E85 Optimized Engine through Boosting, Spray Optimized DIG, VCR and Variable Valvetrain

DELPHI / Wayne State University

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This presentation does not contain any proprietary or confidential information

Outline

- Purpose of work
- Barriers
- Approach
- Performance Measures and Accomplishments
- Technology Transfer
- Publications/Patents
- Plans for Next Fiscal Year
- Summary

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Purpose of work

- The objective of this project is to develop and demonstrate an overall engine hardware and control system implementation that minimizes the fuel economy penalty currently seen when bi-fueled ethanol enabled gasoline engines are run on high-percentage ethanol blends.

- Current E85 capable vehicles are normally equipped to run the higher levels of ethanol by employing engine modifications for durability concerns that arise from the use of alcohol. These vehicles are not however equipped to take full advantage of ethanol's properties during the combustion process.

- A system that takes advantage of ethanol's properties during the combustion process and minimizes the fuel economy penalty of ethanol will help promote consumer acceptance of high ethanol blend fuels and associated gains for the US economy and environment .

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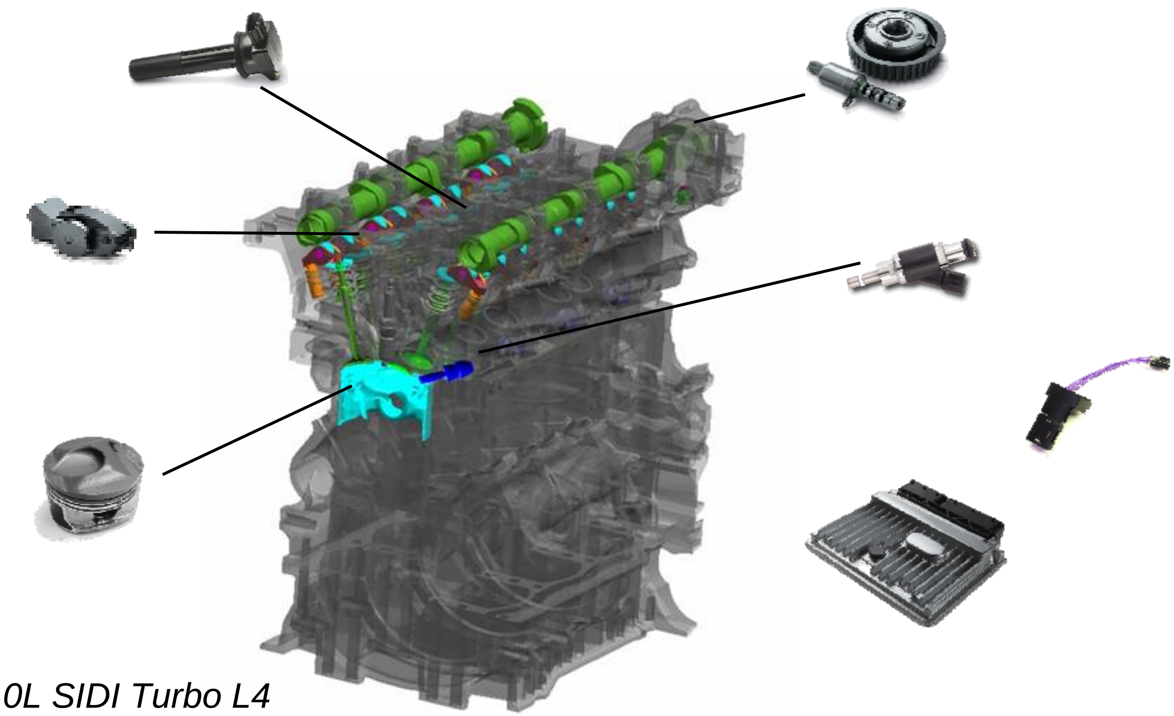
Purpose of work

- Project constraints:
  - Production-viable engine
  - Cost-effective and practical hardware solutions
  - Capable of operating on any gasoline / ethanol blend
  - Cannot negatively impacting emissions
  - Minimize impact on performance and drivability



Test platform is a GM 2.0L SIDI Turbo L4 (RPO: LNF)

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Major Technical Barriers

- The emphasis of this project is on exploiting the unique properties of ethanol; it's higher octane and latent heat of evaporation compared to gasoline.
- These property differences suggest that an optimized implementation can be achieved through the synergistic effects of compression ratio, cam phasing and lift, and direct fuel injection.
- When raising the engines compression ratio to take advantage of ethanol's properties however one technical barrier to overcome is spark knock when running on gasoline.
- To overcome this technical barrier, variable compression ratio will be accomplished through variable valve actuation (VVA). Using both variable valve lift and variable intake and exhaust cam phasing, an effective compression ratio will be achieved.

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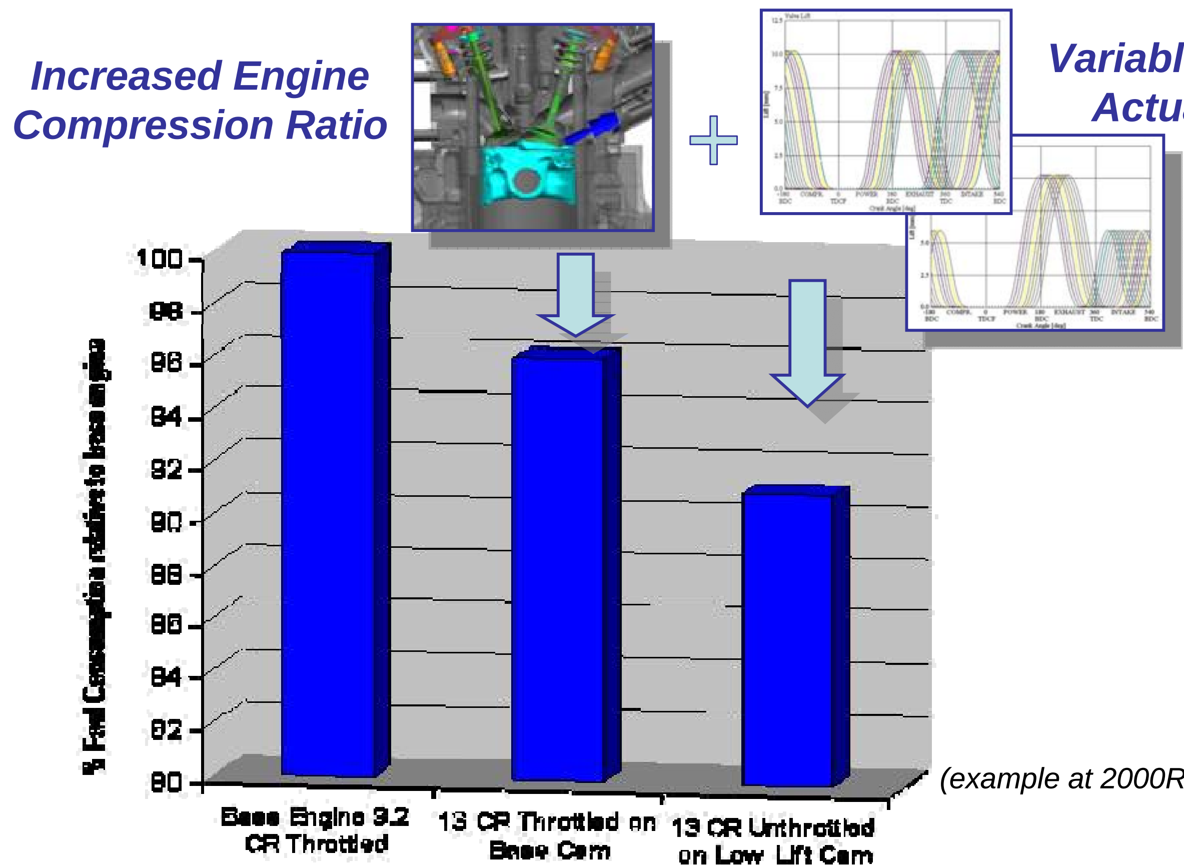
Approach

- Improve E85 BSFC through increased compression ratio and variable valve actuation.
- Avoid knock with gasoline by lowering effective compression ratio using variable valve actuation.



(example at 2000RPM and 3 bar MAP)

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Accomplishments / Progress

- The E85 engine optimization project was kicked off in October 2007. This 36 month project is broken up into four phases. Phase 1 'Applied Research' employs engine, injector spray, and vehicle-level modeling and is scheduled for competition in May of 2008.
- A predictive engine model for the chosen application was constructed using Gamma Technologies software based on CAD geometry provided by the engine manufacturer General Motors.
- After good correlation to actual engine performance data was achieved, the model was used to evaluate various combinations of compression ratio for both E85 and indolene throughout a wide range of intake and exhaust phasing and several cam lift profiles.
- The primary predictive performance outputs of the engine model under consideration are; BMEP, BSFC, exhaust constitute residuals and knock strength.

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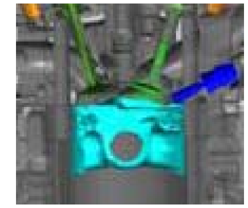
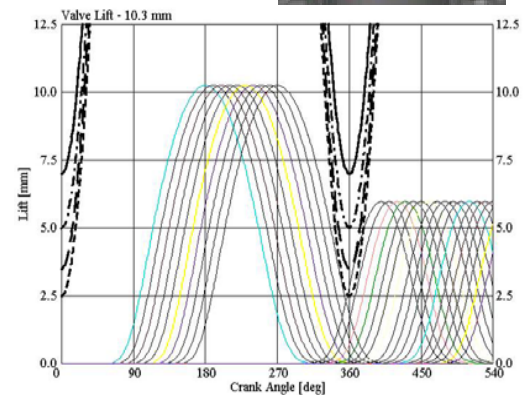
Accomplishments / Progress



- Parametric engine CAD models are used in conjunction with the results of the predictive engine model to establish a maximum practical compression ratio for the subject engine.   Valve clearances to the piston during phased operation are a major design consideration and limit the practical compression ratio.



- A dynamic CFD model was constructed to study spray patterns and spray characteristics of various injector geometries under the varying conditions of simulated engine operation.   The injector model was correlated to bench test data of the production injector. This CFD model will be used to optimize the fuel injectors for use with both E85 and gasoline.

- This project is on target for the completion of Phase 1 by May of 2008.

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<u>Technology Transfer</u>

- Beyond the development of a controls strategy for this approach, this project directly influences the development and refinement of several key engine components:
  - Cam Phasers – actuation speed, accuracy and phasing authority.
  - Fuel injector – dynamic range, SMD, spray targeting.
  - Two step valve lift – optimized cam profiles.
  - Ethanol sensor – confirmation of accuracy.
  - High energy ignition – effect on high dilution combustion (low load efficiency).
  - Engine management system controls
- Since Delphi is a major supplier to the auto industry, the results of this project could be brought to production applications as soon as the 2011 model year.

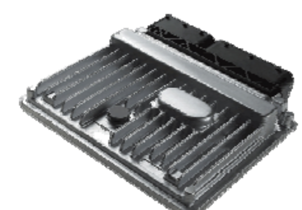
Gasoline Direct injection Injector

Two Step Cam Lift

Intake and Exhaust Cam Phasers

High Energy Ignition

Ethanol Sensor



Engine Control Modules

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Activities for Next Fiscal Year

- Modeling and simulation will be completed for assessment of the potential engine efficiency gains achieved by employing technologies such as optimized injection characteristics, boost, cam phasing, and variable valve actuation.
- A static test chamber will be constructed and experiments will be carried out to verify modeled results for injector spray and establish a matrix of base line design specifications for building injector prototypes.
- Modeling results will be used to specify and construct the hardware for this project's flex fuel optimized valvetrain components for a single cylinder optical engine.

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Summary

- A system that minimizes the fuel economy penalty of ethanol will help promote consumer acceptance of high ethanol blend fuels.
- A combination of increased compression ratio and variable valve actuation applied to a gasoline SI engine can improve the fuel efficiency when high ethanol fuel blends are used.
- This same variable valve actuation can be used to produce a lower effective compression ratio when the modified engine is run on gasoline.
- Predictive models have been completed that will be used to develop an engine that is optimized for low BSFC when run on E85.
- The results of this project can be quickly brought to market through the use of components and subsystems in Delphi's product portfolio.
- Over the next year the analytical studies will be completed then refined through bench tests.

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Publications, Presentations and Patents

- At this early stage of the project no publications, presentations or patents have resulted from this work.