Y-12

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DEPARTMENT OF ENERGY

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Project Accomplishment Summary
for
Project Number 92-MULT-019-B2-04

Y/AMT-482

NITROGEN OXIDE - SENSORS AND SYSTEMS FOR ENGINE MANAGEMENT

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June 24, 1997

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Prepared by the
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PROJECT ACCOMPLISHMENT SUMMARY

Title: Nitrogen Oxide—Sensors & Systems for Engine Management
DOE TTI Number: 92-MULT-019-B2-04
CRADA Number: Y1292-0112
Partner: A. C. Rochester Division of General Motors

BACKGROUND

The auto industry is one of the largest and most important sectors of the US economy. The Big Three US auto makers (GM, Ford, and Chrysler) alone employ over 620,000 workers in this country selling some 8.8 million new cars and trucks in 1991 worth approximately \$150B in sales revenue. When the impact of part suppliers, steel, aluminum, and electronics producers are included, the effect of a downturn in US car manufacturing becomes a nationwide tragedy. For example, US auto makers currently use 1/7 of all US steel production and 1/6 of all US aluminum production. Transplant Japanese factories can not be expected to compensate for reductions by US auto makers; in fact, transplants result in a net loss of US jobs. In 1991, the Big Three US auto makers sold 8.8 million new cars and trucks with over 620,000 employees while the Big Three Japanese firms (Toyota, Nissan, and Honda) sold 2.4 million new cars and trucks with only 37,000 US employees. It is estimated that the Japanese owned, US located, auto assembly facilities enjoy an \$8 to \$9 an hour cost advantage over the US Big Three by building new plants in rural areas and hiring young workers with smaller health and pension needs. Most of the parts in these 2.4 million cars and trucks come directly from Japan and the engineering activities are mostly performed in Japan before US assembly begins. The effect of these issues is reflected in the US-Japan imbalance of trade; currently, about two thirds of Japan's \$41-billion trade surplus is attributable to autos and auto parts.

Increasingly stringent US government regulations regarding average fuel economy and exhaust emissions control add to the problems challenging US auto makers. While the Japanese auto makers appear to be ahead in the technology race to bring a "lean burn engine" to the market place. Future automotive engine management systems will require sophisticated digital controllers to collect and analyze signal inputs from engine and exhaust mounted sensors in order to actively control and maintain optimum engine operations. The DOE's National Laboratories have developed technologies which, if further developed and transferred to US auto makers, may become vital to the survival of the US auto industry. In-vehicle sensors, an enabling technology for engine management and control, have been identified as essential to GM and the entire US automobile industry. The auto makers have decided that advances in exhaust gas monitoring, combustion monitoring, engine fluid condition monitoring, and engine control are required for the US manufacturers to remain competitive. Severe functional, environmental, price, lifetime, and reliability requirements on these smart sensors exceed the present "state of the art" electronics technology. The demand for these and other automotive electronics remains high; it was estimated in by 1995, that 20-25% of the cost of a car was attributed to the electronics content. In addition to meeting new regulatory requirements, US auto makers must continue to attract US customers and recently, US consumers have shown a clear preference for automobiles with enhanced, sensor based features (e.g., anti-lock braking systems and air bag protection systems) thus furthering the need for improvements in the sensors and electronics areas.

DESCRIPTION

The goal of this Cooperative Research and Development (CRADA) effort is to further develop sensors and sensor systems in order to meet current and anticipated air emissions requirements due to the operation of Defense Program facilities and the emission standards imposed on new vehicles operating in this country.

All automobile manufacturers have a mandate by the federal government and the State of California to reduce emission from all their new automobiles. The new California law is not now achievable without seriously degrading the performance of the automobile in terms of acceleration and mileage. A company must stay competitive while meeting emissions standards throughout the world. Specific objectives of this work are to be able to measure and control on-line and in real-time, emissions, engine operation, air-to-fuel intake ratios, and throttle/accelerator positions in future models of consumer automobiles.

Sensor and application specific integrated circuit developments within Lockheed Martin Energy Systems are applicable to the monitoring and engine controls needed by General Motors. In the case of emissions sensors, base technology in thick/thin film sensors and optical systems will be further developed to address the combination of high temperature and accumulated deposits expected in the exhaust stream. Other technologies will also be explored to measure fuel-to-air ratios and technologies such as fiber optic and acoustic wave devices that are applicable to the combustion sensing on an individual bases.

Two non-contact rotary position sensors have been developed for use in control-by-wire throttle control applications. The two CRADA developed sensors consist of a non-contact, differential capacitance position transducer and a custom complementary metal oxide semiconductor (C-MOS) application specific integrated circuit (ASIC) suitable for use in both passenger and engine compartments. The two sensor packages are essentially identical in function and operation with alternate packages for passenger and engine compartment operation.

The custom CMOS ASIC was developed as a demonstration of the use of standard commercial CMOS fabrication processes to produce extended temperature range, engine compartment automotive circuits. Two each of the prototype sensors have been delivered to the A. C. Rochester Division of General Motors for test and evaluation.

BENEFITS TO DOE

The development of this high reliability, differential capacitance position sensing method and reliable high temperature CMOS readout electronics can be readily applied to a large number of harsh environment monitoring applications throughout the DOE Complex.

The effort on sensing with the small time-of-flight mass spectrometer has utility for general emissions sensing at the production plants.

ECONOMIC IMPACT

At this time, it is not possible to assess the economic impact of the endeavor.

PROJECT STATUS

This project is complete.

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

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COMPANY SIZE AND POINT(S) OF CONTACT:

The General Motors Corporation, founded in 1908, is the world's largest full-line vehicle manufacturer. GM manufactures and markets cars, trucks, automotive systems, heavy-duty automatic transmissions, and locomotives worldwide. Other substantial business interests include EDS, Hughes Electronics Corporation, and General Motors Acceptance Corporation. GM sells cars and trucks in 170 countries and has manufacturing, assembly, or component operations in over 50 countries. Automotive sales for 1995 was \$152 billion.

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PROJECT EXAMPLES

This project has produced prototype devices that are undergoing testing at General Motors.

TECHNOLOGY COMMERCIALIZATION

The technology is being evaluated by General Motors. At this time, a decision on commercialization has not been made.

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