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

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Delphi Advanced Powertrain
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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

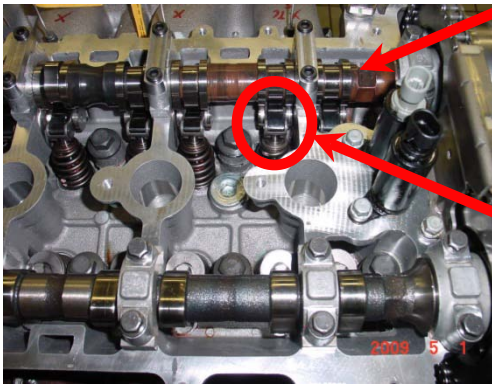
- Naturally aspirated operation
- Benefits of single intake valve deactivation

Hardware Features



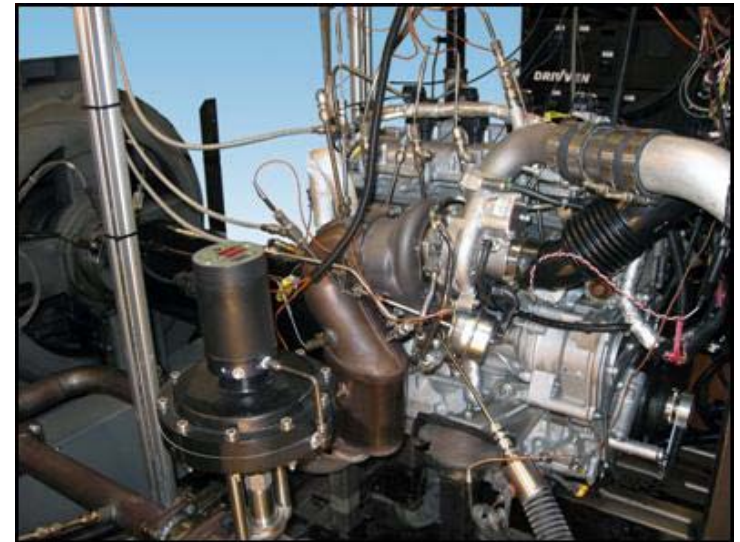
Extended Range Intake Cam Phaser

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



2 Step Valvetrain

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



Custom Pistons

- ◆ Increased CR from 9.2:1 to 11.85:1

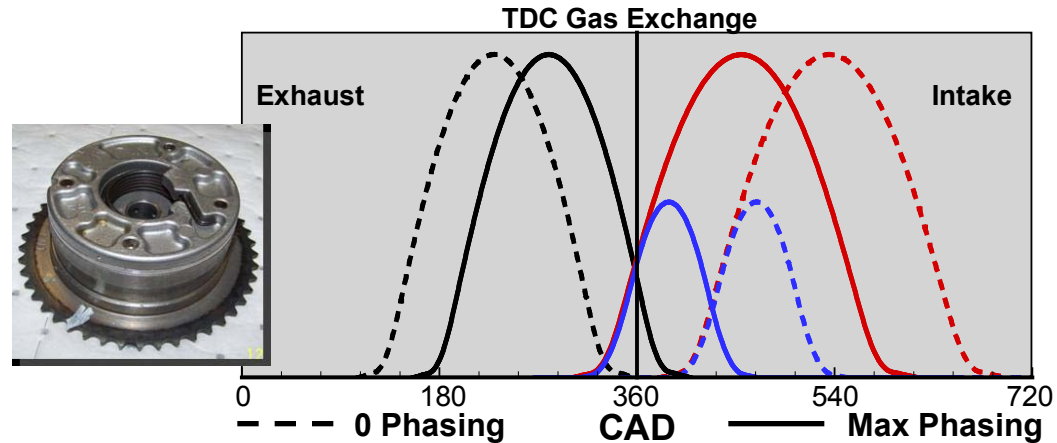


DICP Dual Independent Cam Phasing
LIVC Late Intake Valve Closing
EIVC Early Intake Valve Closing
CR Compression Ratio
WOT Wide Open Throttle

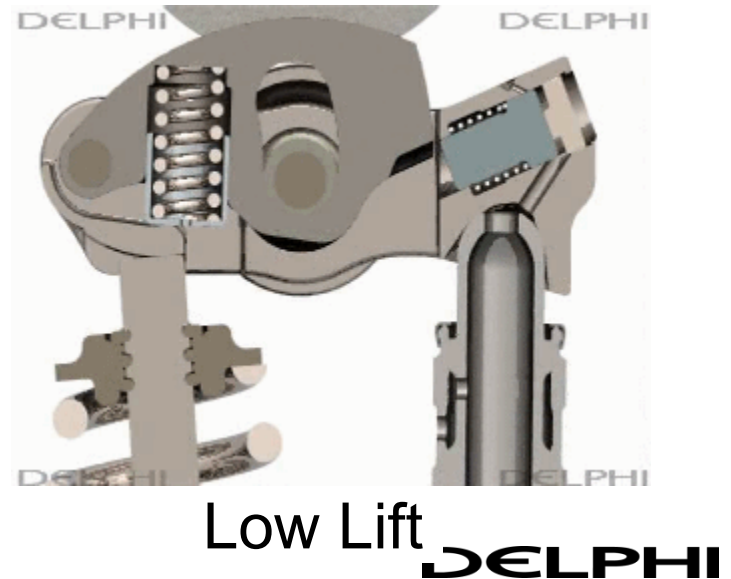
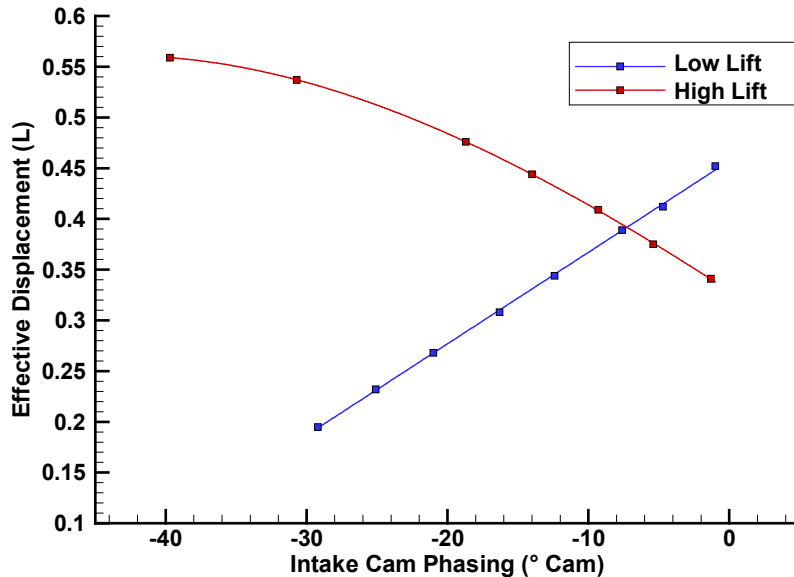
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Valvetrain Implementation

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

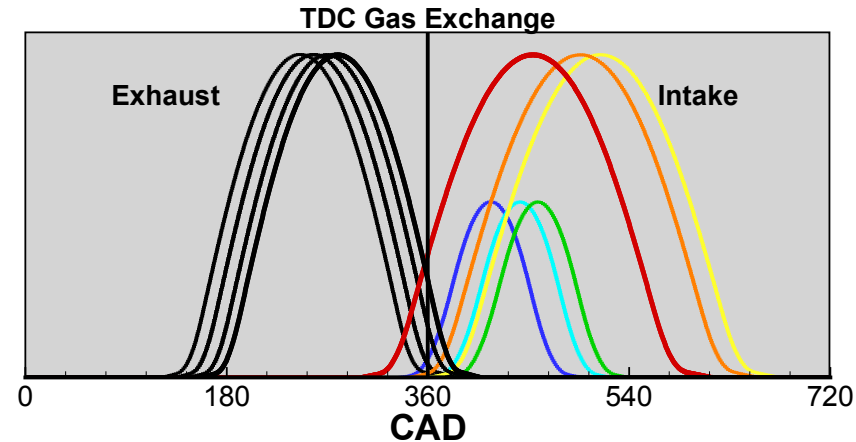


Valvetrain Effective Displacement Control
E85 Fuel, Unthrottled

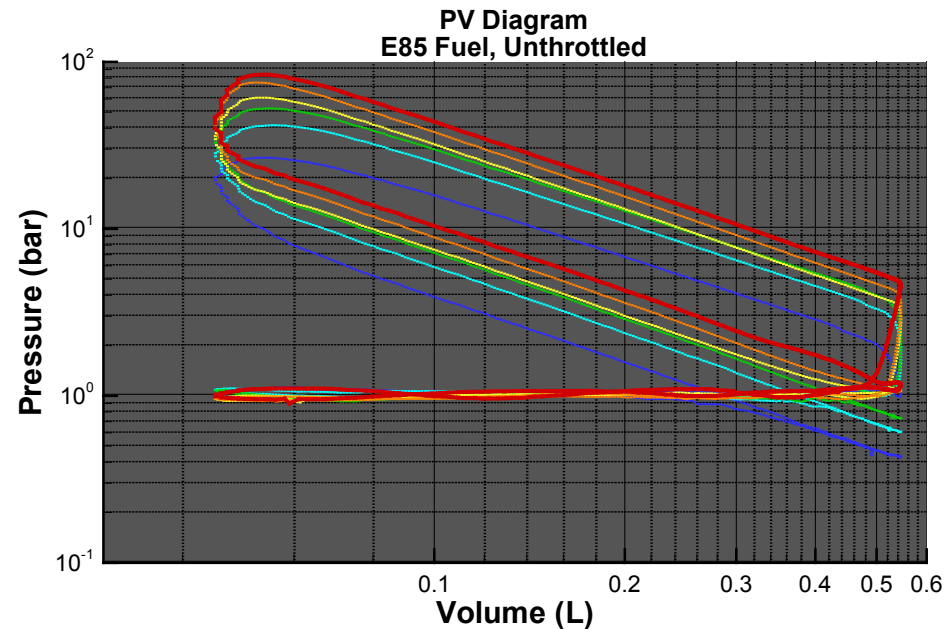
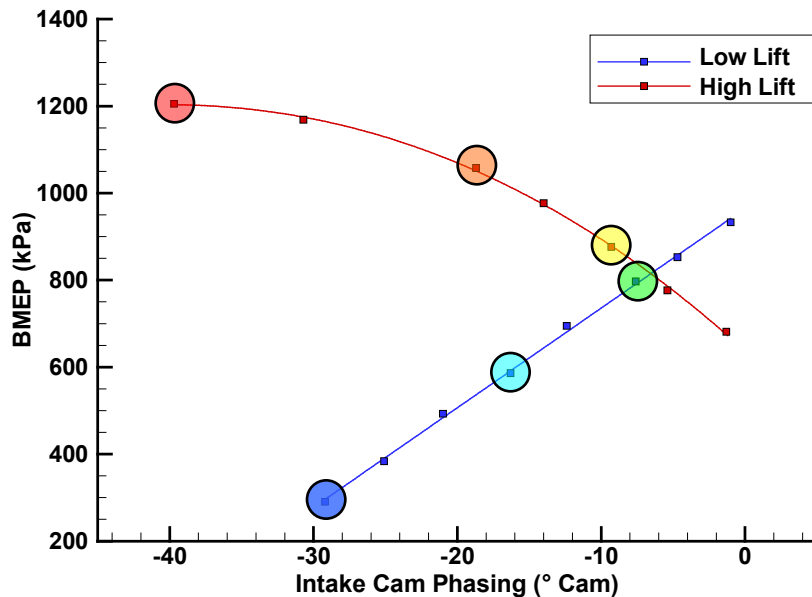


Valvetrain Implementation

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



Valvetrain Based Load Control
E85 Fuel, Unthrottled

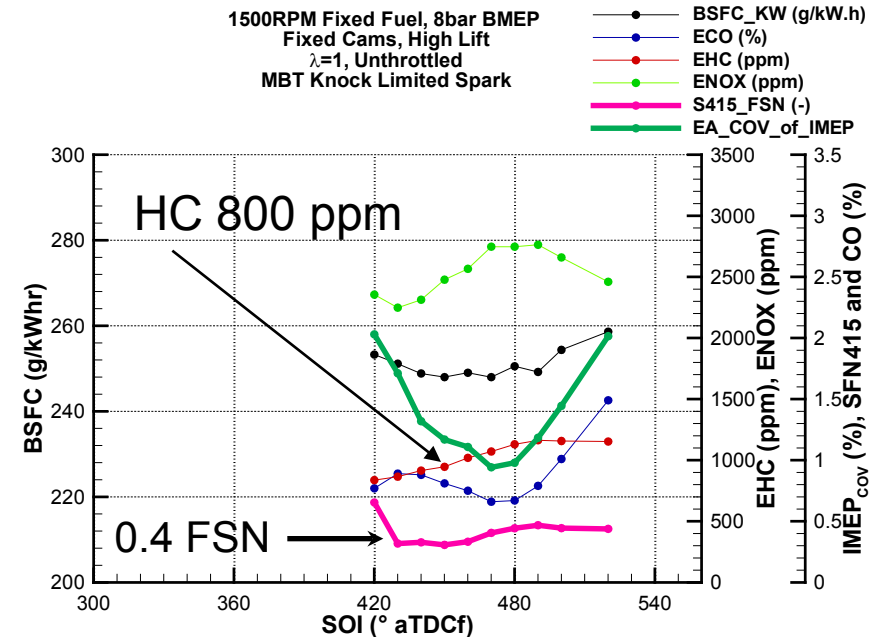
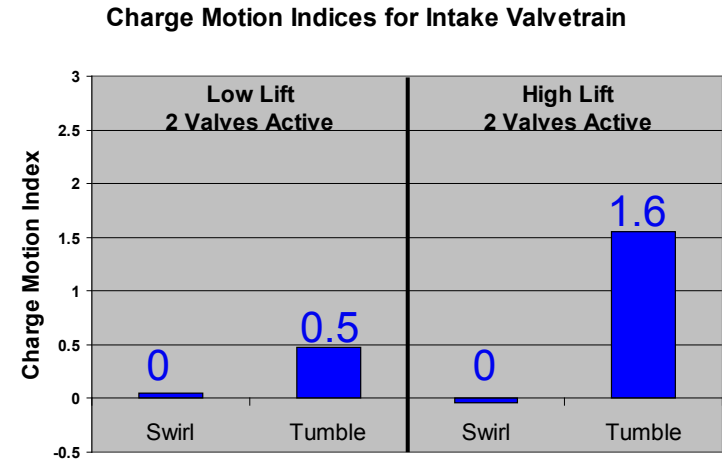
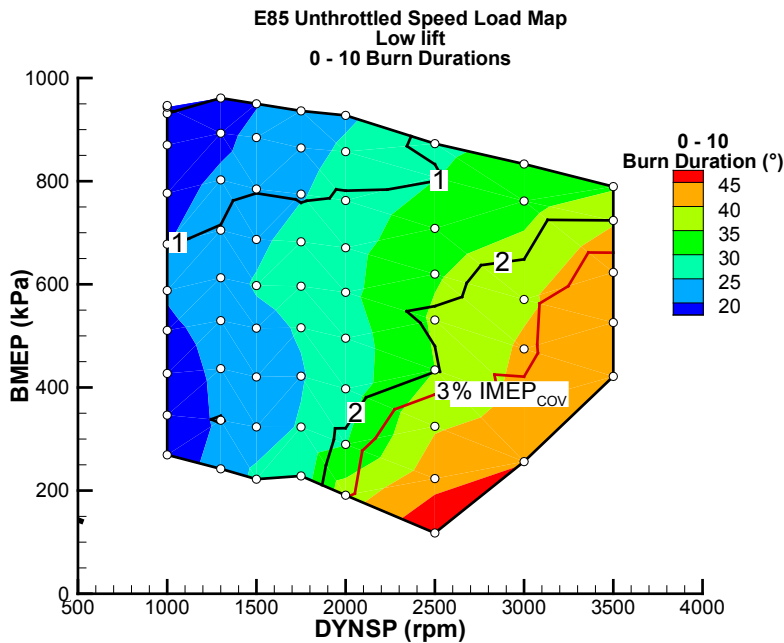


Opportunities for Valvetrain Optimization

◆ Low lift operation vs Speed

- Limited charge motion
- Slow burn rates at unthrottled conditions

◆ Soot at high loads with gasoline

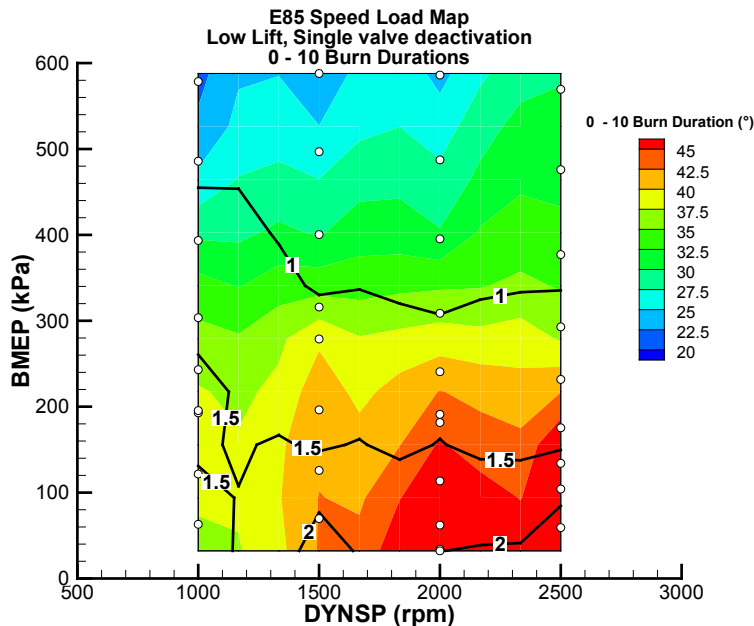


Valve Deactivation

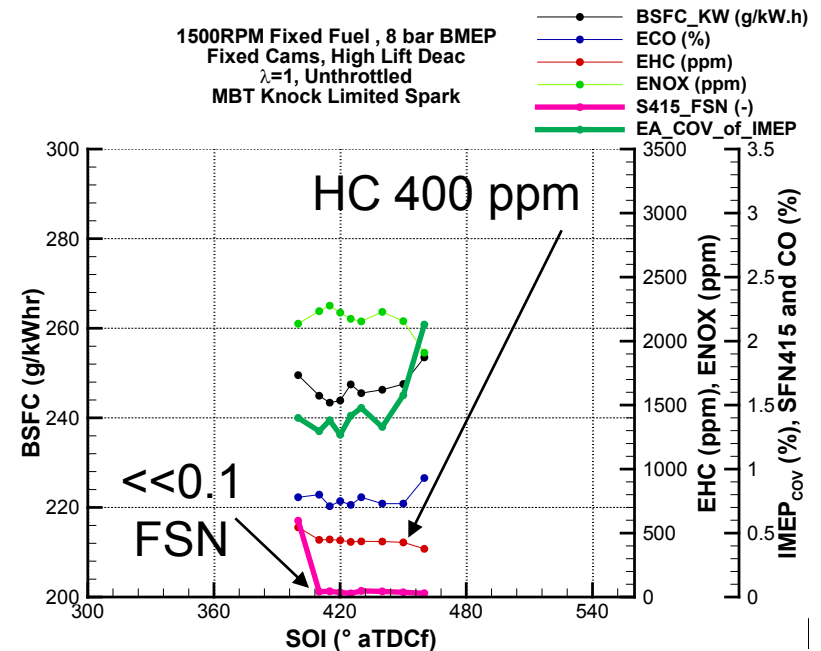
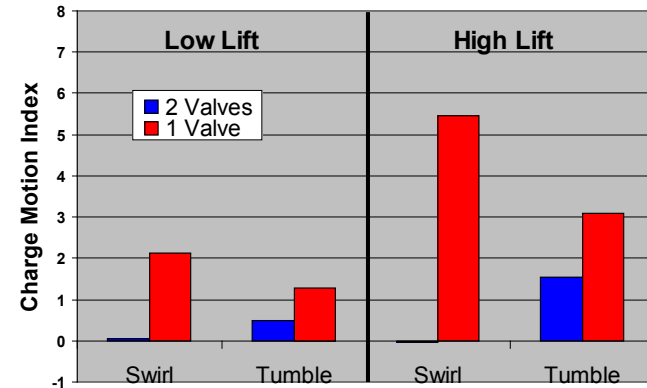
◆ Low lift Deactivation

- Improved Charge Motion
- Improved burn rates

◆ Use of high lift deactivation reduces gasoline soot and HC



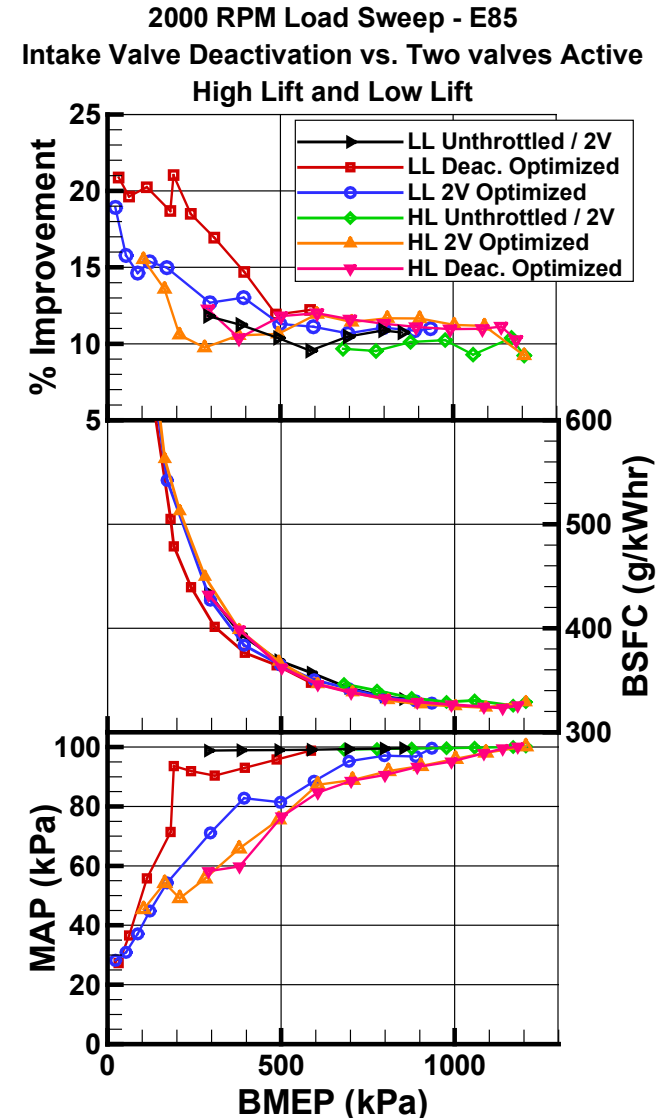
Charge Motion Indices for Intake Valvetrain
Comparison of 2 Valve vs. 1 Intake Valve



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

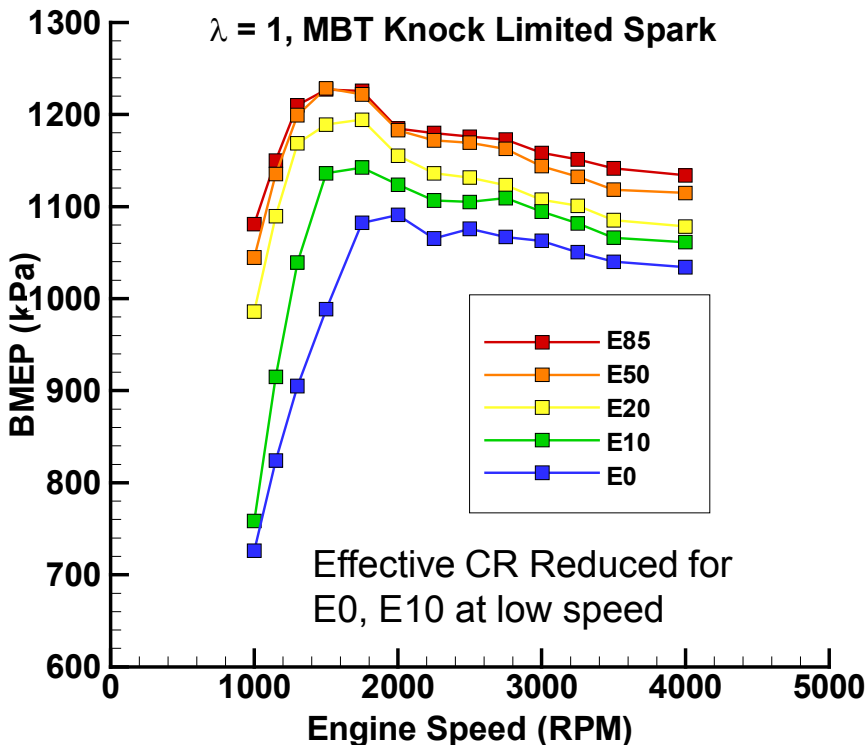


Engine Performance (Peak NA Torque)

- ◆ 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

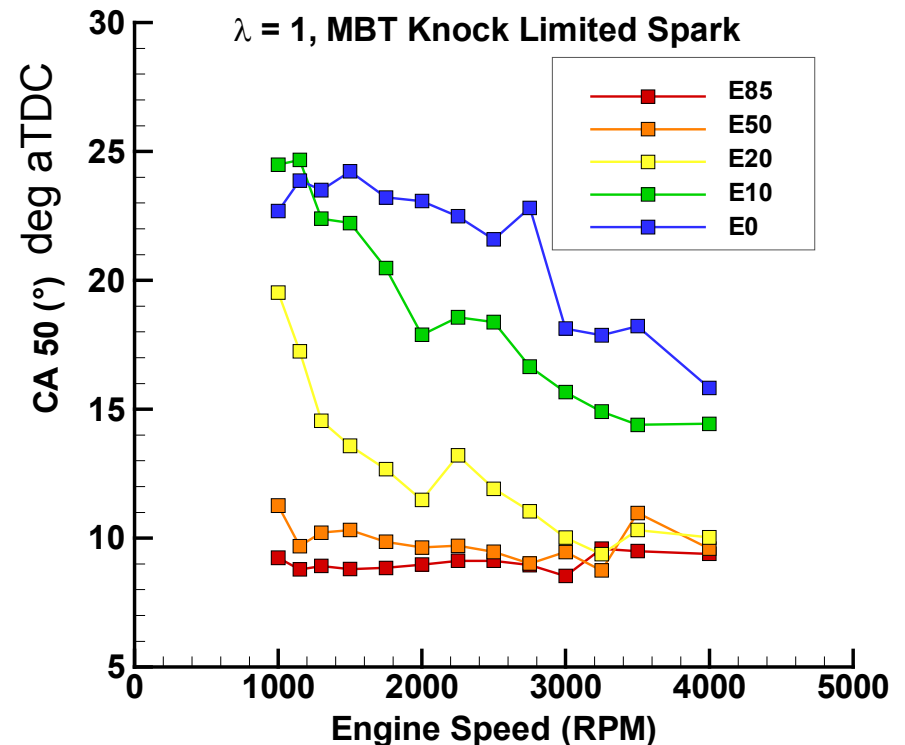
Max Torque Curves
Ethanol Blends

$\lambda = 1$, MBT Knock Limited Spark



Max Torque Curves
Ethanol Blends

$\lambda = 1$, MBT Knock Limited Spark



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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