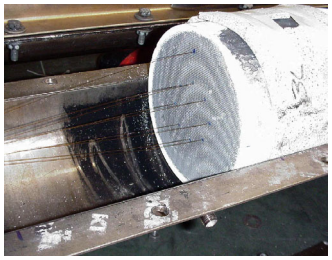
Measurement and Characterization of NOx Adsorber Regeneration and Desulfation

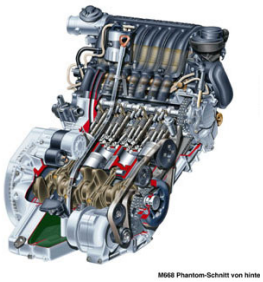
As part of the Department of Energy's strategy to reduce petroleum imports and enhance energy security, the FreedomCAR and Vehicle Technologies Program researches enabling technologies for more efficient diesel engines that will meet EPA's emissions regulations for oxides of nitrogen (NOx). Control of NOx emissions is a critical enabler of clean, fuel-efficient diesel engines. NOx adsorber catalysts are very effective but must be regenerated as often as every 30 to 90 seconds. Regeneration is accomplished by exposing the adsorber to a reductant that desorbs the NOx and transforms it into nitrogen. Hydrogen (H_2) and carbon monoxide (CO) are excellent reductants for NOx adsorber catalysts. ORNL, using the highly versatile engine controllers in its Fuels, Engines and Emissions Research Center, has developed engine control strategies that can be tuned to form H_2 and CO during periods of fuel-rich operation for NOx adsorber regeneration. The SpaciMS (spatially resolved capillary inlet mass spectrometer), a unique instrument developed by ORNL, is used to measure the H_2 and other chemical species within the engine exhaust stream and the catalyst.



SpaciMS instrument, developed at ORNL, enables measurements of chemical species within

NOx adsorbers also have a high affinity for sulfur. Sulfur from the fuel and possibly engine lubricant can adsorb to NOx adsorbent sites. Desulfation -- removal of the sulfur -- must be performed periodically to maintain effective performance. Desulfation also requires rich operation, but for several minutes, at much higher temperatures.

ORNL is developing and characterizing control strategies for introducing the fuel-rich environment needed for NOx adsorber regeneration and desulfation. Using a modern 1.7-L Mercedes common-rail, turbocharged, diesel engine with full electronic control of fuel injection, throttle, EGR, and wastegate, several strategies have been developed. These strategies are being thoroughly characterized for H_2, CO, and hydrocarbon species formed; fuel economy penalty; and overall NOx reduction performance, including unique in-situ measurements of some species within the catalyst channels. Catalysts are being sulfur poisoned and desulfurized repeatedly, and characterized before, during, and after repeat sulfations/desulfations. These data are being used to improve the understanding of NOx adsorber catalysts. Engine experiments are complemented by benchflow reactor experiments and model development, where the goal is to evaluate a catalyst formulation on a bench in the development stage, in order to predict how it will perform on an engine.



Mercedes 1.7-L diesel engine.

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