Reducing NOx Emissions From Diesel Engines

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Environmental Problem

Nitrogen oxides (NOx) lead to acid rain and contribute to unhealthy ground-level ozone and smog, often leading to severe respiratory problems among affected communities. Diesel engines produce unacceptably high levels of NOx at high loads, and NOx from nonroad diesel engines represents an increasing percentage of the environmental pollution in nonattainment regions (areas that do not meet primary environmental standards), where more than 90 million Americans live. Economical, easy-to-integrate solutions are needed to meet the NOx reduction goals of the Clean Air Act.

SBIR Technology Solution

A promising new method of reducing NOx emissions involves the recycling of exhaust gas in a process called exhaust gas recycle (EGR). EGR sends captured exhaust gas back into the combustion chamber of the engine, thereby increasing fuel economy and reducing emissions: a 25% EGR leads to a 50% reduction in NOx. There are some problems, however, associated with the process, including: (1) extra pumping and cooling of the EGR stream, (2) engine wear from recirculating engine soot, and (3) high feed air water vapor levels. These issues can be avoided by the use of nitrogen-enriched air (NEA), which reduces the diesel combustion temperature and, in turn, the amount of NOx emitted in the engine exhaust. The NOx reductions achieved through NEA are similar to those accomplished through the EGR process, while simultaneously avoiding the pumping, cooling, wear, and water vapor issues associated with EGR.

With support from EPA's SBIR Program, Compact Membrane Systems, Inc. (CMS), in cooperation with its commercialization partners, has developed stable fluoropolymer membranes to nitrogen enrich the turbocharged intake air to diesel engines. Cooled turbocharged air is processed by an NEA membrane to supply NEA to the diesel engine intake. NEA reduces the diesel combustion temperature; in turn, the amount of NOx produced and emitted in the engine exhaust is greatly reduced.

CMS membrane modules are designed for very high flux, harsh operating conditions, stable performance, and production of NEA in the range of 79.5% up to 84%. As a result of EPA's SBIR funding and collaborations with downstream partners and commercial membrane manufacturers, CMS has made large advances in demonstrating and commercializing NEA membranes for NOx reduction in diesel engines, particularly for truck, generator, marine, and locomotive platforms.

Commercialization Information

Working with major industrial gas companies (e.g., Praxair and Air Liquide) and their membrane divisions (IMS and MEDAL), CMS has produced large, commercial-sized membrane modules. In collaboration with Caterpillar, these large commercial-sized modules have operated successfully in excess of 1 million on-road miles on five Class 8 diesel trucks. Independent laboratory testing of the membrane systems showed them to have excellent fouling resistance to ingested dust and durability to an excess of 1 million pressurization cycles while operating at high temperature (85°C) and high pressure (30 psig). Caterpillar tests over a broad cycle showed that the membranes exceeded the target NOx emission reduction of 50%.

CMS' successful field demonstration with Caterpillar in combination with support from EPA's SBIR Program has led to additional opportunities that presently are under commercial/developmental evaluation. Low-speed marine diesel CMS membranes on Scandinavian ferries and ships have been tested and achieved the target 30% NOx reduction with less than 5% fuel penalty.

Membranes within the black housing mounted over the diesel engine pictured above generate NEA from cooled turbocharged air.

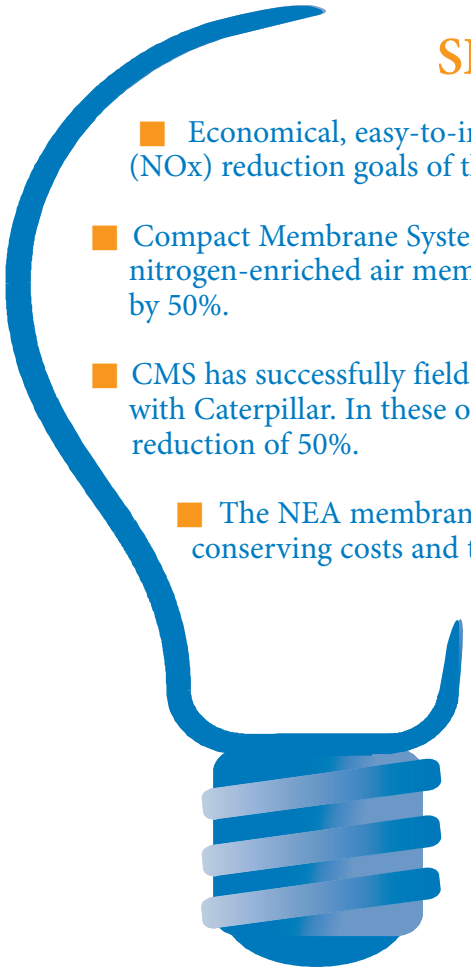
The retrofitting of installed emergency generators with CMS NEA membranes is being evaluated, and the membranes show promise for creating cost savings from peak electric power rates. Stand-alone membrane units driven by a vacuum pump have been developed, offering an alternative to retrofitting machinery with minimal or no downtime. These additional programs have successfully completed the feasibility phase.

Company History and Awards

CMS was founded in 1993, based on membrane technology acquired from E.I. DuPont. CMS is located in Wilmington, Delaware. CMS' focus is on the research, development, and commercialization of membranes and thin films composed of fluorinated polymers with exceptional gas transport properties and chemical resistance. The firm holds numerous patents for its technology.

In 1998, 2000, and 2007, CMS received the Tibbetts Award as an Outstanding Small Business in the State of Delaware. This award is given by the U.S. Small Business Administration to firms judged to exemplify the best in small business innovation and research. The company's goal is to become, in combination with its partners, the world market leader of amorphous perfluoropolymer membranes for gas transport (including NEA).

Although CMS products are focused on perfluoropolymers, the company serves a broad range of markets that can utilize the unique features of CMS membranes. The California Air Board certified CMS' membrane cartridge to capture escaping gasoline vapors at pumps and tank vents and return the gasoline to underground storage tanks.



SBIR Impact

- Economical, easy-to-integrate solutions are needed to meet the nitrogen oxides (NOx) reduction goals of the Clean Air Act.
- Compact Membrane Systems, Inc. (CMS) demonstrated that a high-productivity nitrogen-enriched air membrane can be used to reduce diesel engine NOx emissions by 50%.
- CMS has successfully field demonstrated commercial-sized membrane modules with Caterpillar. In these on-road tests, the membranes exceeded the target NOx reduction of 50%.
- The NEA membrane system approach also allows for a stand-alone unit, conserving costs and time needed for retrofitting equipment.