Development of an SI DI Ethanol Optimized Flex Fuel Engine Using Advanced Valvetrain

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Introduction

- Project Objective
  - Minimize the fuel economy penalty currently seen when flex fueled engines are run on high-percentage ethanol blends
- Approach
  - Increased base engine compression ratio
  - Control of intake valve closing time with 2 step valvetrain
    - » Compression ratio management
    - » Load control with effective displacement
- Presentation Content
  - Naturally aspirated operation
  - Benefits of single intake valve deactivation

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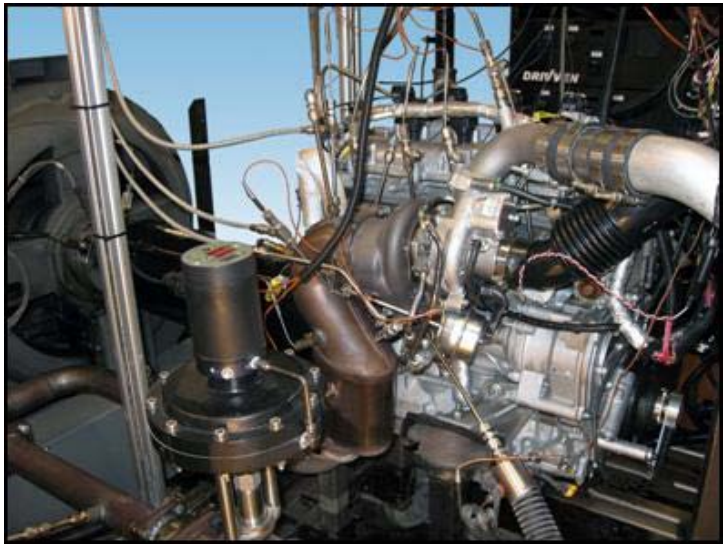
Hardware Features

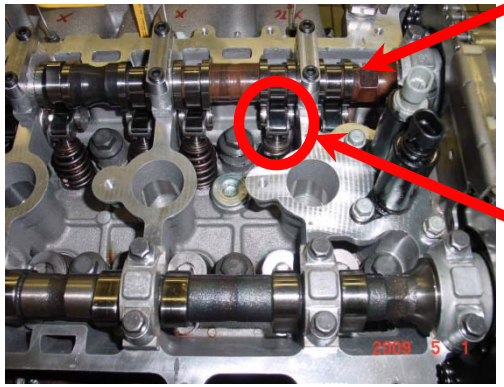
Extended Range Intake Cam Phaser

- 80° crank Intake authority
- 50° crank Exhaust authority

2.0 L DI Turbocharged Engine with DICP



2 Step Valvetrain



- LIVC High-lift cam
- EIVC Low-lift cam

Custom Pistons

- Increased CR from 9.2:1 to 11.85:1

DICP Dual Independent Cam Phasing
LIVC Late Intake Valve Closing
EIVC Early Intake Valve Closing
CR Compression Ratio
WOT Wide Open Throttle

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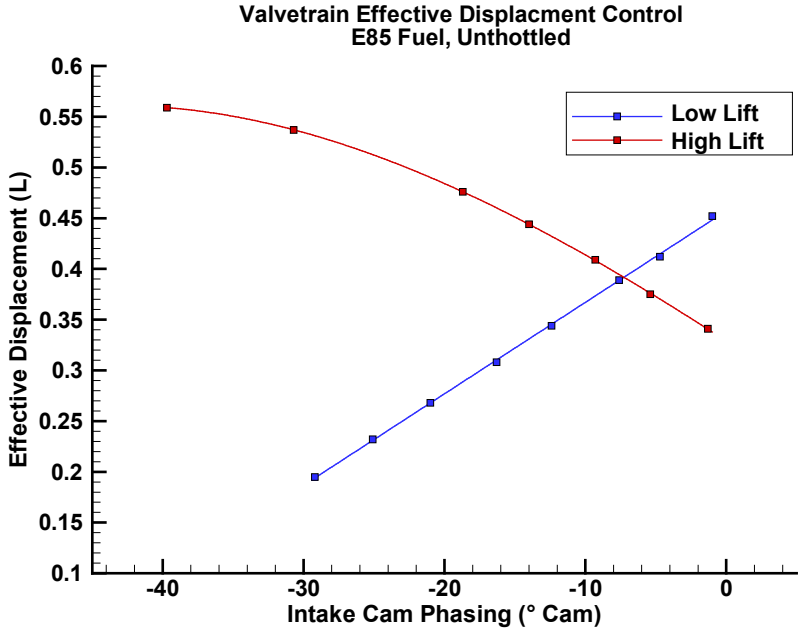
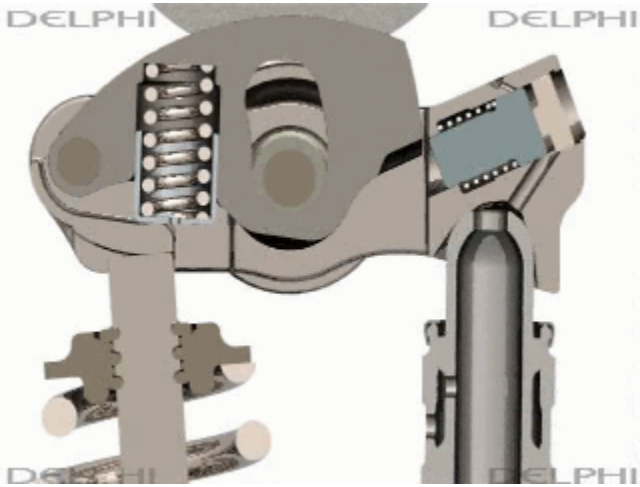
Valvetrain Implementation

- Intake Phasing enables effective displacement control
- 2-Step increases dynamic load range

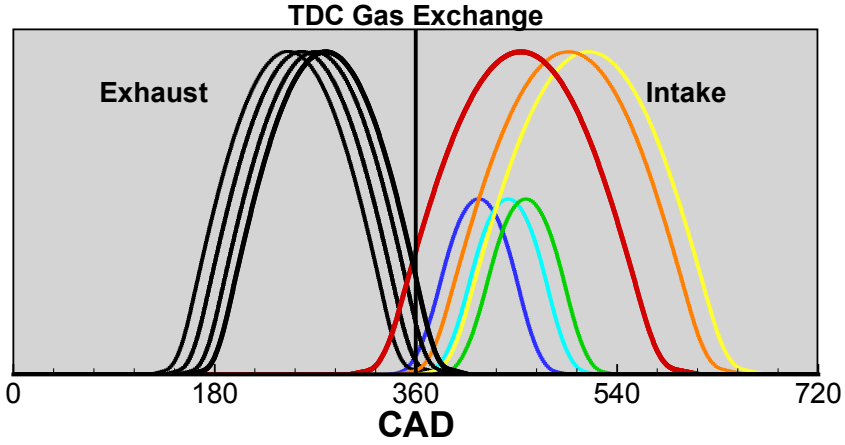


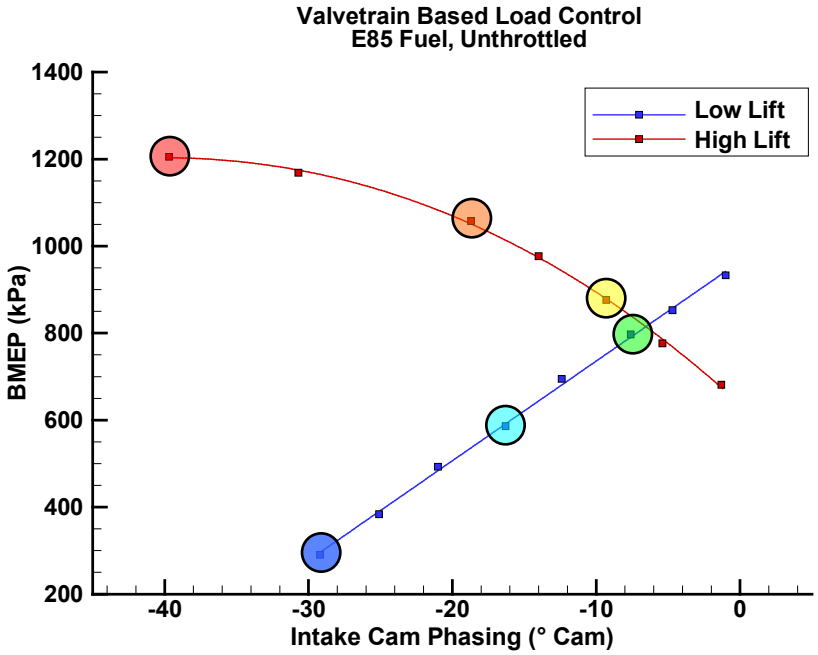


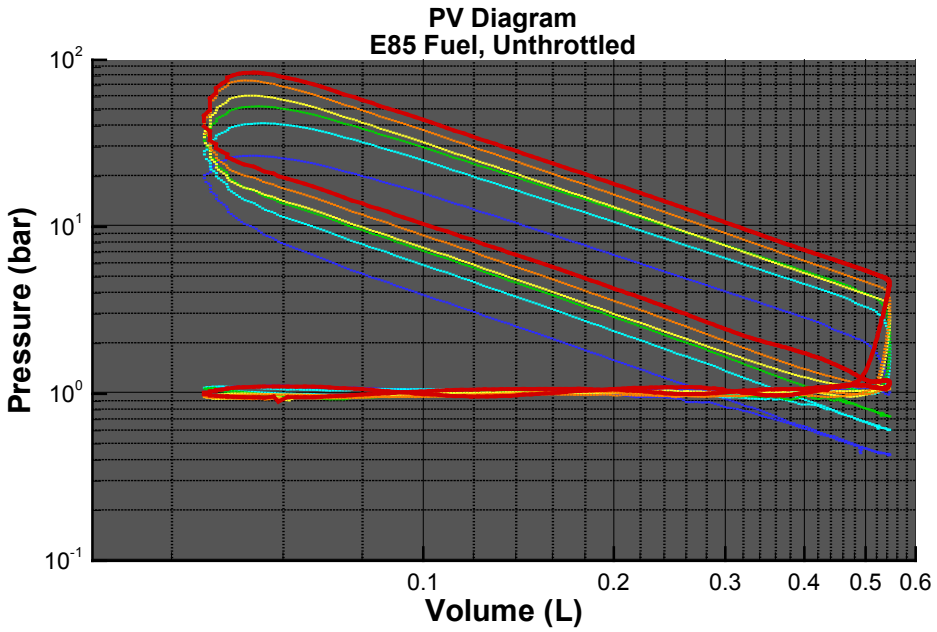
Low Lift

Valvetrain Implementation

- Unthrottled low load range
- Phase from low/high lift with torque continuity

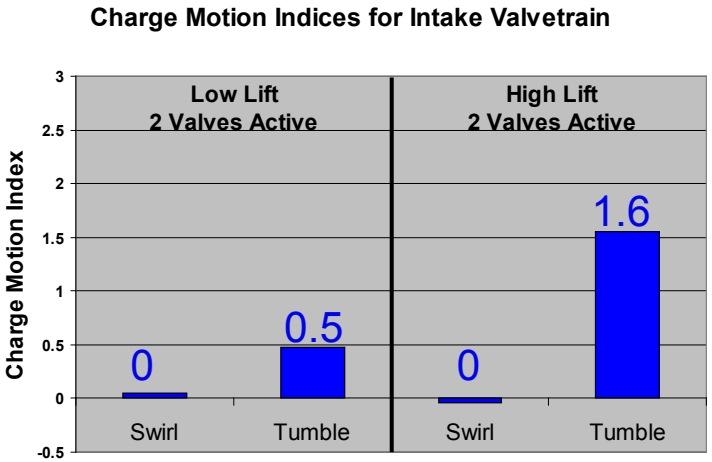


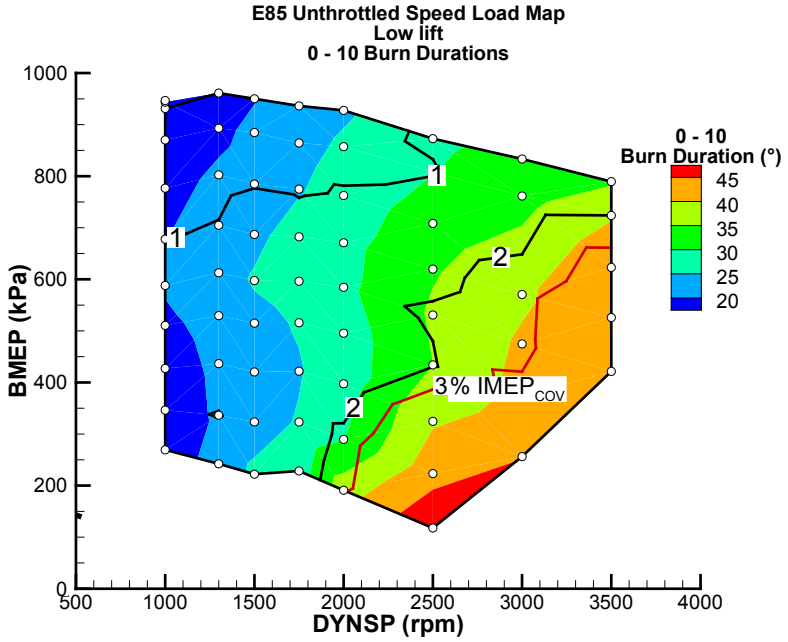


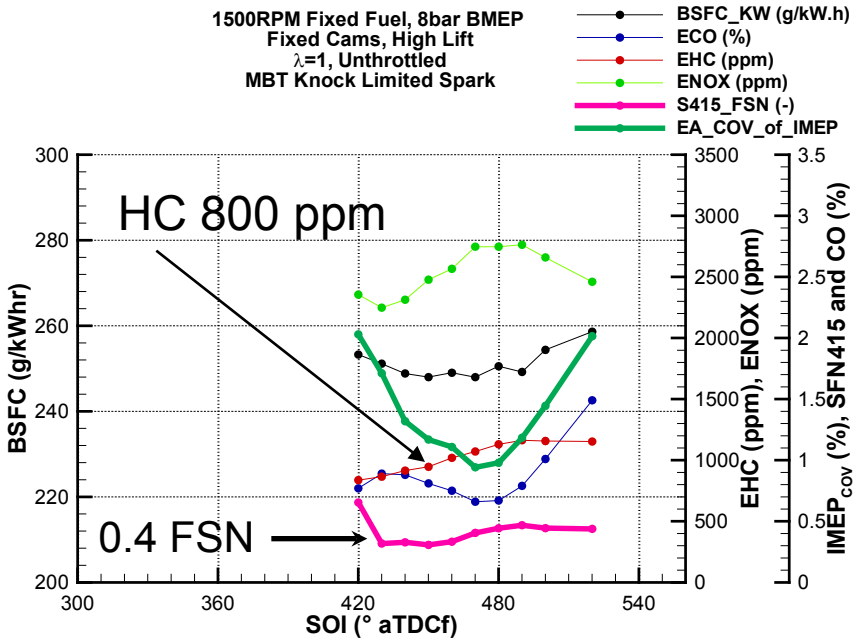


Opportunities for Valvetrain Optimization

- Low lift operation vs Speed
  - Limited charge motion
  - Slow burn rates at unthrottled conditions
- Soot at high loads with gasoline

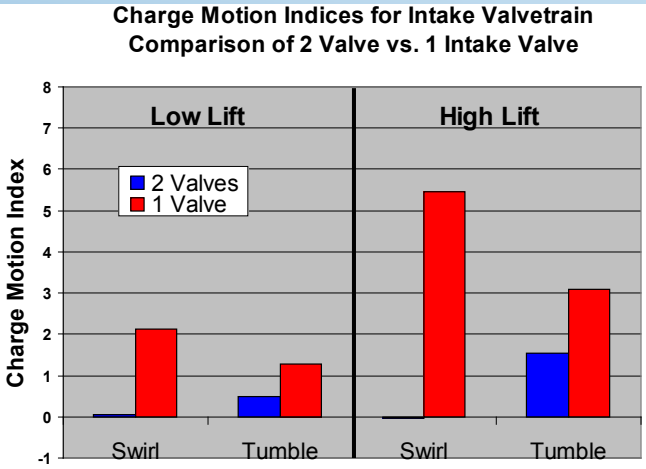


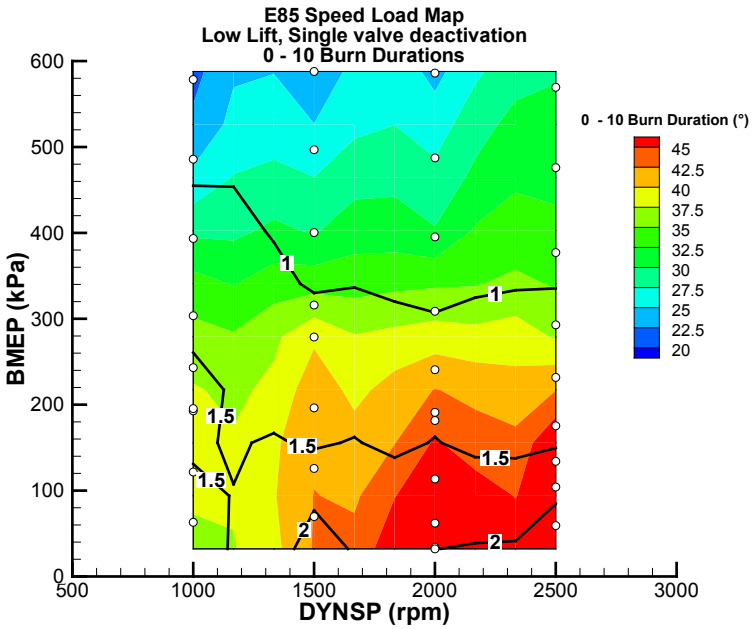


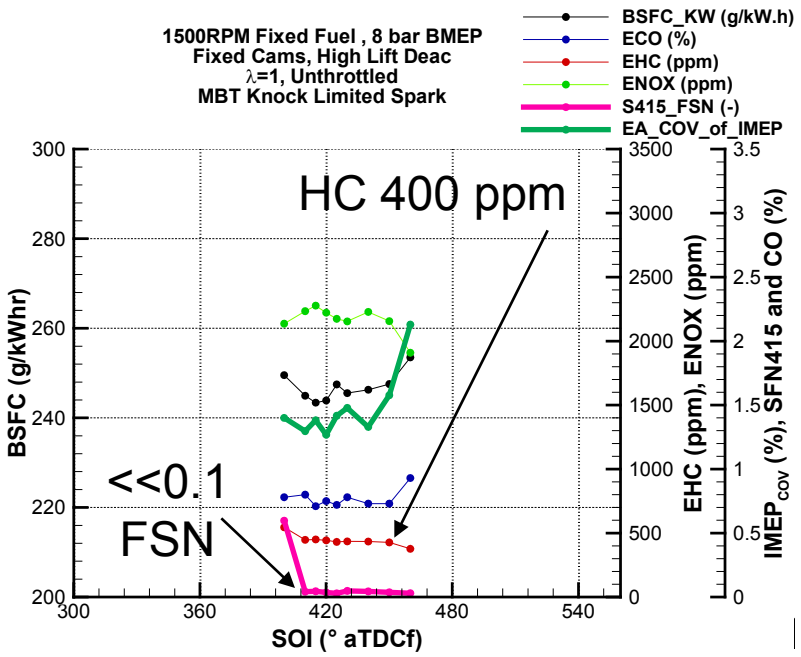


Valve Deactivation

- Low lift Deactivation
  - Improved Charge Motion
  - Improved burn rates
- Use of high lift deactivation reduces gasoline soot and HC



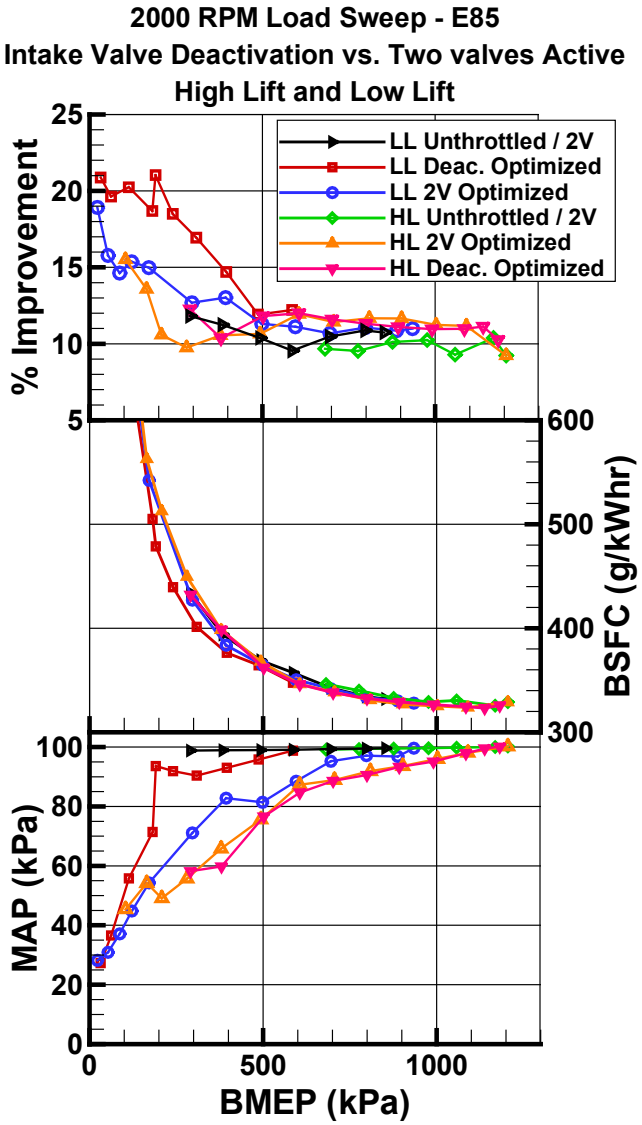




Intake Valve Activation Strategies vs. Baseline

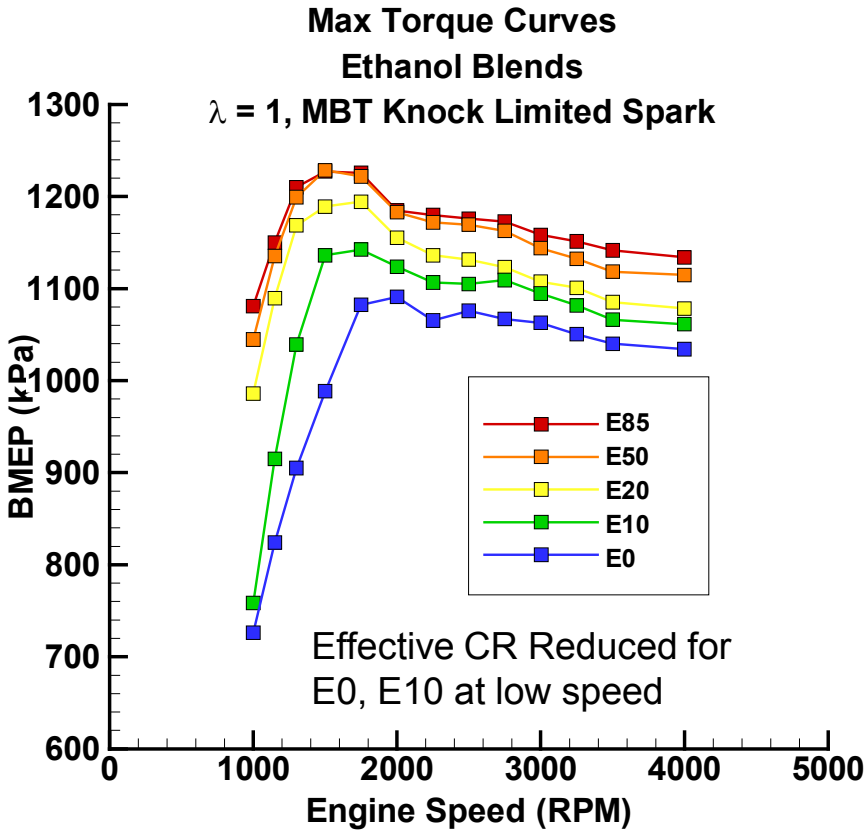
- Low lift valve deactivation improves performance
- Light throttle for EGR control superior to unthrottled operation
- High lift deactivation optimal option for high load / low speed

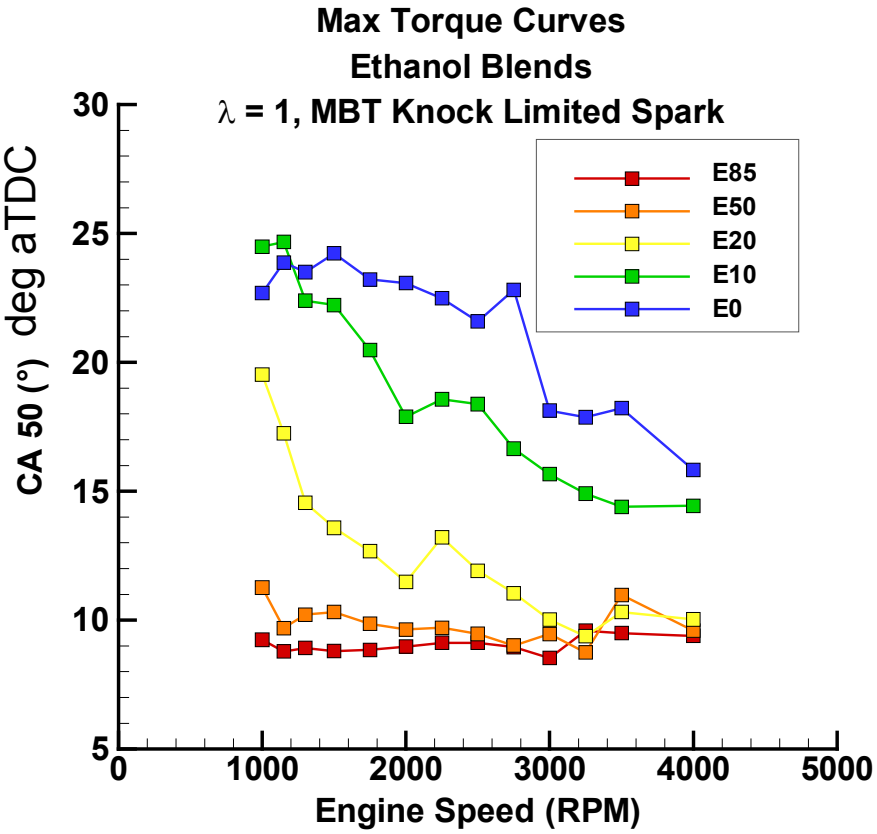
Baseline is gasoline, 9.2:1 CR performance scaled to E85 LHV



Engine Performance (Peak NA Torque)

- Blends Tested 91 RON E0 Blended with ethanol
  - E0, E10, E20, E30, E40, E50, E85
- High Ethanol Fuels E50-E85 did not require spark retard
- E0, E10 Require retard at all speeds





Conclusions

- Reduced E85 fuel penalty from low energy density by 1/3
- Valve deactivation improves flame speed and dilution tolerance with EIVC
- Light throttle for EGR control more efficient than unthrottled EIVC
- Valve deactivation reduces soot and HC for Gasoline at high loads.
- E85 capable of improved low end torque.
- E20 Sufficient for 97% of peak torque with minimal retard.
  - Minimal 7% Fuel density penalty

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