freedomCAR & vehicle technologies program

U.S. Department of Energy • Office of Energy Efficiency and Renewable Energy

Oak Ridge National Laboratory

Fuels, Engines, and Emissions

Downstream Emissions Control (Aftertreatment) Modeling

Background

Achieving ultra-low emissions levels from lean-burn engines remains a difficult technical barrier that must be overcome before these fuel-efficient engines can be incorporated into advanced vehicles for public use. Although hybridization can provide benefits in terms of decreased pollutant emissions (as well as fuel efficiency gains), it is unlikely that advanced, highly efficient vehicles can meet the stringent EPA Tier 2 emissions requirements without using one or more advanced emissions control technologies such as nitrogen oxide (NO_X) adsorbers, urea-selective catalytic reduction systems, and diesel particle filters.

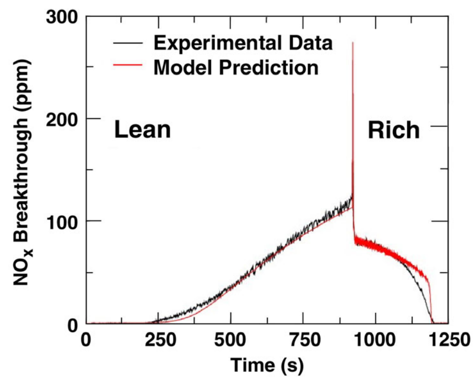
This activity focuses on developing low-order physically based models of emissions control devices, followed by laboratory characterization of prototype devices provided by industry partners. The laboratory characterization provides performance data to calibrate and "anchor" the physical models.

The Technology

Current research focuses on development of a model for an NO_X adsorber. This technology poses many issues for developing a model. The device operates in three steps: adsorbing NO_X from the exhaust stream during lean engine operation, releasing stored NO_X during the early stages of regeneration, and chemically reducing the released NO_X during regeneration. The model must therefore take all three steps into account. Uncertainty in the chemical kinetics involved with these devices and application-specific characteristics complicate the model.

ORNL has devised a low-order model made up of several algorithms to replicate the three steps and is calibrating the model with laboratory data from several sources. The chart at right shows the NO_X released from the adsorber during both lean and rich operation. At present the model very closely predicts the adsorber performance under laboratory conditions, but further calibration is needed to match the behavior during complex engine transients.

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle



Model prediction of NO_X release during lean and rich operation compared with laboratory data for a prototype.

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Low-order models of this type are not intended to replace more computationally intensive models aimed at device design, but they are expected to be useful for evaluating the integrated system performance of these technologies in vehicles. They are also expected to be useful for on-board diagnostics and control.

Benefits

- Model is relatively fast and accurate
- Models allow better concentration of experimental resources

Where Can I Find More Information?

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A Strong Energy Portfolio for a Strong America

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