Reduced Petroleum Use Through Easily-Reformed Fuels and Dedicated EGR

SOUTHWEST RESEARCH INSTITUTE®

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Project ID: FT066

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Overview

Timeline

- Start date: October 1, 2014
- End date: June 30, 2019
- Percent complete: 37%

Barriers Addressed

- Improve combustion robustness for EGR-diluted SI combustion
- Wide speed- and load-range operation of high EGR dilution
- Improved understanding of ethanol/gasoline blend combustion

Budget

- Contract value: $1,008,945
  - DOE share: $793,913
  - Cost share: $215,032

Partners

FCA
FIAT CHRYSLER AUTOMOBILES

TOTAL

Relevance / Project Objectives

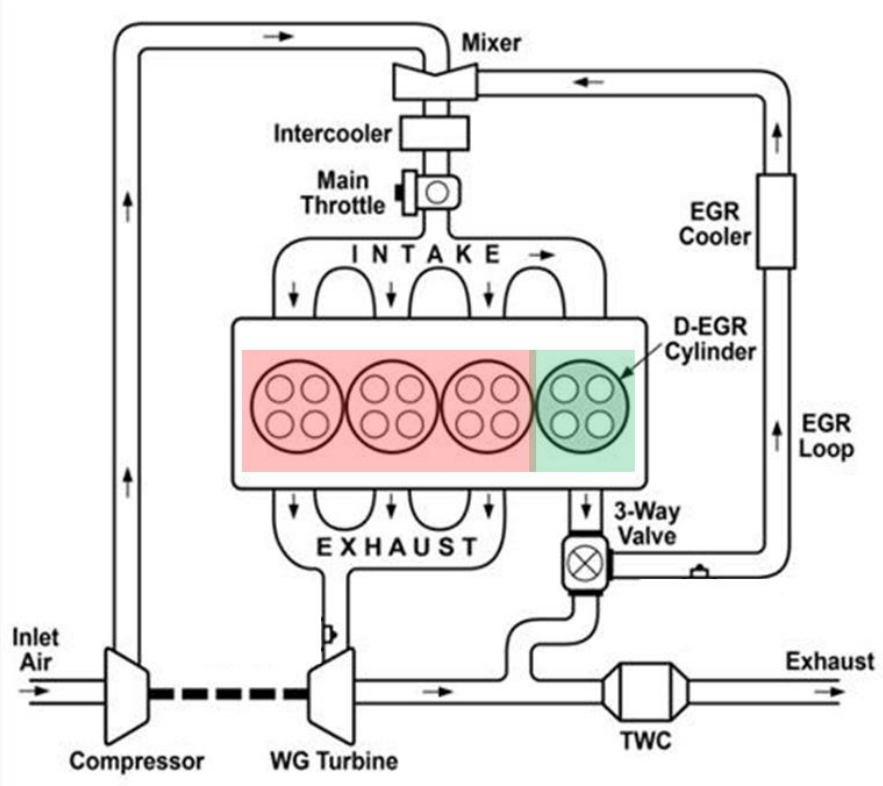
- Efficiency
  - Extend the efficiency of spark ignition engine combustion through synergistic application of dilute combustion and optimized fuels
- Petroleum use reduction
  - Through a combination of improved engine efficiency and increased bio-sourced fuel content, demonstrate a path to a 20% reduction in petroleum consumption
- Emissions reduction
  - Extend the efficiency of stoichiometric EGR-diluted combustion to be competitive with lean burn while using conventional emissions control solutions

Milestones

Date	Milestone or Go/No-Go	Status
September 2015	Demonstrate H_2 production > 2.5% in-engine with regular fuel	Complete
September 2018	Model fuel evaluations for increased H_2 production	On track
December 2018	Minimally-processed (refinery) fuel evaluations – Demonstrate <3% H_2 production in-engine	On track
June 2019	Full engine demonstration with increased compression ratio to quantify H_2 benefit	On track

Approach

- Optimize the H_2 production of a dedicated EGR engine cylinder using available control authority
- Improve the H_2 production by adjusting the fuel chemistry to increase the H:C ratio and the chemical reformation potential
- Use the increased H_2 to enable an increase in compression ratio to yield a 20% reduction in petroleum consumption



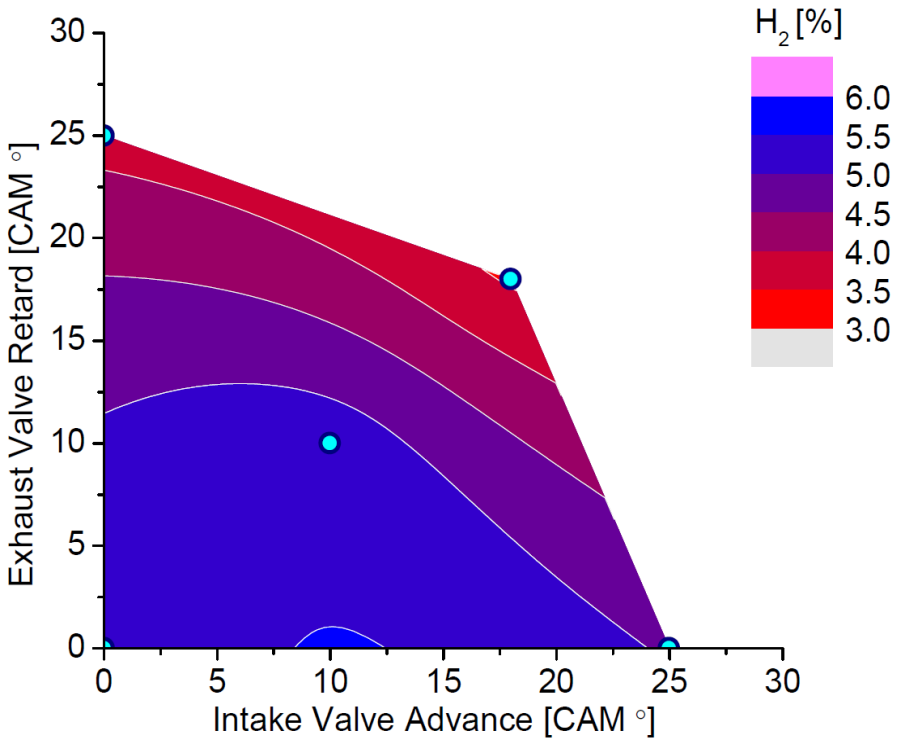
Accomplishments

- Initial engine evaluations were made on an installed 2.0 L turbocharged and direct-injected gasoline engine at SwRI
- Cam phasing and injection strategies were investigated to extend the rich limit of the dedicated cylinder and optimize the H_2 production

Independent Variables	Range
Intake valve phasing [cam °]	0-32
Exhaust valve phasing [cam °]	0-32
Fuel injection	Production side-mount GDI or retrofitted PFI
GDI Injection pressure [bar]	20-200
Injection timing [°bTDC]	DI: single early (310), split 50:50 (310, 230), single late (260) PFI: 200
Fuel	Haltermann HEE (Tier 2)

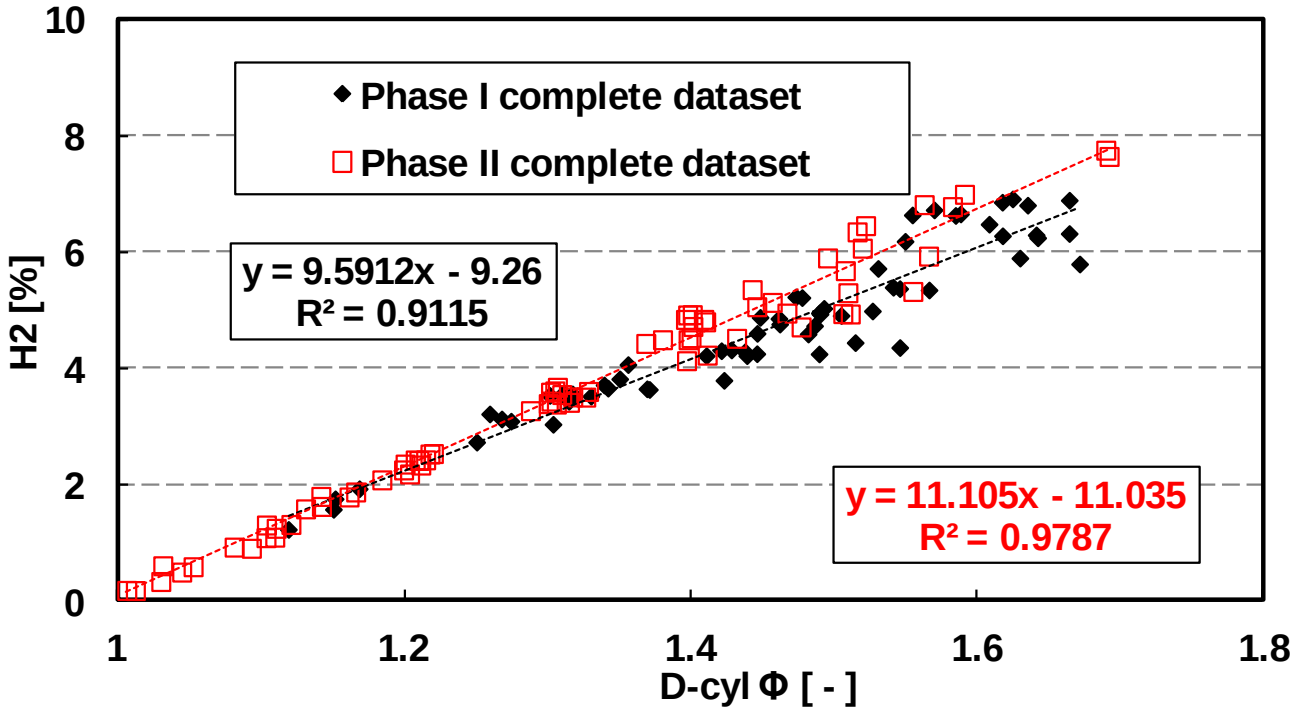
Accomplishments – Cam Phasing

- A design of experiments study identified optimum cam phasing for H_2 production
- Results showed a modest dependence of enrichment potential with cam phasing which led to H_2 production improvement



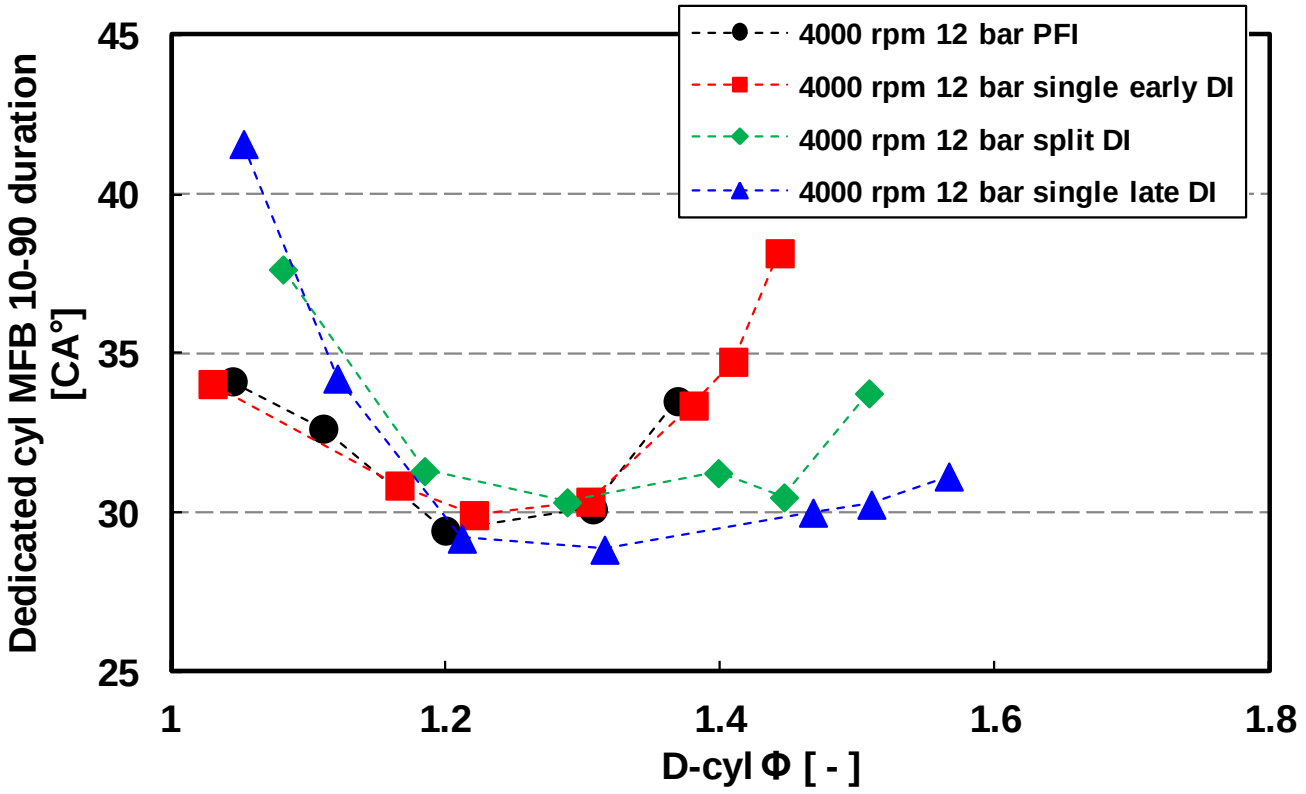
Accomplishments – Injection Strategy

- Injection optimization yielded enrichment to 75% excess fuel and 8% H_2 production in the dedicated cylinder
- Slope of the H_2 / ϕ line indicates that the chemical path to H_2 was not impacted, only the degree of possible enrichment



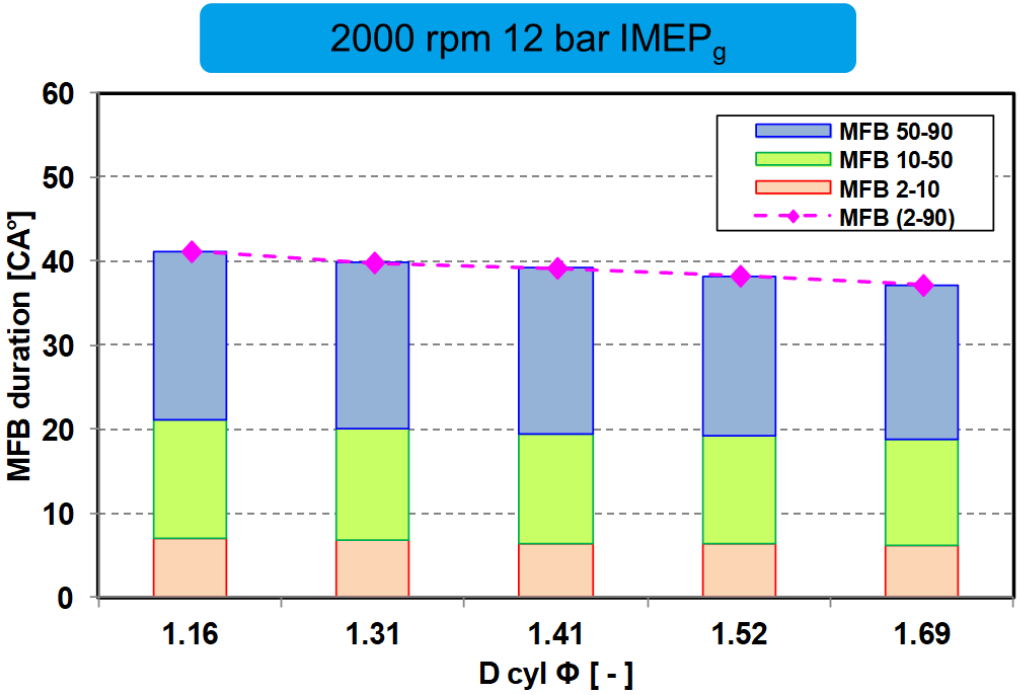
Accomplishments – Injection Strategy

- Late DI and split DI injection offered a significant increase in dedicated cylinder enrichment – maintained burn rates and COV of IMEP at highly enriched conditions



Accomplishments – Combustion Gains

- The increased enrichment and resulting increase in H_2 production enabled faster burn rates in the main (stoichiometric) cylinders
  - Enables increased dilution and / or increased compression ratio potential



Responses to Previous Comments

Due to cost share challenges, this project was not previously reviewed so there are no comments from past years to address

Collaborations

Cost share partner
Engineering support and engine hardware to support test activities at SwRI

FCA
FIAT CHRYSLER AUTOMOBILES

Cost share partner
Engineering support and test fuels

TOTAL

Industrial interaction
Industry feedback and parallel combustion system Development

HEDGE
HIGH-EFFICIENCY DILUTE GASOLINE ENGINE
A Consortium of SwRI

Remaining Challenges and Barriers

- Production of fuels with desired chemical composition using refinery outputs – goal is to demonstrate fuels which would be producible using current production processes
- Update of the test engine to permit higher compression ratios to realize the efficiency benefits brought by the new fuels – must balance compression ratio and chamber geometry to maintain combustion efficiency

Future Work

- FY18:
  - single cylinder fuel studies will identify the fuel chemistry impact on H_2 production
  - Production of refinery-blend fuels to confirm the findings of the simple fuel studies
  - Demonstration of compression ratio increase potential from H_2 production
- FY19:
  - Demonstrate efficiency gains using the produced fuels in a multi-cylinder engine

Summary

- The performance of a dedicated cylinder on a D-EGR engine has been optimized for maximum enrichment and resulting H_2 production
- Enrichment was approximately doubled from the pre-project maximum found in earlier development work in the HEDGE II program
- H_2 production of up to 8% has been demonstrated, yielding a per-cylinder H_2 concentration of 2% for improved burn rates, dilution tolerance, and eventual compression ratio increase