Argonne NATIONAL LABORATORY

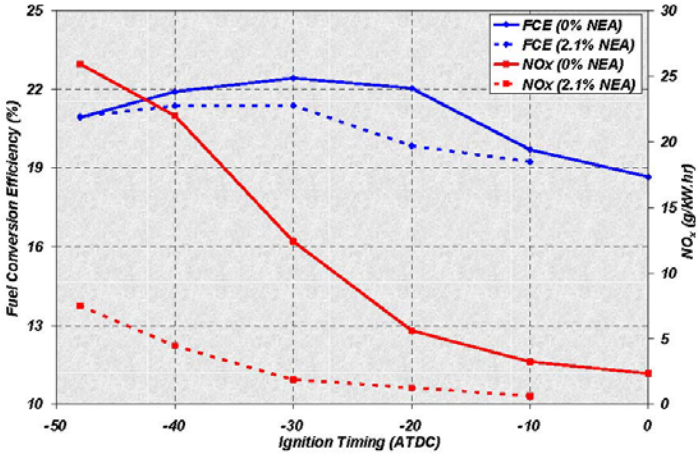
Energy Systems Division

Nitrogen Enrichment of Intake Air for Gas Engines

DOE's Advanced Reciprocating Engine Systems (ARES) program targets remain >50% efficiency and, of prime concern, NOx emissions < 0.1g/bhP-hr. by 2010. One strategy to achieve such low emissions in a rich-burn (φ = 1.0) engine is to use a combination of EGR and a three-way catalyst. While such a strategy benefits from low-temperature combustion and thereby leads to lower NOx formation, it also compromises engine maintenance: particulate matter and acidic compounds in the exhaust lead to hardware corrosion and lube oil contamination. Following a parallel path, Argonne has developed a strategy that benefits from low-temperature combustion while avoiding all the shortcomings of EGR. Under Argonne's strategy, engine intake air is selectively enriched with nitrogen (up to 2%) to reduce NOx by close to 70%.

Four kW Test Engine

Initially, a zero-dimensional computer modeling was performed to evaluate the effectiveness of nitrogen enrichment in natural gas fired engines. Such a modeling showed the present strategy to be very effective for rich-burn engines. Subsequently, testing was performed in a 4 kW Kohler engine. Through optimization of nitrogen content in intake air and ignition timing, NOx reductions up to 70% could be achieved (*cf*. fig. 2). The concurrent efficiency penalty was marginal, amounting to less than 1%.



Fuel Conversion Efficiency and NOx with respect to Ignition Timing

Reference: "Nitrogen Enriched Combustion of a Natural gas Engine to Reduce NOx Emissions," ASME ICEF2004-843, Long Beach, CA, Oct. 2004.

Technical Contacts:
rsekar@anl.gov
mbiruduganti@anl.gov