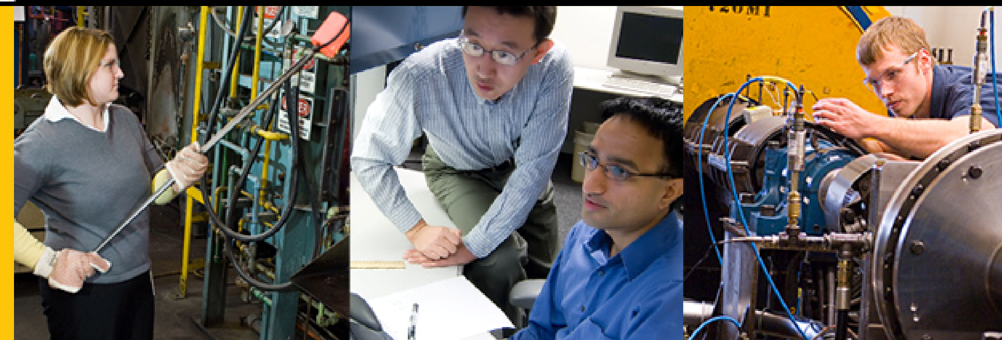

Development of Advanced Combustion Technologies for Increased Thermal Efficiency

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DOE Contract DE-FC26-05NT42412
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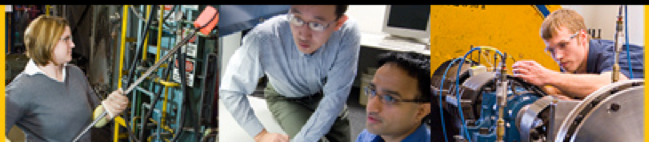
Disclaimer

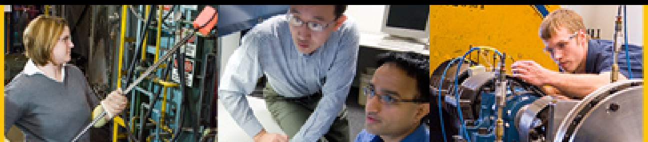
The work described in this presentation, conducted under a Caterpillar / DOE cooperative research agreement, was conducted by the Product Development Center of Excellence of Caterpillar Inc. The cooperative research described in the presentation was done to evaluate proof-of-concept for technologies that meet EPA 2010 on-highway emissions with the potential to improve peak brake thermal efficiency by 10%. Cursory consideration was given to which technologies may have some ability to be commercialized by the engine divisions of Caterpillar which have commercialization responsibility.

The process to validate technologies as commercially viable was not in the scope of the program, nor was it undertaken. Commercialization aspects such as cost/benefit analysis, reliability, durability, serviceability and packaging across multiple applications were only considered at a cursory level. Until such analysis is completed,any attempt to imply commercial viability as a result of the material in this presentation is not justified.



Introduction

- Investigation of fuel effects on low-temperature combustion, particularly HCCI / PCCI combustion
- Collaboration between Caterpillar and ExxonMobil
- Present work focused on gasoline / diesel blend fuels

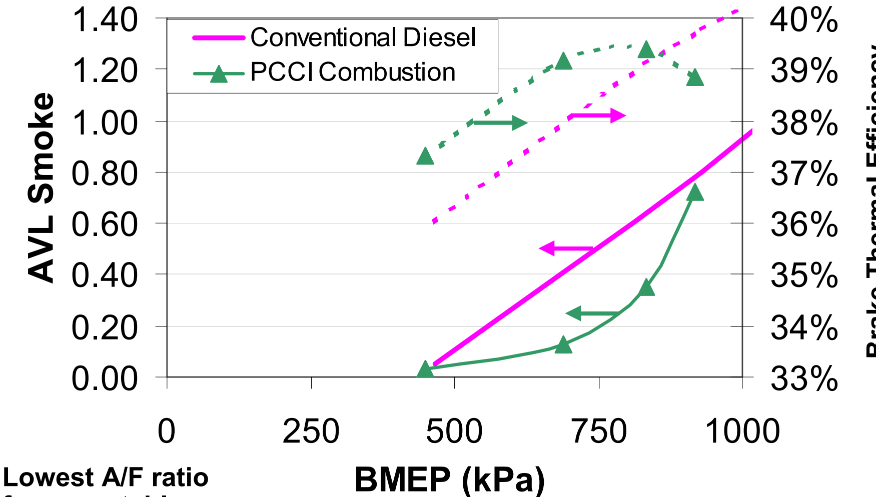


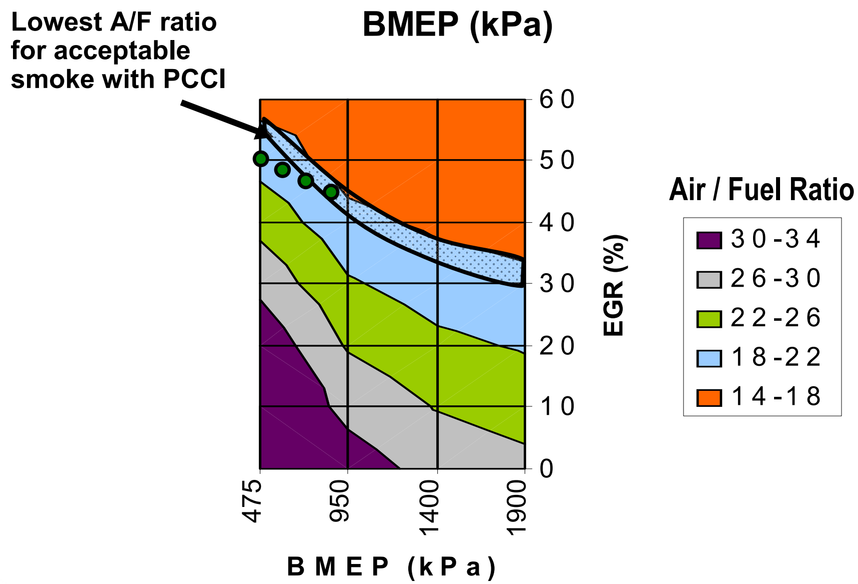
Motivation

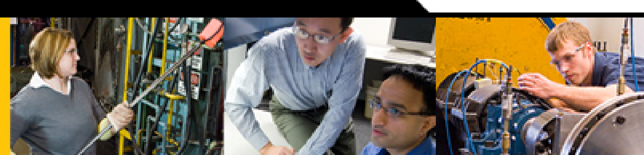
- High EGR rates → Low NOx
- Premixed combustion → Low soot at low A/F ratio
- High cylinder pressure rise rates
  - limited load range to ~ 500 kPa

- To enable PCCI at higher load
  - Increase ignition delay without increasing EGR

- Can we benefit from changing the ignition characteristics of the fuel ?

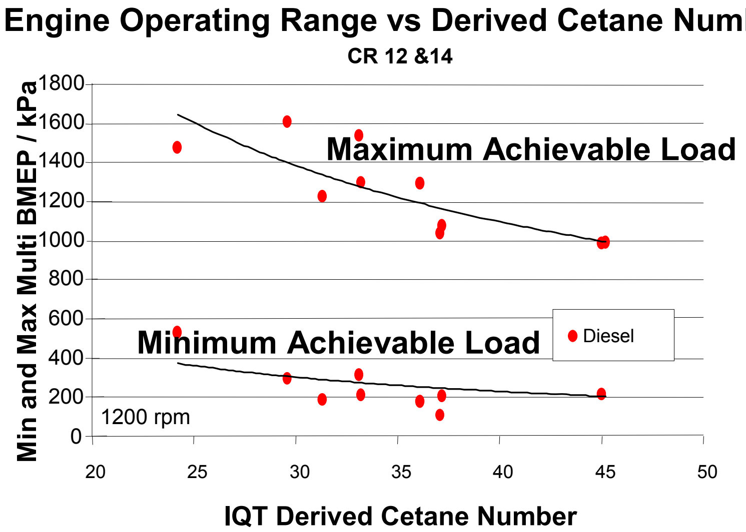






Background

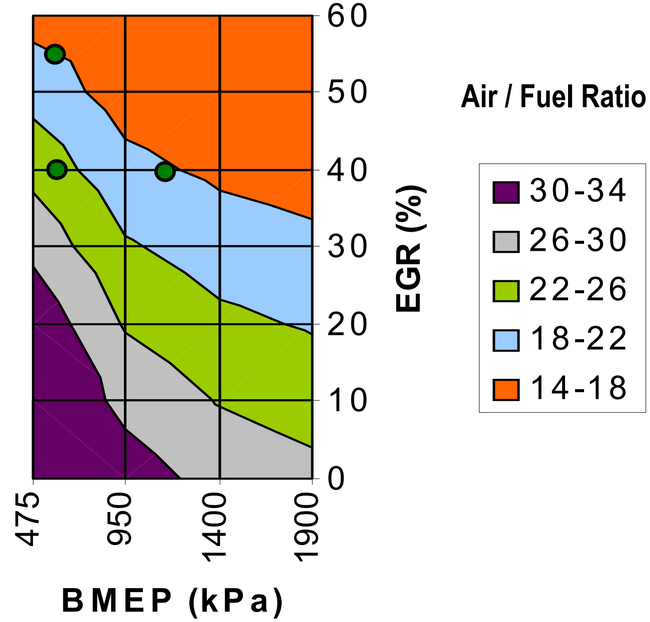
- Previous experience with lower cetane diesel fuels suggests load range can be extended
- Could blending of gasoline and diesel fuel to control ignition delay extend the PCCI operating range?

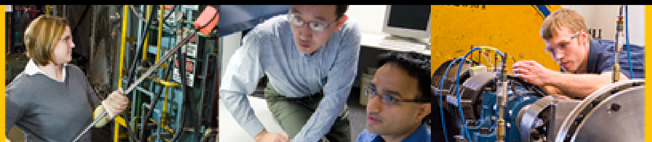


Objectives

- Investigate gasoline/diesel fuel blends as a means to extend the PCCI operating range and increase thermal efficiency

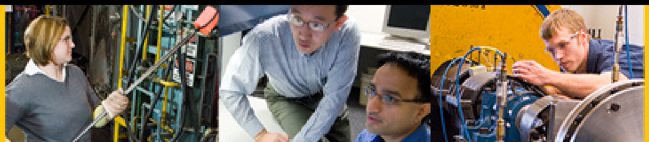
- Compare performance of diesel fuel to a gasoline/diesel blend fuel with a ~25 derived cetane (GD25).
  - Single-cylinder test engine (C15)
  - Compression Ratio = 16.8:1
  - Production injector nozzles
  - 1200 rpm @ 6.6 bar BMEP and 11.4 bar BMEP
  - 40% and 55% EGR
  - Single direct-injection



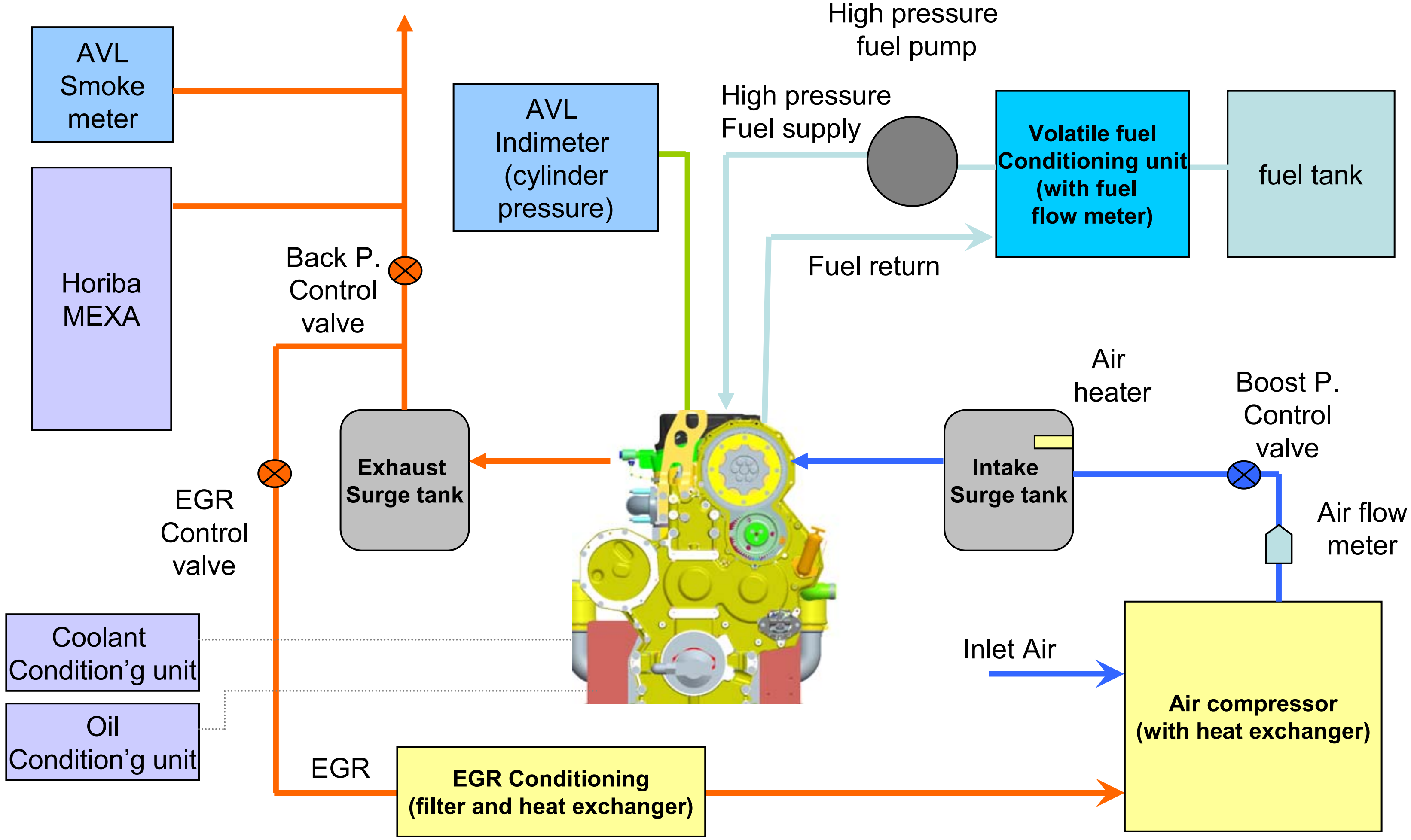


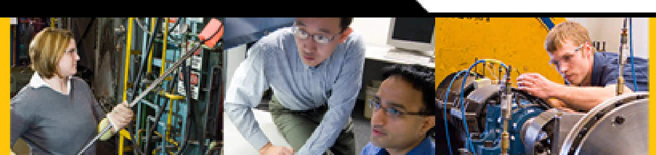
Fuel Properties

		Diesel	GD25
Derived Cetane Number		43	26
Density @ 60°F (g/cm^3)		0.8319	0.7829
Distillation (°F)	**IBP**	367	97
	50%	504	280
	EP	662	622
Heating Value (BTU/lb)		19718	19281



Single Cylinder Test Engine Schematic

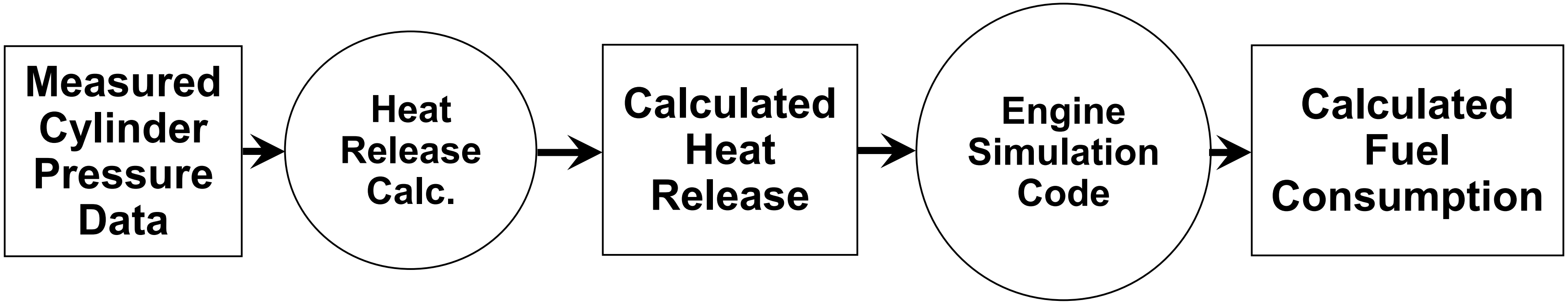


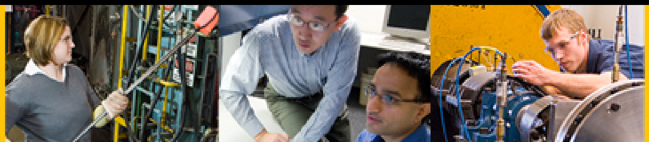


Data Analysis

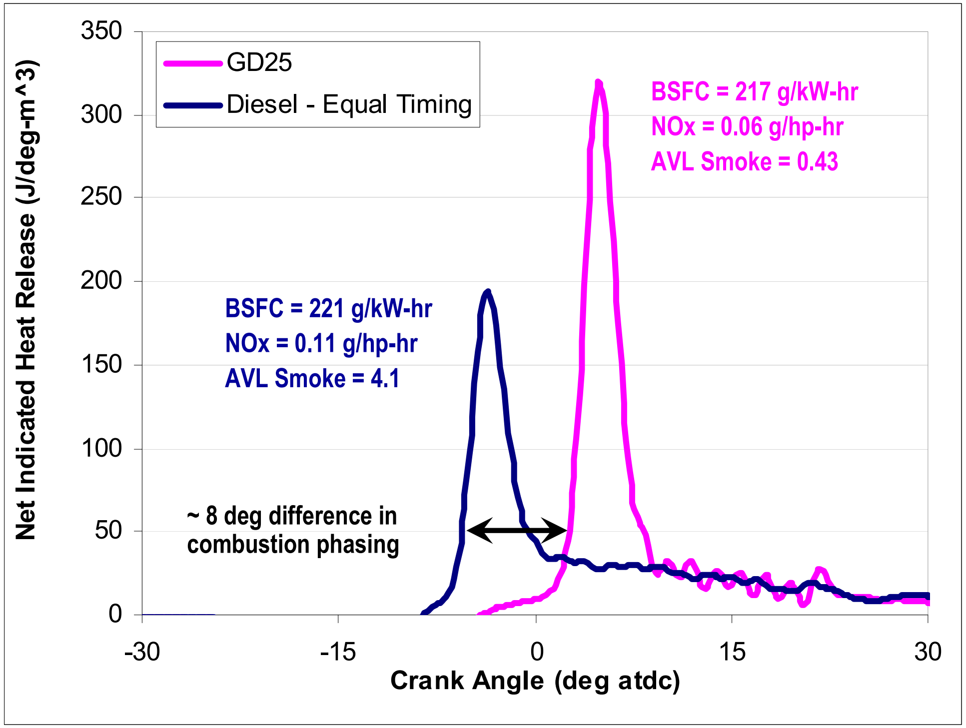
- Issues with measured fuel consumption
  - Issues with fuel rate measurement
  - Heating value differences

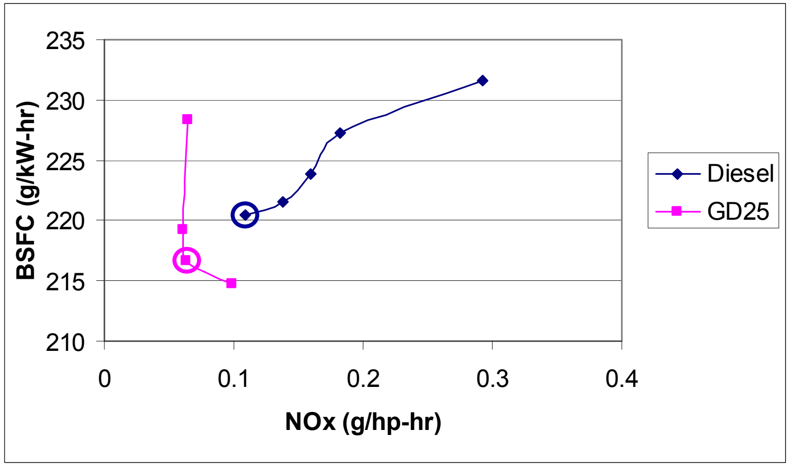
- All fuel consumption values shown are calculated based on measured cylinder pressure using Caterpillar's engine simulation code.

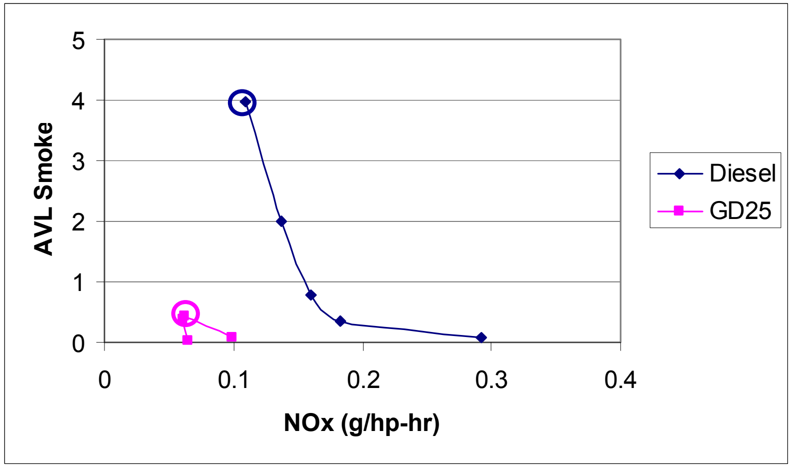


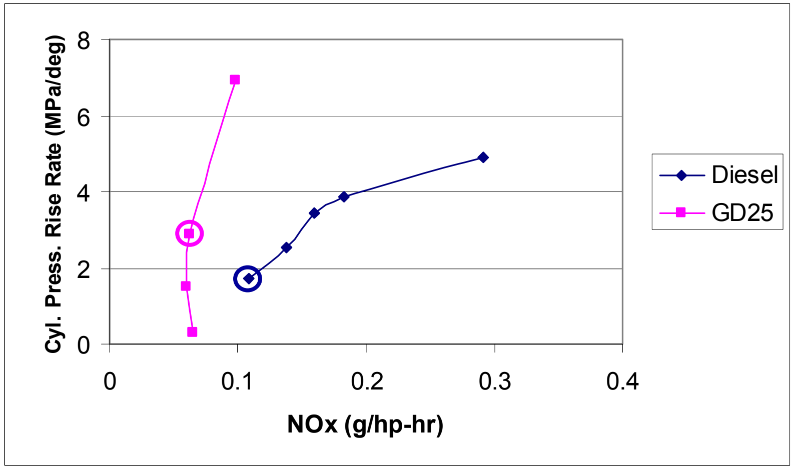


1200 rpm, 6.6 bar BMEP, 55% EGR





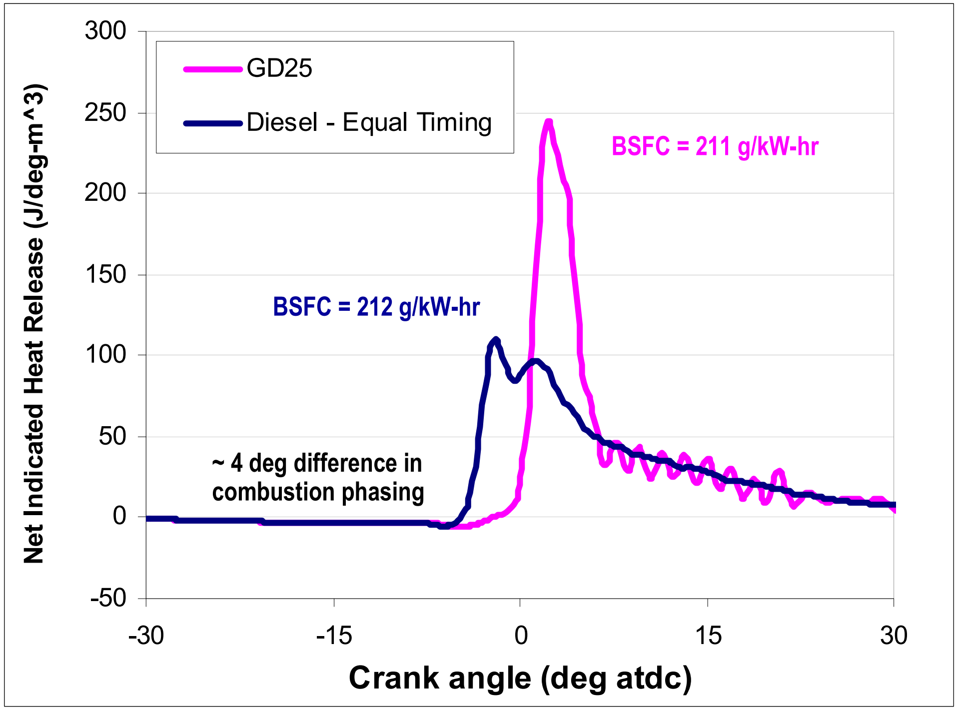


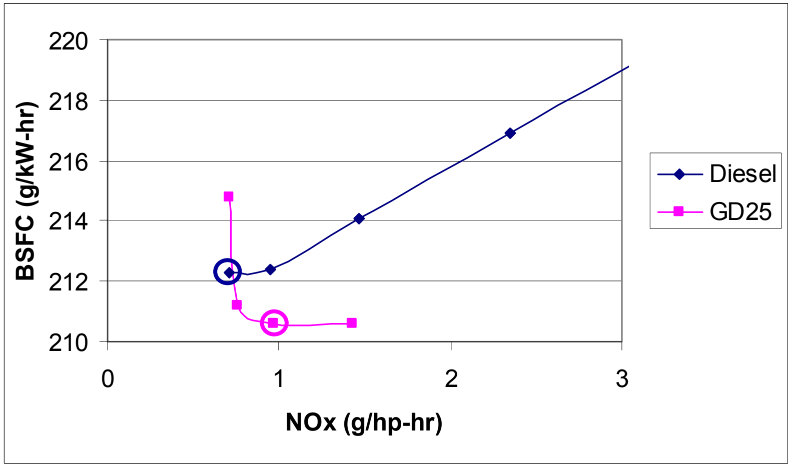


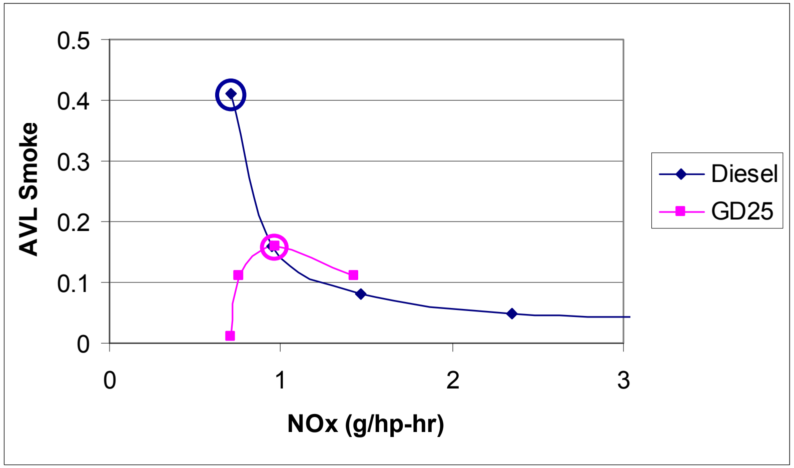
- Achieved low NOx, low smoke PCCI combustion with acceptable cylinder pressure rise rate using GD25

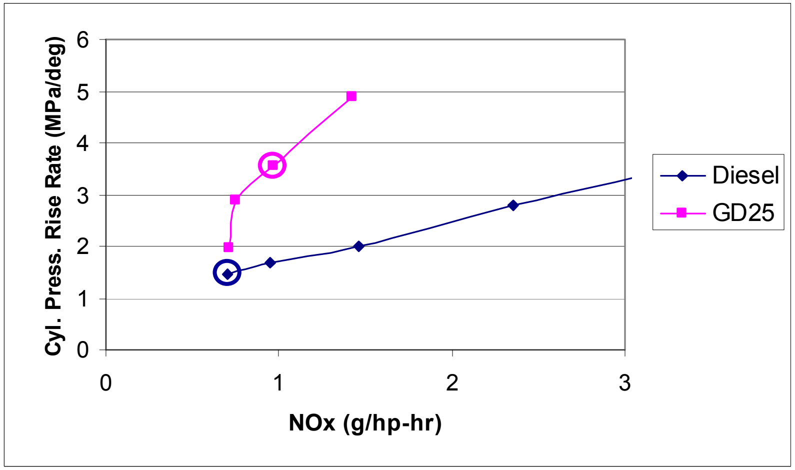
- GD25 at edge of combustion stability

1200 rpm, 6.6 bar BMEP, 40% EGR



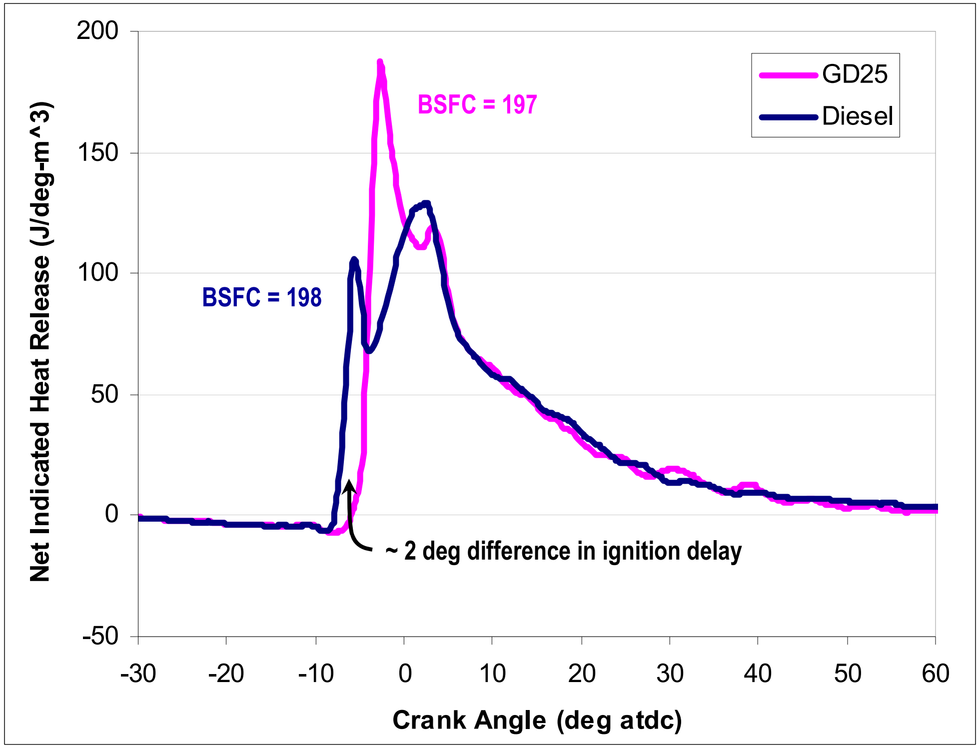


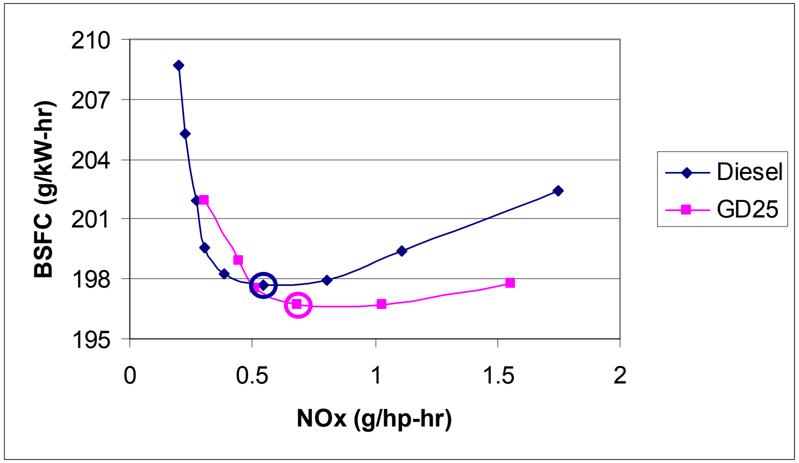


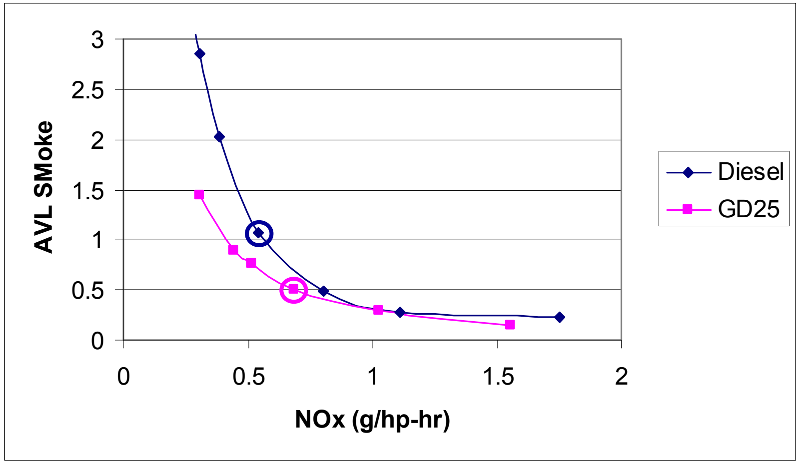


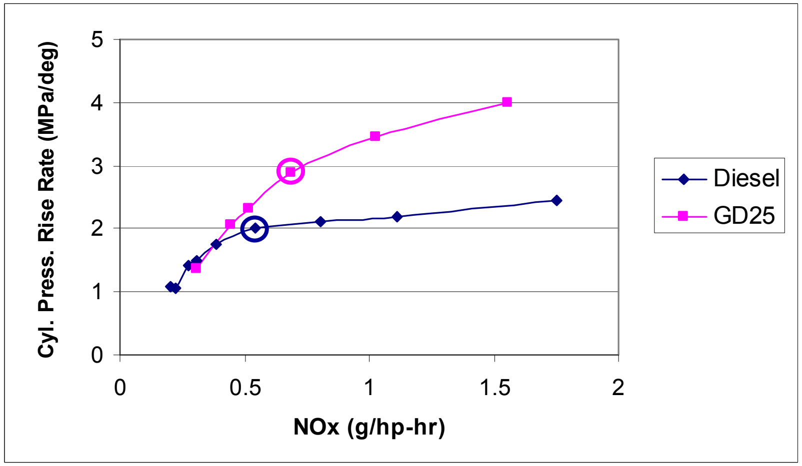
- Lower smoke with GD25 as fraction of mixing-controlled combustion increases
- For acceptable cylinder pressure rise rates, GD25 combustion needs to be phased near combustion stability limit

1200 rpm, 11.4 bar BMEP, 40% EGR





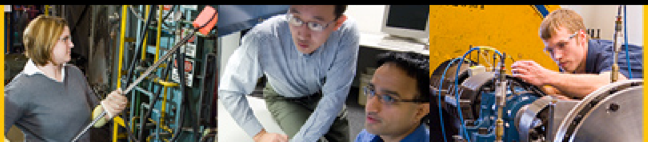




- Significant mixing-controlled combustion
- Minimal difference in BSFC
- Primary benefit of GD25 is lower smoke emissions, especially at retarded timings

Summary

- Performance of a direct-injected gasoline/diesel blend fuel was compared to direct-injected diesel fuel at 6.6 and 11.4 bar BMEP at 1200 rpm
- GD25 increased the operating range of low NOx, low smoke PCCI combustion versus diesel fuel
- The gasoline/diesel blend tested produced lower smoke emissions than diesel fuel under mixing controlled combustion conditions.
- For the engine configuration tested, the gasoline / diesel fuel blend provided minimal fuel consumption reduction relative to diesel fuel
- Different fuel blending or fuel injection strategies (ie. stratification of the fuel blend, multiple injections) may produce more favorable results.



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