A Parametric Study Using Biodiesel Blends and Injection Schedules on Diesel Engines to affect Emissions

Marc Pedersen\textsuperscript{1}, Javier Montalvo\textsuperscript{2}, Aaron Bertram\textsuperscript{3}, Song-Charng Kong\textsuperscript{3}

\textsuperscript{1}West Des Moines Valley High School, \textsuperscript{2}Des Moines Lincoln High School, \textsuperscript{3}Mechanical Engineering, Iowa State University

Background

In 2004, the EPA introduced Tier 4 emission standards, which called for a continued reduction of Particulate Matter (PM) and Nitrous Oxide (NOx) emissions from Diesel engines. The previous Tier standards had already reduced NOx, PM, and unburned hydrocarbons (HC). By 2014, Tier 4 emissions will be fully phased in as shown below.

Research Question

Do Biodiesel Blending, Pilot Injections, and Exhaust Gas Recirculation (EGR) affect engine emissions the same way as low-sulfur Diesel #2?

Methods

John Deere 4045 Engine (4 cylinder, 4.5 liter)
John deere DevX v1.0 Engine Control Unit Software
General Electric Dynometer Model 9005
National Instruments LabVIEW 2009 SP1
AVL 41SS Smoke Meter
Horiba MEXA-7100DEGR Motor Exhaust Gas Analyzer

Results – Biodiesel Blending

- Four engine emissions that were tested: NOx, HC, Carbon Monoxide (CO), and PM
- Start of Ignition (SOI) for the engine and how much emission was expelled:
  - As NOx decreased, HC and CO generally increased.
  - The best SOI values for the lowest overall emission values ranged between -5 and -3 ATDC.
  - B100 produced a similar level of NOx, however fewer HC, CO, and PM.
  - Other biodiesel blends showed similar results.

Results – Pilot Injections

- Pilot injections happen when a portion of the fuel is introduced into the piston chamber before the main injection takes place.
- Allows additional time for fuel to mix with the air and create a better combustion cycle.
- The pilot injection is used to reduce the ignition delay, lowering the intensity of combustion, and thus lowering the temperature and reducing the amount of NOx produced.
- Because temperature is reduced, HC and CO should increase due to incomplete combustion.
- At a pilot injection of -15 ATDC, NOx decreased and there was no significant change in CO or HC, making it an improvement over non-pilot injections.

Results – Exhaust Gas Recirculation

- EGR allows for some exhaust gas to be recirculated into the combustion chamber.
- Diluting oxygen gas slows combustion and increases the specific heat of the mixture which decreases the peak combustion temperatures.
- Using more EGR reduced the NOx generated, however, it also cooled the combustion chamber, which increased the amount of unburned HC, and allowed for more CO as there was incomplete combustion.

Discussion/Future Work

- Using proper Start Of Injection timings changed emissions as did the blending of biodiesel.
- Pilot injections also affected the emissions along with using Exhaust Gas Recirculation.
- Biodiesel blends accounted for a large reduction of emissions (excluding NOx) as shown below left.
- When pilot injections and EGR were added, additional reductions were made as shown below right.
- Looking forward, what would happen if biodiesel blending, pilot injections, and EGR were done together? Would it average results? Compound them?

Acknowledgements:

I would like to thank Aaron Bertram and Song-Charng Kong for laboratory assistance, REG for support with the biodiesel, Iowa State University, and NSF Award #EEC-0813570 for the funding of this project.

References: