Y/AMT-608

Y-12

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LOCKHEED MARTIN

Project Accomplishment Summary
for
Project Number 93-MULT-148-C1-4

REDUCTION OF NITROGEN OXIDE EMISSIONS FOR LEAN BURN ENGINE TECHNOLOGY

Ralph N. McGill
Lockheed Martin Energy Systems, Inc.

GM, Chrysler, Ford

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Prepared by the
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DISCLAIMER

PROJECT ACCOMPLISHMENT SUMMARY

Title: Reduction of NOx Emissions for Lean Burn Engine Technology
DOE TTI Number: 93-MULTI-148-C1-4
CRADA Number: Y1293-0166
Partner: USCAR (GM, Chrysler, Ford Consortium)

BACKGROUND

Lean-burn engines offer the potential for significant fuel economy improvements in cars and trucks, perhaps the next great breakthrough in automotive technology that will enable greater savings in imported petroleum. The development of lean-burn engines, however, has been an elusive goal among automakers because of the emissions challenges associated with lean-burn engine technology. Presently, cars operate with sophisticated emissions control systems that require the engine's air-fuel ratio to be carefully controlled around the stoichiometric point (chemically correct mixture). Catalysts in these systems are called "three-way" catalysts because they can reduce hydrocarbon, carbon monoxide, and nitrogen oxide emissions simultaneously, but only because of the tight control of the air-fuel ratio.

Lean-burn engines offer greater fuel economy potential, but for these engines the three-way catalyst technology will no longer reduce nitrogen oxide emissions. Therefore, to realize the benefits of such engines, emissions reducing technologies addressing these obstacles must be developed. The lean-burn NOx catalyst represents such a challenge. There is a worldwide race to develop the first successful lean NOx catalysts, and the winners in the race will realize considerable competitive advantage for several years.

This CRADA is one of five CRADAs with national laboratories that USCAR entered into in 1993, all in a coordinated team effort to develop successful prototype lean NOx catalysts. Funding was provided by Defense Programs under its TTI initiative for three years, at which time the funding was assumed by the Office of Advanced Automotive Technologies in the Office of Transportation Technologies. The LMES/Y-12 role has been to provide a state-of-the-art test facility in which all of the candidate catalyst prototypes can be evaluated in real-world conditions. Other national laboratories as well as USCAR have provided the prototype catalysts. Additional responsibility for systems engineering to optimize catalyst performance has been with LMES/Y-12.

DESCRIPTION

The purpose of this cooperative effort is to develop advanced catalyst systems, materials, and necessary engine control algorithms for reducing NOx emissions in oxygen-rich automotive exhaust (as with lean-burn engine technology) to meet current and near-future mandated Clean Air Act standards. These developments will represent a breakthrough in both emission control technology and automobile efficiency. The total project is a joint effort among five national laboratories, i.e., Lawrence Livermore National Laboratory, Sandia National Laboratory, Los Alamos National Laboratory, Argonne National Laboratory and Lockheed-Martin Energy Systems, together with USCAR. The role of Lockheed-Martin Energy Systems in the total project is two fold: characterization of catalyst performance through laboratory evaluations from bench-scale flow reactor tests to engine laboratory tests of full-scale prototype catalysts, and microstructural

characterization of catalyst material before and after test stand and/or engine testing.

BENEFITS TO DOE

Success in the project will help improve the international competitiveness' of the domestic automobile and supplier industries, thereby helping to reduce dependence on foreign sources of petroleum and to assure the economic security of the nation. This project will help the Department of Energy meet the goals of the Energy Policy Act through improved energy efficiency and improved worldwide competitiveness of U.S. industry. Furthermore, this project helps to maintain critical skills at the Y-12 plant in spectroscopy, measurement technology, and skilled trades by providing challenging work and employing Y-12 personnel in the project.

ECONOMIC IMPACT

Results of this project will eventually be used by the companies that make up the USCAR consortium (GM, Ford, Chrysler) in their product lines. In the interim, the project has been made a centerpiece of the Partnership for a New Generation of Vehicles - a large partnership between the U.S. government and USCAR intended to develop prototype advanced light duty vehicles capable of achieving up to three times the fuel economy of today's family sedans. Lean-burn engine technology has been selected as a prime candidate for use in these prototype vehicles, and lean NOx catalysts will be required for emissions reductions. It is anticipated that prototype catalysts from this project will be used in these prototype vehicles. At the time when the lean-NOx catalyst technology is taken beyond the prototype stage, it is expected that these catalysts will be utilized in the product mix of the automakers, and the impact on the health of these companies will be huge.

PROJECT STATUS

The project is ongoing. DP funding for the project in Oak Ridge was terminated in September of 1996. Since then the project has been funded through EE. Estimated completion date for the project is January 2000.

Since this project is ongoing, much progress has been made in developing and screening catalyst materials that reduce NOx effectively under lean-burn engine conditions. To date, a state-of-the-art engine dynamometer test facility was designed and built at Y-12 to support the catalyst-testing phase for lean-burn engines. This test facility is equipped with specialized engine and emissions instrumentation. A direct injected turbo diesel engine, provided to Y-12 by the industrial partners, is being used for catalyst evaluation. A variety of catalyst formulations were prepared at Sandia National Laboratory (SNL) and Lawrence Livermore National Laboratory (LLNL) over the course of the CRADA. SNL also scaled-up processing of the best performing catalyst and produced several full-sized catalytic converters for engine testing at Y-12. LLNL also has sent several large converters to Y-12 for testing. These catalyst prototypes, along with others supplied by the industrial partners, have been tested under varying exhaust temperature, engine exhaust rate, and fuel composition. Catalyst materials tested so far include hydrous metal oxides, aerogels, noble metals, and zeolites.

Microstructural evaluation is also an integral part of this CRADA, both for the catalyst development process and for the characterization of the catalyst before and after test stand and/or engine testing - an important step in the understanding of the catalyst performance. Small cores from catalysts

showing the best NOx conversion were sent to ORNL for additional microstructural characterization. Microstructure studies were also undertaken to aid in the development of catalyst coating processes used by SNL, LLNL, and LANL. To date, this has included full evaluation of approximately 20 catalyst cores as well as 10 additional experimental powders. Several different characterization techniques have been used to understand the differences in microstructure between catalysts and to relate observed microstructure differences to the observed difference in emissions-reducing performance of the different catalyst systems.

Oak Ridge has additionally contributed significantly to the understanding of the "systems" issues in developing successful catalyst systems, i.e., how the catalyst performance is optimized with the rest of the engine and emissions-reducing system. All of these catalysts require the use of a reductant in order to lower NOx emissions, and the issues of which reductant, how to introduce the reductant, and how to optimize the performance of the catalyst with the reductant have been addressed quite successfully by the Oak Ridge team.

DOE FACILITY POINT(S) OF CONTACT FOR PROJECT INFORMATION:

Ralph McGill, Principal Investigator
Lockheed Martin Energy Research Corp.
Y-12 Plant. Bldg. 9108. Mail Stop 8087
Oak Ridge, TN 37831
423-574-407 FAX: 423-574-2102

Norberto Domingo, Project Engineer
Lockheed Martin Energy Research Corp.
Y-12 Plant. Bldg. 9108. Mail Stop 8087
Oak Ridge, TN 37831
423-576-0520 FAX: 423-574-2102

John Storey, Analytical Instrumentation Specialist
Lockheed Martin Energy Research Corp.
Y-12 Plant. Bldg. 9108. Mail Stop 8087
Oak Ridge, TN 37831
423-574-0574 FAX: 423-574-2102

COMPANY SIZE AND POINT(S) OF CONTACT:

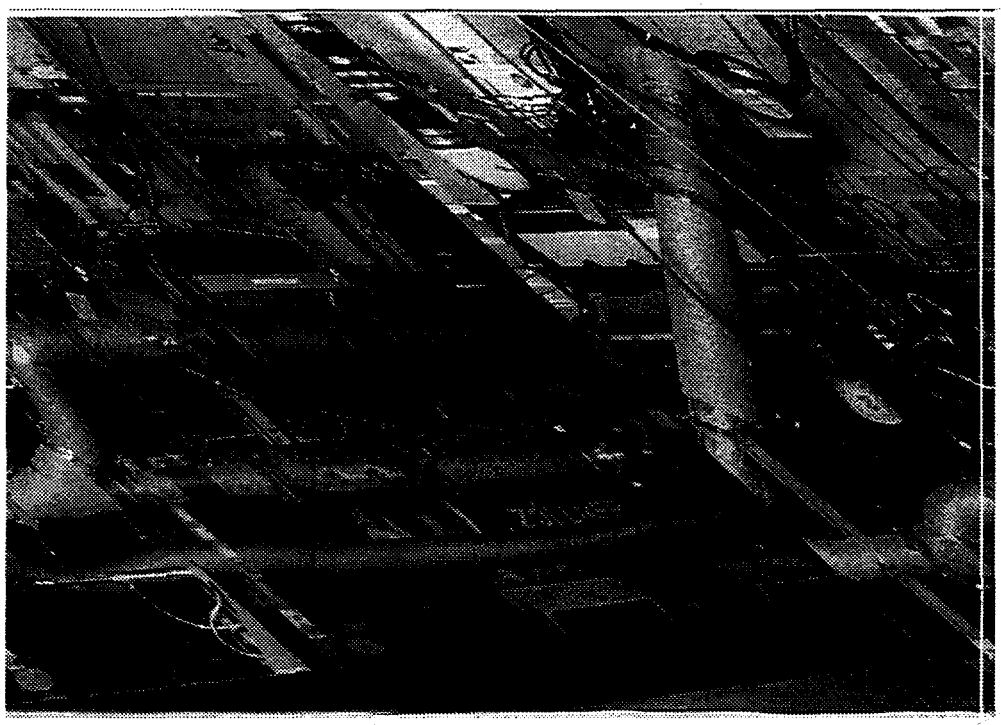
Michael J. Royce (USCAR Coordinator for Catalyst CRADA Y12-93-0166)
Program Manager
Low Emissions Partnership
Vehicle Engineering
Chrysler Corporation
Auburn Hills, MI 48326-2757
810-576-4996 FAX 810-576-2182

Kathy Taylor
Department Head
Physical Chemistry Department
NAO Research and Development
General Motors Corporation
30500 Mound Rd.
Warren, MI 48090-9055
313-986-2010 FAX: 313-685-6374

Haren S. Gandhi
Technical Fellow
Manager, Chemical Engineering Department
Scientific Research Laboratories, MD-3179
Ford Research Laboratory
20000 Rotunda Drive
Dearborn, MI 48121-2053

PROJECT EXAMPLES

Engine laboratory for evaluating lean NOx catalysts in real-world environment. Picture shows engine (a 7.3 liter Navistar diesel engine), dynamometer, and catalyst evaluation setup.



TECHNOLOGY COMMERCIALIZATION

It is possible, perhaps likely, that technology evolving from this project will be commercialized by the domestic automakers, but not likely to be commercialized by the national laboratories. If commercialized, this might likely happen in the time frame of the years 2005-2010.

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