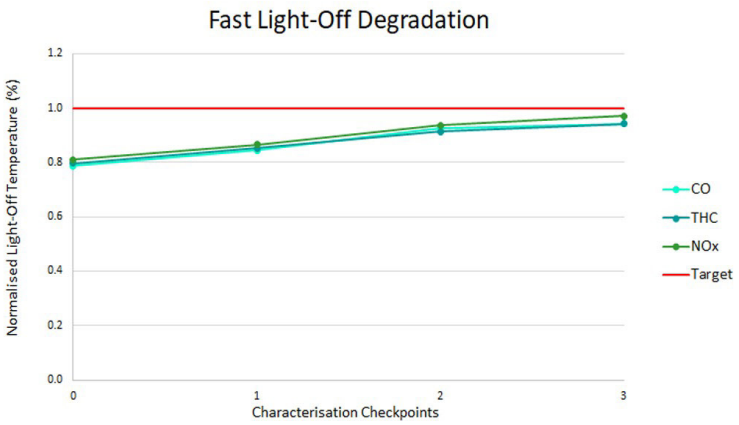

Figure 2 - WMTC Emissions Data

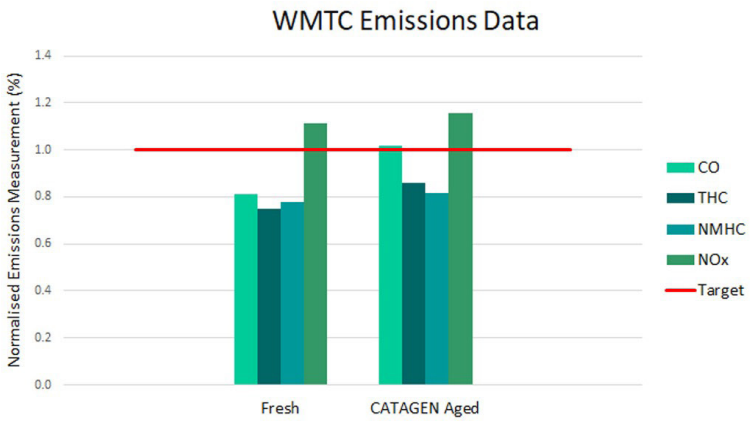

Figure 2 demonstrates the performance degradation caused by CATAGEN ageing from fresh, and how that related to the vehicle aged catalyst's performance, based on tailpipe emissions from a World Motorcycle Test Cycle (WMTC).

Key points from the data include:

- Good cloning achieved on CO tailpipe emissions measurement, with the CATAGEN aged hardware within 2% of the vehicle aged target.
- Negligible differences in NOx measurement across all samples, indicating that NOx conversion performance is unlikely to shift through thermal ageing. This could be in relation to the small OSC measured across the aftertreatment system.
- Some degradation observed on both the THC and the NMHC species through CATAGEN ageing.

The use of CATAGEN ageing in this project demonstrated a capability to degrade catalyst performance across multiple species, at a fraction of the time and cost to the OEM. The Italian Motorcyle OEM concluded that the project was successful and that the CATAGEN aged catalyst accurately replicated a vehicle aged catalyst. Further development tests are now being considered by the OEM.