Effects of Regeneration Conditions on NO_X Trap Performance

Fuels, Engines, and Emissions

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Background

Under the direction of the U.S. Department of Energy FreedomCAR and Vehicle Technologies Program, the Oak Ridge National Laboratory (ORNL) is conducting research on new emissions control technologies to improve the emissions and fuel efficiency of diesel engines. Maximizing the effectiveness of emissions control technologies is key to enabling light-duty diesel vehicles to achieve ultra-low emissions while maintaining high fuel efficiency.

Researchers at ORNL have been working with members of the Manufacturers of Emission Controls Association (MECA) to examine factors that influence the performance of NO_X traps for light-duty diesel applications. MECA partners work in collaboration with ORNL by providing prototype devices that can be applied to a Mercedes A170 CIDI research vehicle at ORNL.

The Technology

Three-way catalysis, which has been the mainstay of spark-ignition emissions control for over two decades, works very well within a narrow regime around fuel-air stoichiometry, but is less effective when subjected to other conditions. Lean-burn engines (to date, mostly CIDI engines) have relied upon oxidation catalysts to remove carbon monoxide (CO), hydrocarbons (HCs), and some particulate matter (PM) from the exhaust, but new emissions regulations will require further reductions in both PM and nitrogen oxides (NO_X), which are more difficult to accomplish.

One promising technology for removing NO_X emissions from the exhaust streams of lean-burn engines is the NO_X adsorber, also known as a NO_X trap or NO_X storage and reduction catalyst. During lean exhaust conditions, NO_X is selectively trapped on the surface of the device. Periodic fuel-rich excursions allow the stored NO_X to be both released and chemically reduced. Achieving maximum benefit will require successful modeling and integration of these devices into the candidate vehicle, which in turn requires a thorough understanding of how NO_X adsorbers function.

The goal of this study was to investigate how exhaust conditions during regeneration events impact the overall drive-cycle efficiency of NO_X adsorbers. Specifically, the minimum air/fuel ratio (AFR) during the regeneration event and the length of the regeneration event were varied. The impact of these changes on the efficiency of five NO_X adsorbers was studied and the results were published through the Society of Automotive Engineers.

Future Directions

Information and experience gained from this study are being used in the Crosscut Lean Exhaust Emissions Reduction Simulation (CLEERS) initiative and are being used in other R&D efforts at ORNL aimed at continuing to resolve technical barriers facing diesel-powered vehicles.

Benefits

- More information available for detailed models of this technology
- Demonstrated trade-offs associated with changes in catalyst formulation
- Showed that most NO_X emissions occur during lean periods, not during regeneration

ORNL researchers utilized a Mercedes A170 CDI as a platform for studying NO_X trap technology.

For more information on how ORNL is helping America remain Competitive in the 21st century, please contact:

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Success Story

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