Abstracts

SESSION 3 – Fuels and Lubrication, Part 2

Chair: **Gary Yowell, California Energy Commission**

Robert McCormick, National Renewable Energy Laboratory

An Integrated Surface Modification Technique to Reduce Friction and Increase Durability

Stephen Hsu
National Institute of Standards and Technology

Surface texturing, thin film coatings, and coating specific lubricant chemistry can be integrated into a surface modification technology to dramatically alter material surface properties to achieve friction reduction and durability enhancement. This concept has been explored to see whether this technology can be applied to engine technology under various serving conditions for different components. The presentation will cover historical background, novel surface texture designs, fabrication techniques, and test results under elastohydrodynamic, mixed, and boundary lubricated conditions. It will be shown how these different surface textures, geometrical shapes, and design patterns impart different degrees of benefits.

Demonstrated Petroleum Reduction Using Oil By-Pass Technology on Heavy and Light Vehicles

J.E. Francfort, L.R. Zirker, and T.C. Murphy
Idaho National Laboratory

The Oil Bypass Filter Technology Evaluation is an ongoing fleet evaluation of an oil bypass filter technology by the Idaho National Engineering and Environmental Laboratory (INEEL) for the U.S. Department of Energy's FreedomCAR & Vehicle Technologies Program. Eight four-cycle Diesel-engine buses used to transport INEEL employees on various routes have been equipped with oil bypass filter systems from the puraDYN Corporation. The bypass filters are reported to have engine oil filtering capability of 1 micron and a built-in additive package to facilitate extended oil-drain intervals. As of March 2004, the eight buses have accumulated 400,000 test miles. This represents an avoidance of 33 oil changes, which equates to 1,165 quarts (290 gallons) of new oil conserved and therefore, 1,165 quarts of waste oil not generated. The test fleet has been expanded to include six INEEL Chevrolet Tahoe sport utility vehicles with gasoline engines and they have accumulated 68,000 miles in four months of testing, representing an additional 100 quarts (25 gallons) of oil not used or disposed of. To validate the extended oil-drain intervals, an oil-analysis regime is used to evaluate the fitness of the oil for continued service by monitoring the presence of necessary additives, undesirable contaminants, and engine-wear metals. The oil use and disposal saving rates are being extrapolated to the entire DOE complex as well as the entire Federal fleet of vehicles in order to identify the potential engine oil reduction throughout the nation. The INEEL evaluation progress, oil use reduction, and oil sampling results, as well as the potential to reduce engine oil use in all Federal fleets will all be presented.

X-Ray Characterization of Diesel Sprays and the Effect of Nozzle Geometry

Christopher F. Powell
Argonne National Laboratory

The development of accurate engine models is a key step toward producing Diesel engines with reduced in-cylinder emissions. One of the primary limitations of existing models is the simulation of the fuel spray itself. Since the mechanisms of spray atomization are not well-understood, it is very difficult to develop accurate models of the formation and structure of sprays. These uncertainties in the structure of the spray are very significant for emissions since the results of the spray models are used as the initial conditions for the combustion and pollutant formation models. The large uncertainties introduced by the spray sub-models limit the usefulness of overall engine models.

The x-ray absorption technique can make important contributions to solve this problem. This technique has the unique ability to make quantitative measurements of the spray core, even in the near-nozzle region which is inaccessible by other techniques. Such measurements allow modelers to test their simulations against measurements of fundamental spray properties such as mass distribution. This will lead to continual improvement of spray models and a better understanding of spray structure and dynamics.

In this talk, we will present some of our latest results of nozzle studies with different internal geometries which were given to us by DaimlerChrysler and Robert Bosch. This data will allow modelers to test their predictions of how the internal nozzle design affects the structure of the spray and will aid them in the development of newer, more accurate spray models. As spray models improve, engine models will gain more predictive power. More accurate engine models will allow quick and cost-effective design of fuel systems and engines with improved efficiency and reduced emissions.

Demonstration of the Low-Emission Potential for Urea Selective Catalytic Reduction and Diesel Particulate Filter Technologies

Magdi Khair and Chris Sharp
Southwest Research Institute

Ralph McGill
Oak Ridge National Laboratory

The objective of this project is to integrate several Diesel emission control technologies to demonstrate their capability to comply with the 2007-2010 heavy-duty Diesel engine emission requirements. Once the engine and control system were developed, several fuels having various sulfur content were evaluated to establish the sensitivity of the control system to sulfur. Two different emission control systems, both employing urea selective catalytic reduction catalysts and Diesel particulate filters, were calibrated and showed the potential for controlling nitrogen oxides and particulate matter to levels near the 2007-2010 requirements. Calibration of both systems has been completed and emissions with fuels of different sulfur levels have been measured. Additionally, a full suite of unregulated emissions has been measured using a low-sulfur refinery-type fuel. Both systems are undergoing the aging tests now with the target of achieving 6,000 hours of aging on a prescribed aging cycle. Both systems have completed over 2,000 hours of the aging, and emission tests of the systems at that point have been completed.

Phosphorous Exhaust Chemistry and Catalyst Poisoning

Bruce Bunting, Karren More, and Sam Lewis
Oak Ridge National Laboratory

Phosphorous in Diesel exhaust is derived from the zinc dialkyldithiophosphate (ZDDP) additive in lube oil used for wear control. Phosphorous emitted in the engine exhaust can react with an aftertreatment catalyst and cause loss of catalyst performance through masking or chemical reaction. It appears that there is a minimum level of ZDDP in lube oil needed for engine durability. One of the ways of reducing the effects of the resulting phosphorous on catalysts might be to alter the chemical state of the phosphorous to a less damaging form. One of the first requirements of altering the chemical state of phosphorous is to be able to measure its chemical state and compounds in Diesel exhaust.

In this study, lube oil containing ZDDP was added at an accelerated rate through a variety of engine pathways simulating various types of engine wear or oil disposal practices. In all cases, the phosphorous was found in an oxidized state as discrete particles on the exhaust particulate with the form and chemistry varying according to the method of introduction. Diesel oxidation catalysts run under these conditions of oil introduction showed phosphorous poisoning and masking effects as measured by light-off characteristics and material and chemical property changes. The analytical techniques and testing procedures have been related to field aging rates and can be used as a means to rapidly screen additives or catalysts for phosphorous poisoning behaviors.

Hydrocarbon Selective Catalytic Reduction Using a Silver-Alumina Catalyst with Light Alcohols and Other Reductants

John F. Thomas, Bruce G. Bunting, Samuel A. Lewis, Sr., John M. Storey, and Ron L. Graves, Oak Ridge National Laboratory Alexander G. Panov and Paul W. Park, Caterpillar, Inc.

Previous work with a full-scale ethanol-SCR (selective catalytic reduction) system featuring an Ag-Al_2O_3 catalyst demonstrated that this type of system has potential to reduce nitrogen oxides (NO_X) emissions by 80 to 90 percent. Increased emissions of hydrocarbons, acetaldehyde and ammonia were measured, but very little dinitrogen oxide was found. In this next increment of work, a number of light alcohols and other hydrocarbons were used in experiments to look at their potential with the same Ag-Al_2O_3 catalyst. A secondary goal was to "shed light" on the possible catalytic reaction mechanisms that make this system perform well. Experiments show that heavy-duty Diesel engine exhaust NO_X emissions can be reduced by more than 80 percent, utilizing ethanol as the reductant for a space velocity near 50,000/h and catalyst temperatures between 330 and 490°C. Similar results were achieved for other light alcohols, with a (desirable) shift to a lower temperature range. Heavier alcohols and other oxygenated organics were also tested as reductants, but with somewhat less successful results. Non-oxygenated hydrocarbons appear to be poor reductants for this system. Some speculative explanation is offered for the mechanisms governing the observed results.

APBF-DEC Heavy-Duty NO_x Adsorber/DPF Project: Catalyst Aging Study

Shawn D. Whitacre
National Renewable Energy Laboratory

This presentation summarizes the results of a 2,000 hour aging test conducted on an advanced test platform consisting of nitrogen oxides (NO_X) adsorber catalyst, a diesel particle filter and a heavy-duty engine.

The project that is discussed is one of several being conducted as part of the Department of Energy's Advanced Petroleum-Based Fuels – Diesel Emission Control (APBF-DEC) activity. This government/industry collaboration is examining how systems of advanced fuels, engines, and emission control systems can deliver significantly lower emissions while maintaining or improving vehicle fuel economy.

The potential for systems including NO_X adsorber catalysts and diesel particle filters to significantly reduce emissions from heavy-duty engines is well-documented. However, relatively few practical studies have been conducted which examine their performance over time. Sulfur poisoning and thermal degradation have been identified as potential mechanisms for performance loss.

In this study, a Cummins ISX EGR engine (15 L) has been modified with a secondary fuel injection system to enable NO_X adsorber catalyst regeneration and desulfation. Periodic performance evaluations were conducted during a 2,000 hour endurance test of the emission control system. Criteria pollutants as well as currently unregulated, but potentially toxic, emissions were evaluated over transient and steady-state operating cycles with a 15-ppm sulfur test fuel. Test results indicate that high system efficiency can be maintained when appropriate management strategies are employed.