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Effective Alternative to EGR: Novel Application of Air Separation Membranes Reduces NO_x Emissions (ANL-IN-92-066, ANL-IN-95-152, ANL-IN-98-061 and ANL-IN-03-120)

Usable in engine retrofits and meets EPA standards

The Invention

Nitrogen oxide (NO_x) emissions pose risks to human health, and for this reason, scientists seek methods to reduce them. Because nitrogen oxide is a function of temperature, by reducing engine in-cylinder temperature, NO_x emissions can be reduced. While exhaust gas recirculation (EGR) has proved to be an effective tool for reducing engine in-cylinder temperature, EGR's many disadvantages preclude it from consideration as a viable long-term option.

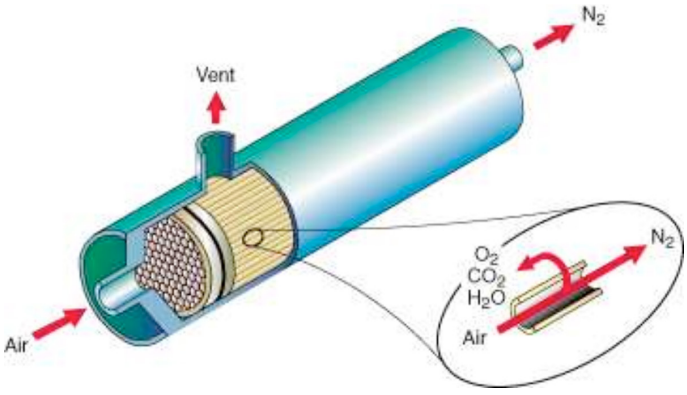
Scientists at Argonne National Laboratory have developed an effective alternative to EGR—nitrogen enrichment of intake air—that has none of EGR's undesirable attributes. This mature technology involves selective permeation of gases using an air separation membrane (ASM). Researchers also succeeded in reducing NO_x emissions by after-treatment of engine exhaust. Different types of catalysts are implemented depending on the combustion recipe adopted (rich burn or lean). For example, current diesel engines employ urea SCR systems, while spark-ignited natural gas power generators employ three-way catalysts.

After-treatment modules add significant cost to the system compared to ASMs. Introduction of inert diluents, like nitrogen, into a fuel-air mixture slows down the reaction rates of participating chemical species, which eventually results in lower combustion temperatures and, hence, lower NO_x. Since ASMs produce oxygen-rich and nitrogen-rich streams by passing air through them, the nitrogen-rich stream can be introduced into the engine to control NO_x.

Argonne pioneered the application of membranes in internal combustion engines, testing the technology on several platforms including locomotives, vehicles, and power generators. The results of this work have triggered more in-depth studies of ASM and its applicability to various engine configurations for both stationary and transportation applications.

Benefits

- Significantly reduces NO_x emissions (as much as 70 percent) with just a 2 percent nitrogen enrichment of intake air
- Ability to retrofit existing engines with the technology
- Membranes meet EPA standards
- Ability to reduce combustion temperature



Schematic representation of the air separation process through a membrane module.

Applications and Industries

- Automotive industry
- Power generation
- Locomotives

Developmental Stage

Proof of concept

Availability

Available for licensing

Argonne Invention Numbers

ANL-IN-92-066, ANL-IN-95-152, ANL-IN-98-061 and ANL-IN-03-120

Intellectual Property

US Patents 5,526,641; 7,455,046; 5,649,517; 6,055,808

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