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A Unique Application of Gasoline Particulate Filter Pressure Sensing Diagnostics

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Abstract

Gasoline particulate filters (GPFs) are important aftertreatment components that enable gasoline direct injection (GDI) engines to meet European Union (EU) 6 and China 6 particulate number emissions regulations for nonvolatile particles greater than 23 nm in diameter. GPFs are rapidly becoming an integral part of the modern GDI aftertreatment system.

The Active Exhaust Tuning (EXTUN) Valve is a butterfly valve placed in the tailpipe of an exhaust system that can be electronically positioned to control exhaust noise levels (decibels) under various vehicle operating conditions. This device is positioned downstream of the GPF, and variations in the tuning valve position can impact exhaust backpressures, making it difficult to monitor soot/ash accumulation or detect damage/removal of the GPF substrate.

The purpose of this work is to present a unique example of subsystem control and diagnostic architecture for an exhaust system combining GPF and EXTUN. In particular, the On-Board Diagnostics (OBD) controls are required to detect a disconnected/plugged downstream hose when combining a differential pressure (dP) sensor and an electronically controlled EXTUN valve in an exhaust system containing a GPF. The regulatory implications related to failing to detect a disconnected/plugged downstream hose are also discussed. Validation data from the control strategy under different operating conditions is reviewed.

History

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Keywords

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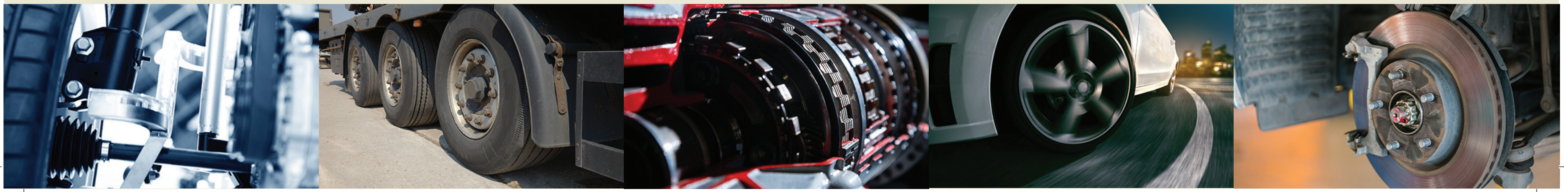
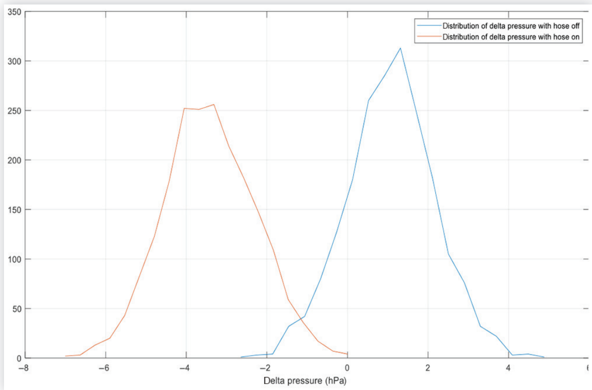


FIGURE 10 Histogram of the monitor metric (pressure difference in hPa) for a set of drive cycles with hose off and hose on.



When the downstream hose is connected, we expect a negative distance from the threshold.

The results of a Monte Carlo simulation with the above noise factors over 40,000 samples are shown in Figure 10. We can define the separation between the intact and failed systems as the difference in means over the geometric sum of the standard deviations.

$$S = \frac{\mu_{\text{hose off}} - \mu_{\text{hose on}}}{\sqrt{0.5.\left(\sigma^2_{\text{hose off}} + \sigma^2_{\text{hose on}}\right)}}$$

And find the value S = 4.05 for this analysis.

Summary/Conclusions

This study focused on using an EXTUN valve to diagnose a disconnected downstream hose on a dP sensor using a 5.0L Ford Mustang as a test vehicle, and the following conclusions emerged.

- A novel method that utilizes an EXTUN valve to conduct an intrusive dP sensor with downstream hose disconnected diagnostic with a GPF was developed.
- The dP sensor with downstream hose disconnected diagnostic method proved robust and showed considerable separation between faulted and non-faulted conditions.
- The diagnostic method developed allows the manufacturer to meet regulatory requirements for the detection of a missing downstream hose off and robustly diagnose a missing or damaged GPF substrate.

Contact Information

Definitions/Abbreviations

CMS - Catalyst monitor sensor
dP - Differential pressure sensor
DPF - Diesel particulate filter
EXTUN - Exhaust tuning valve
GDI - Gasoline direct injection
GPF - Gasoline particulate filter
PCM - Powertrain control module
T - Temperature sensor
UEGO - Universal exhaust gas O2 sensor

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