Enabling High Efficiency Clean Combustion with Micro-Variable Circular-Orifice (MVCO) Fuel Injector and Adaptive PCCI

Deyang Hou, Ph.D. , Founder

QuantLogic Corp., Texas

DOE 14th DEER Conference

August 4-7, 2008

QLC

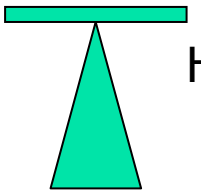
Outline

- The Clean Path – Adaptive PCCI + ADC;
- The High Efficiency Path – CV + CP;
- The System Path - Dual-Mode Adaptive PCCI (D-MAP);
- The Key Enablers I – MVCO Injector;
- The Key Enablers II – MCS Chamber;
- Results
- Summary

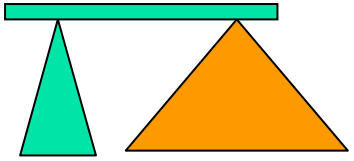
1. The Clean Path – Adaptive PCCI +ADC

(PCCI + Accelerated Diffusion Combustion)

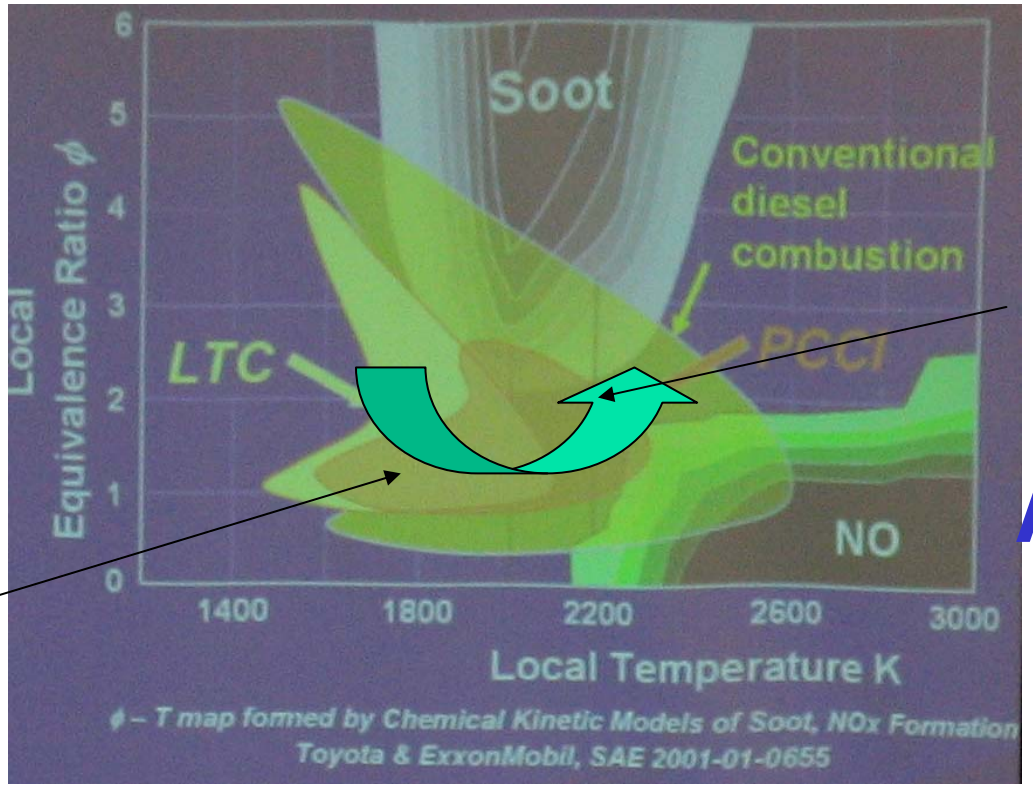
Path to Stable, Smooth, Clean and High Efficiency



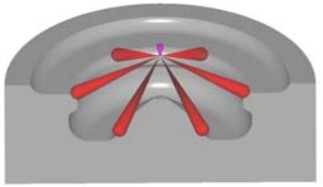
Adaptive PCCI+ADC



Soft, Φ<2



Stronger, L



$PV = nRT$

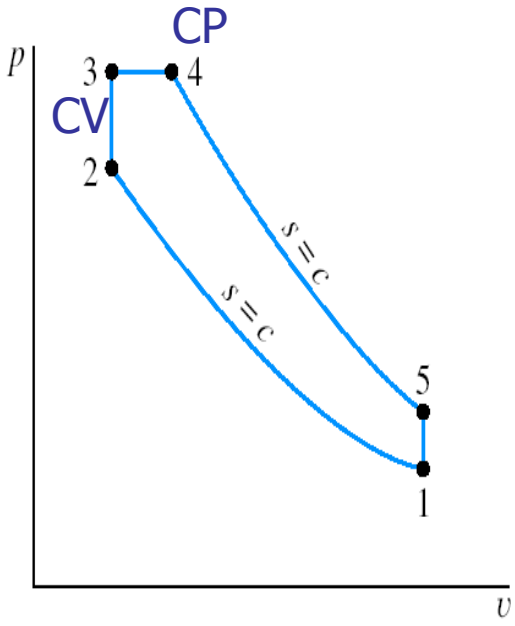
Clean F(NOx, PM, CO, HC) = F (Φ, T)

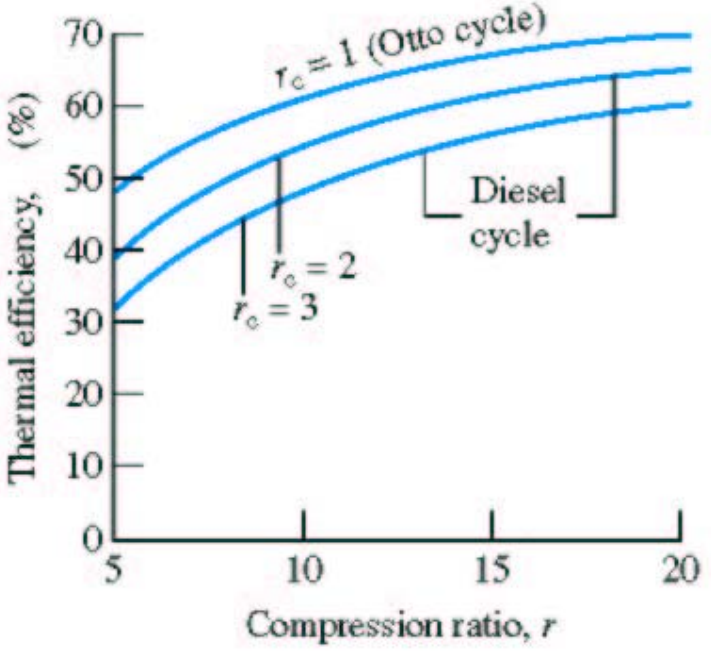
Non-Homogeneous A Reality in Metal Engines

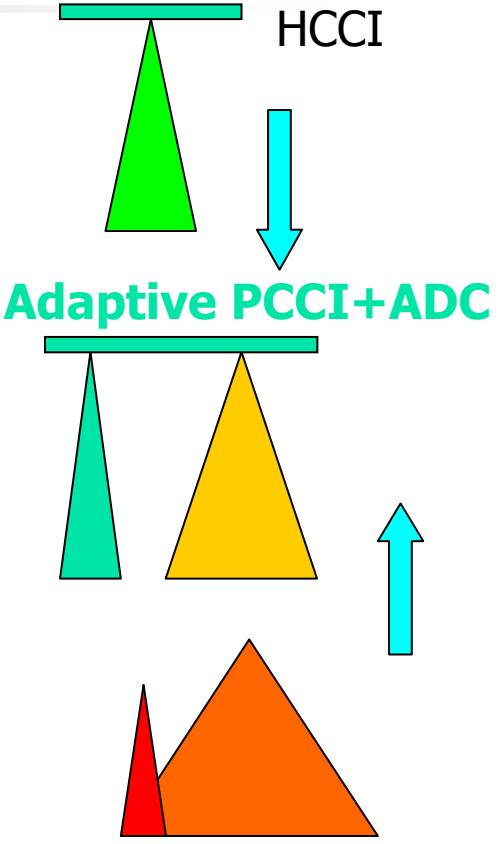
QLC

2. The High-Efficiency Path – Fundamental

(Constant Volume + Constant Pressure / Otto + Diesel Cycle 12~18% difference between the two mode depending on ε)







From Conventional Wisdom to New Wisdom
- Reconcile emissions and thermal efficiency

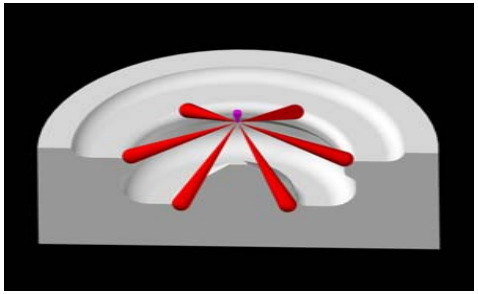
QLC

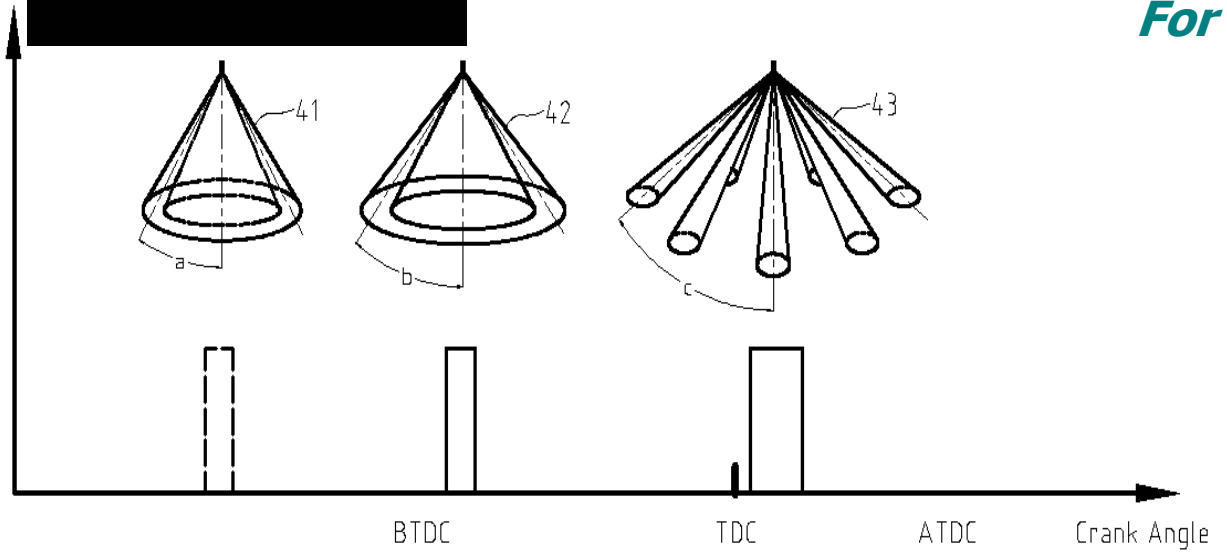
3. The System Path –

The Dual-Mode Adaptive PCCI + ADC (D-MAP)

with a single MVCO injector , single CR, single pump

(US Patent Pending, PCT)





High Efficiency & Clean

Dual-Mode in Same Cycle For All Major Loads

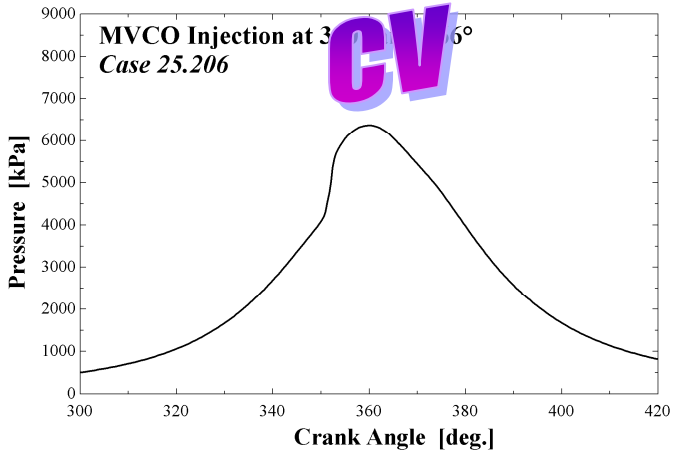
How ?

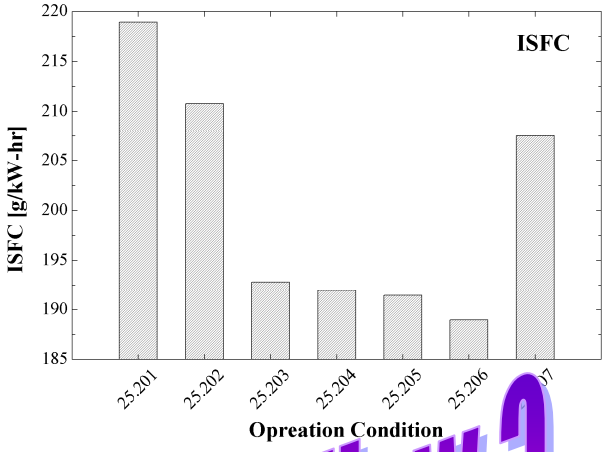
QLC

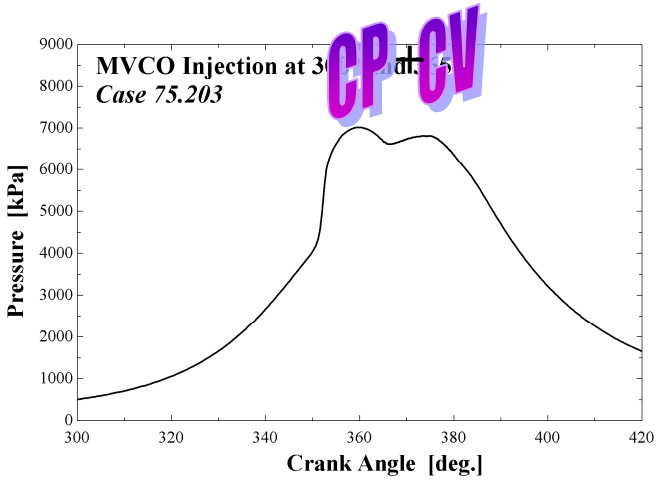
3.1 The High-Efficiency System Path - Practice

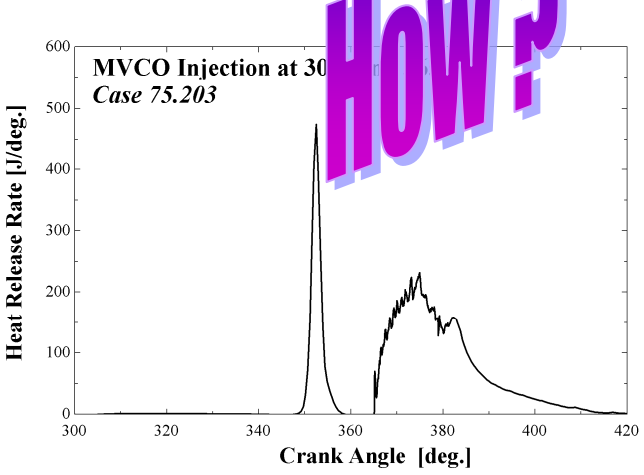
–10~15% Efficiency Improvement Is Feasible

(Impossible? Consider 250~300g/kwh at light loads, conventional combustion loses too much at low loads due to limitation of inflexible fuel injection with fixed orifice nozzle and combustion mode)





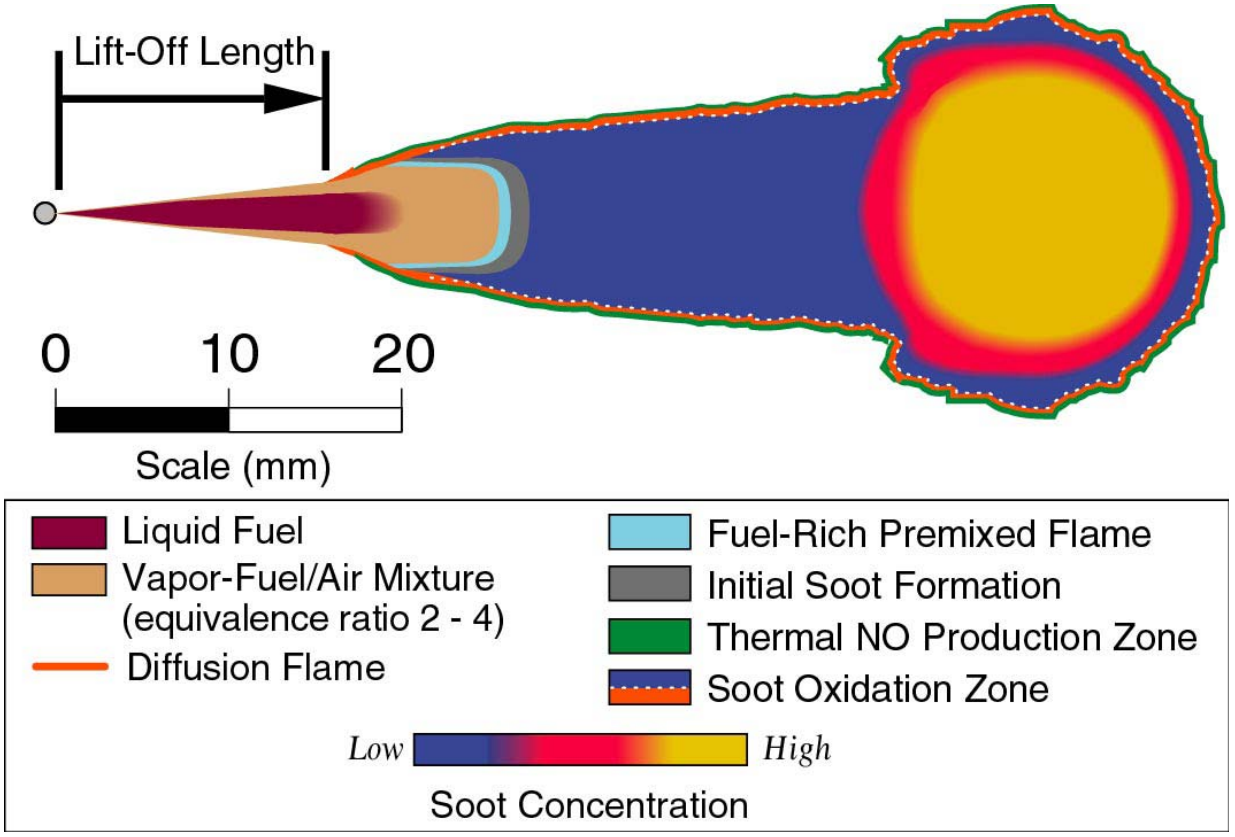




QLC

What Is the **Root Cause** for All the Challenges?

Without reforming the conventional jet, clean in-cylinder combustion is only a dream

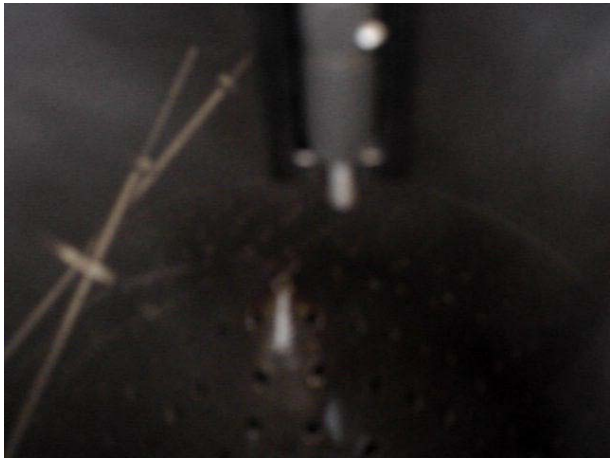


*From SAE 970873, J. Dec; Musculus, DEER 2005

QLC

4. The Key Enabler I – MVCO Injector

(China Patents, US Patents Pending, PCT)



Characteristics:

- ***Variable Spray Patterns;***
- ***conical + multijets;***
- ***Variable Spray Angles (narrow to wide);***
- ***Single needle, low cost;***
- ***Variable SMD for Different Operations***

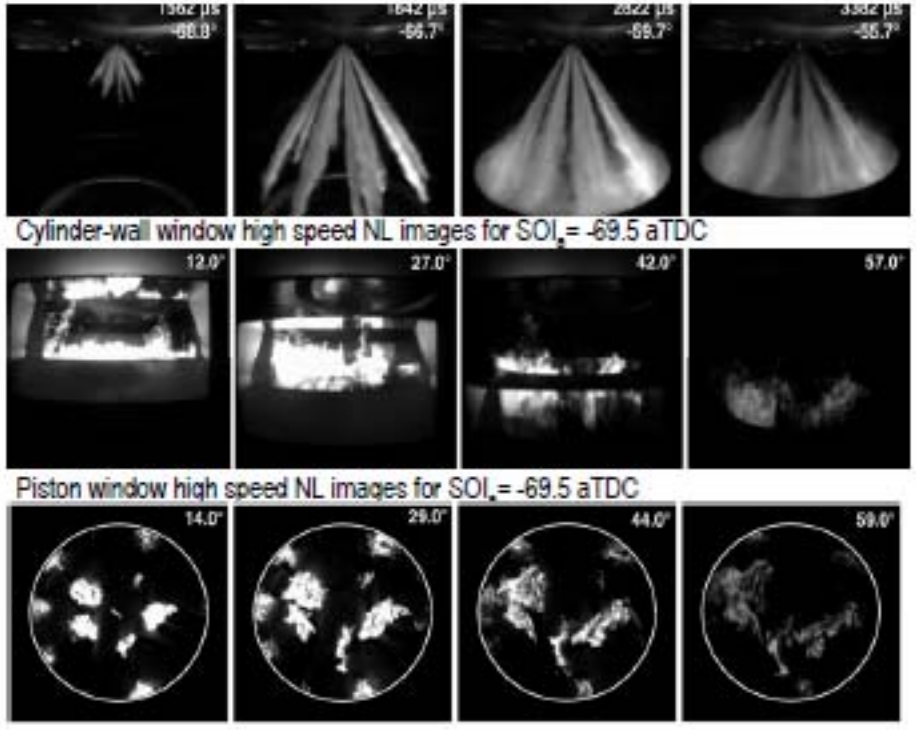
Benefits

1. Flexibility for optimizing combustion for different operating conditions;
2. Conical spray reduces/eliminates oil dilution for pilot/post injection;
3. NOx, PM reduction
4. HC, CO reduction with reduced surface wetting;
5. High injection rate & fine atomization;
6. Controlled fast reaction;
7. 'On-demand' EGR;

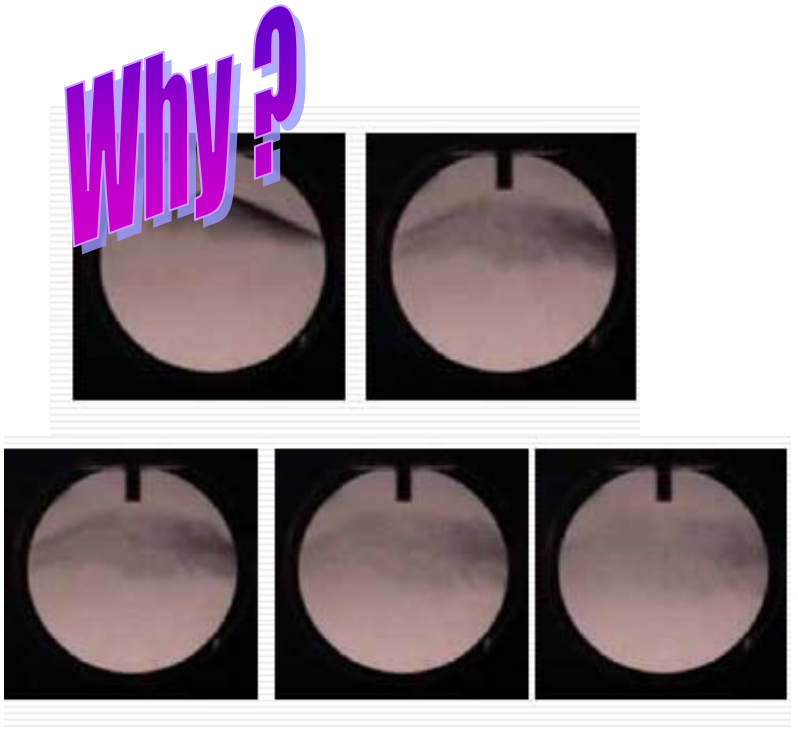
QLC

4.1 Conical vs. Multijet for Early Injection

(conventional jets have high momentum which forms film/spots on chamber surface causing pool fire on later stage of combustion, thus soot & NOx emissions, un-complete burn of formed film may cause high HC & CO)



David Milam, DEER 2006
Results of SNL



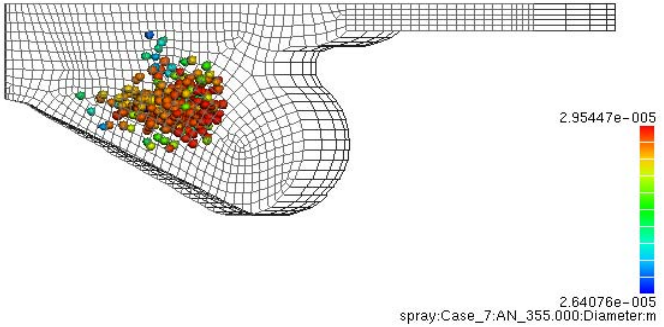
1,2,2.25,3,4ms after injection

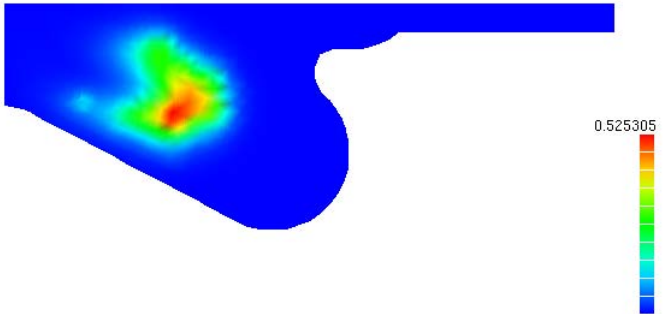
MVCO Conical Spray

QLC

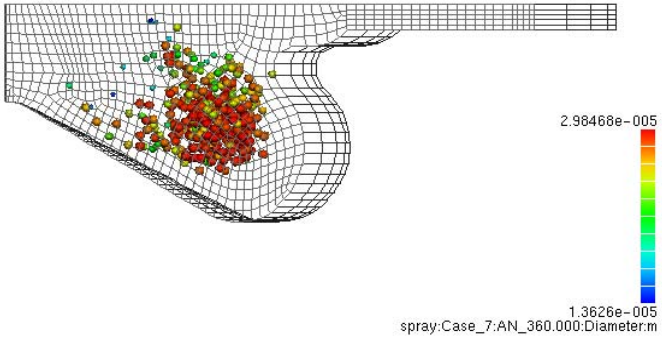
4.3 Drop Distribution

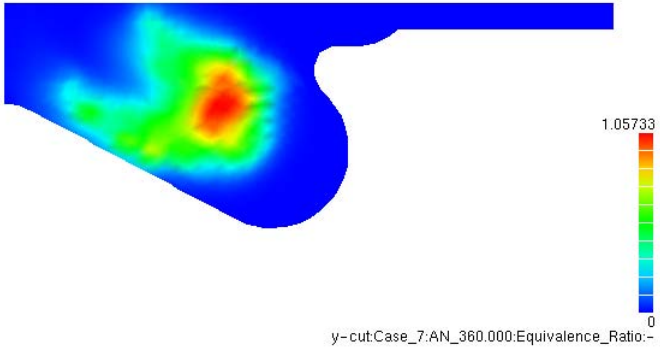
Comparing with conventional fuel injector, MVCO injector provides more dispersed drop distribution in combustion chamber space, which facilitates lean combustion, reduces emissions





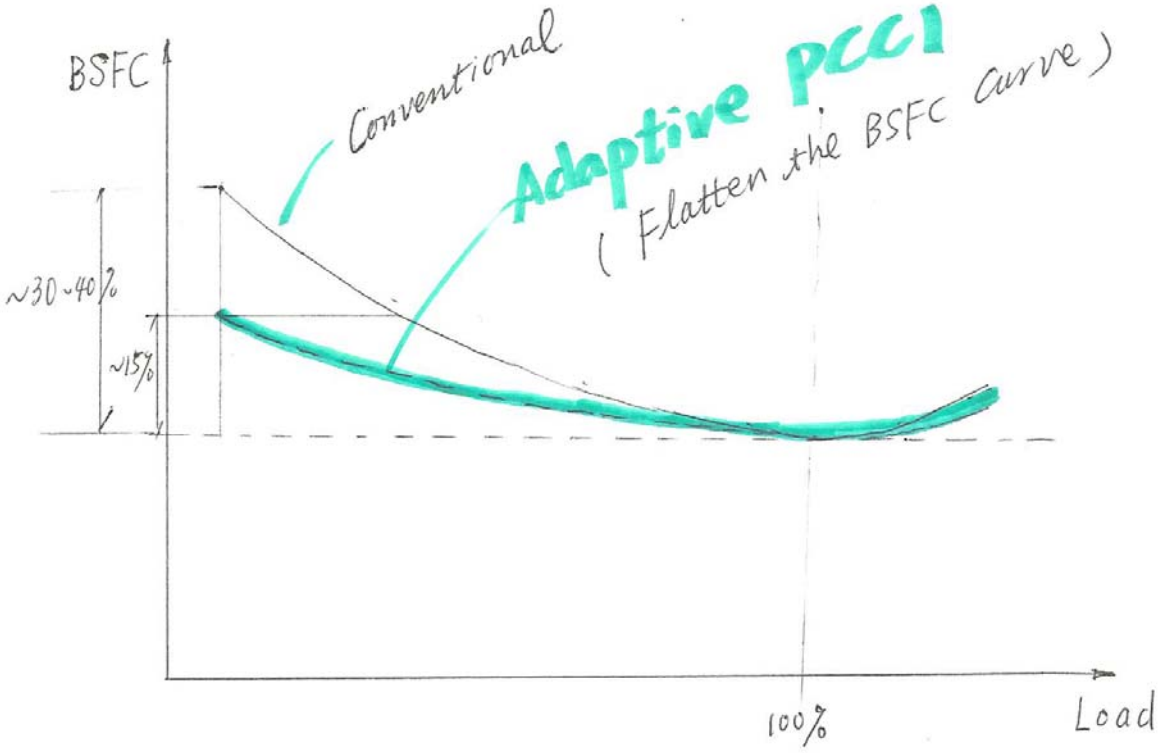
Φ<1.2, 'Lifted-Flame'?





QLC

4.2 Why Variable Spray Pattern and Variable Orifice – MVCO Enables Optimization Over Full Operation Maps (Back up slide)

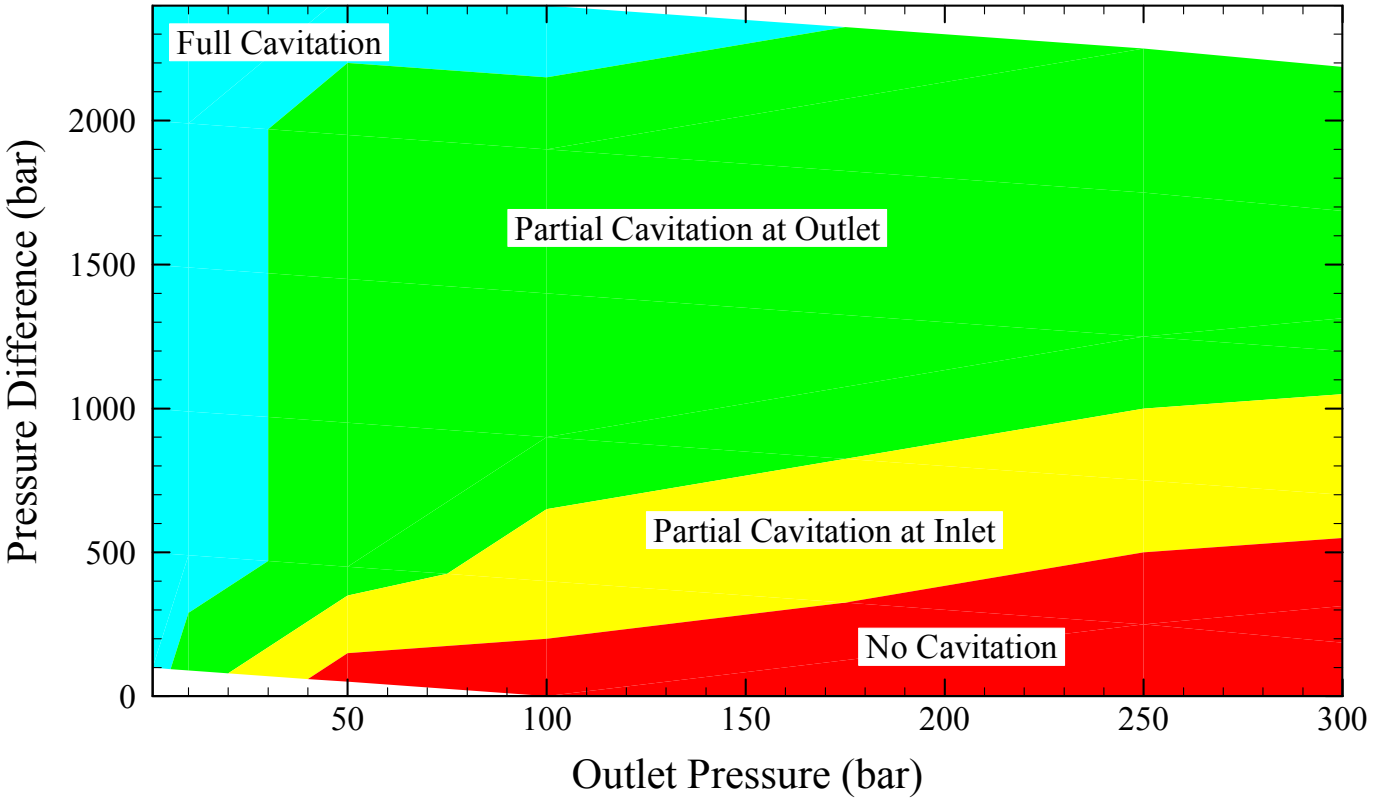


250 bar

300 bar

450 bar

4.4 Atomization Fundamentals Support a Low Cost Fuel Injection System for PCCI, and Dual-Pressure Level for Dual-Mode Combustion



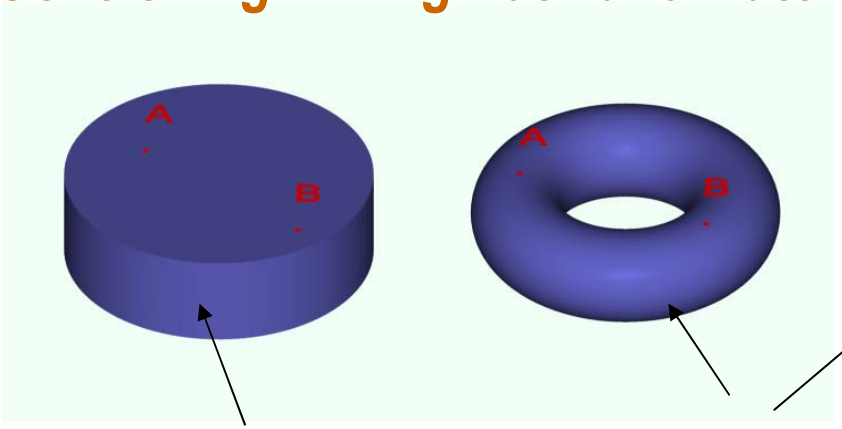
Hou et al, SAE 2007-01-0249

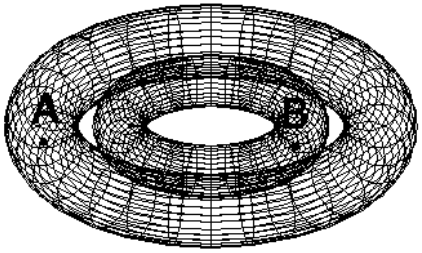
QLC

5. The Key Enablers II – The MCS Chamber

(China Patent, US Patents Pending, PCT)

Smooth Combustion with
Premixed-Premixing Charge Enabled
by Controlling Mixing Path and Rate of Reaction





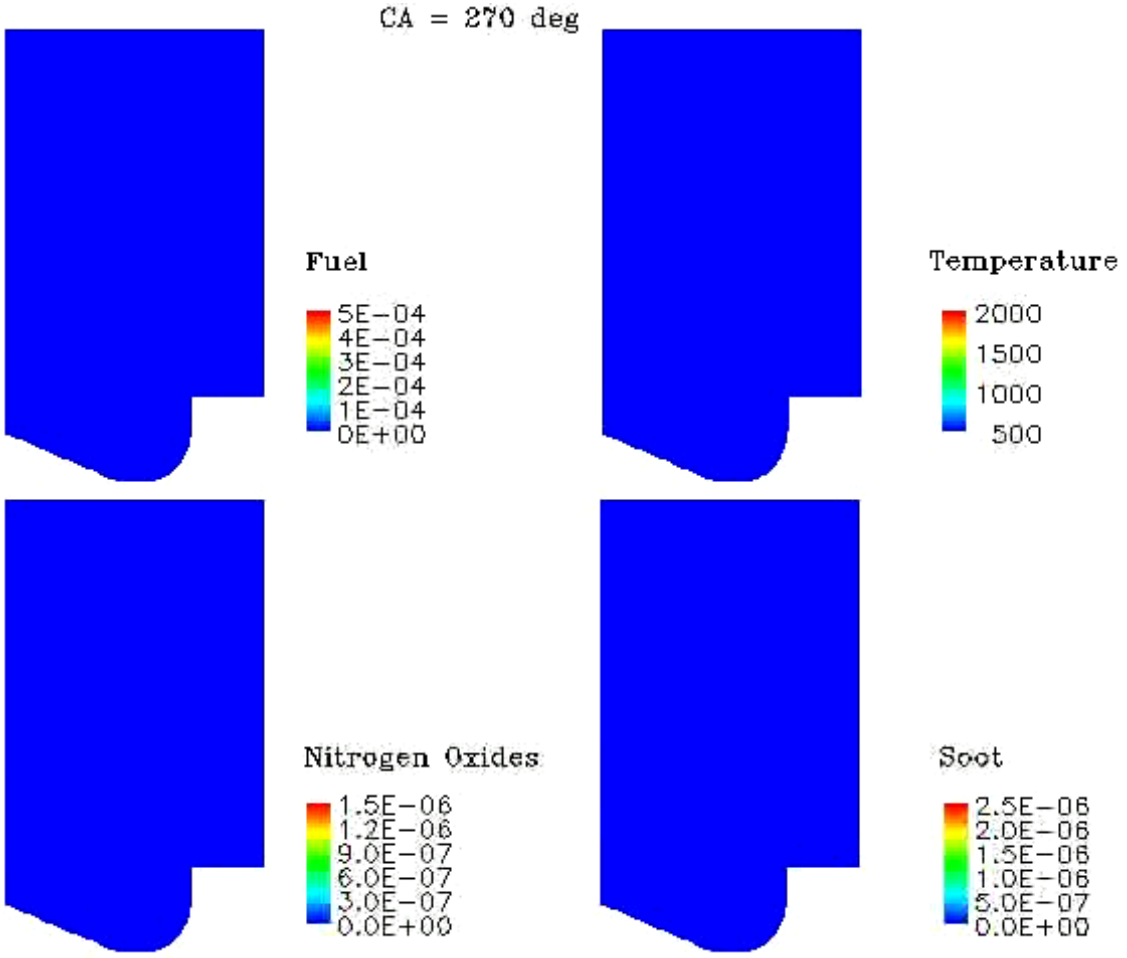
Single Connected Space

Multiple Connected Space

Multiple Connected Space Promotes Mixing, Stratification and Reaction Rate Control

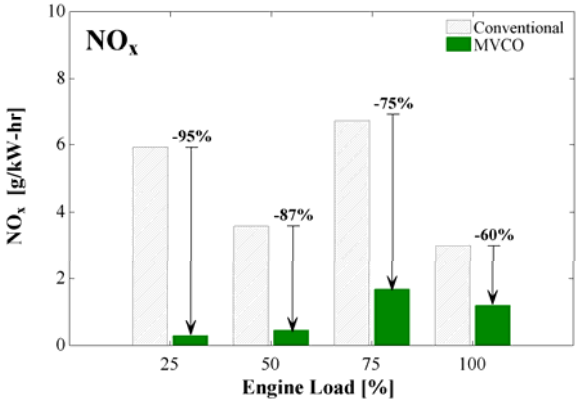
QLC

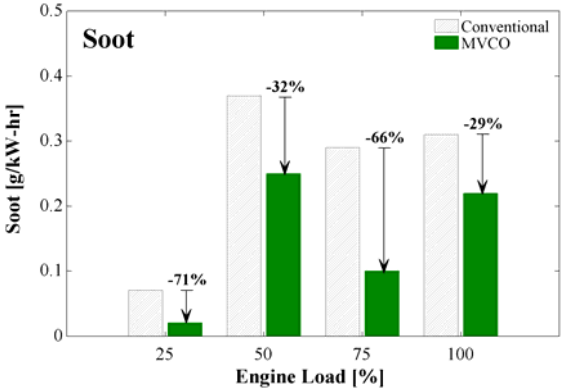
6. Results (1) - An Ultra Clean Solution for An New Engine (NOx has been cut 90%, soot cut 50%, with 12% thermal efficiency enhancement, 25% load)

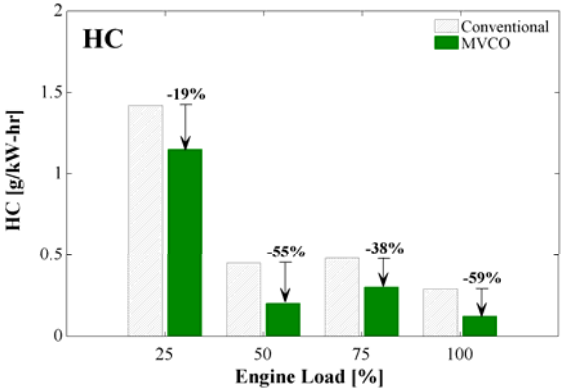


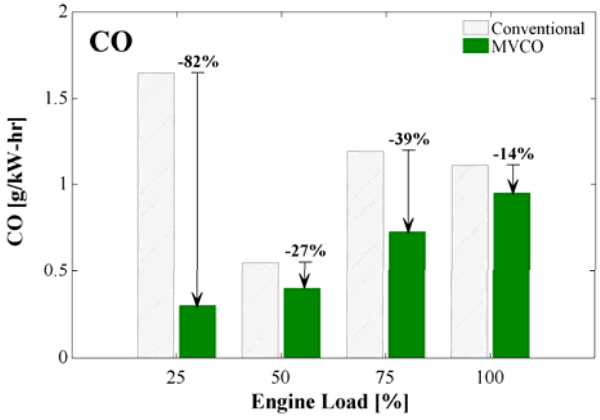
QLC

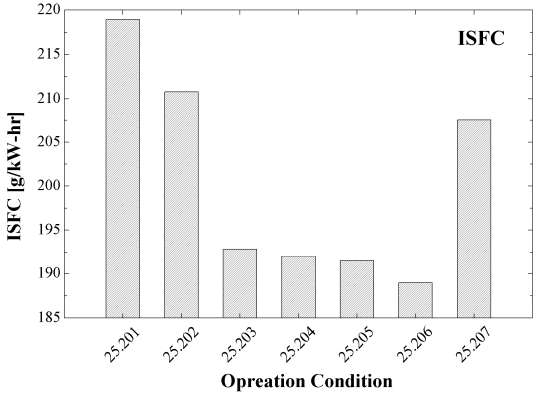
6. Results (2) - A Simple Retrofit Solution for An Old Engine (NOx has been cut more than 70% with 10% thermal efficiency enhancement)

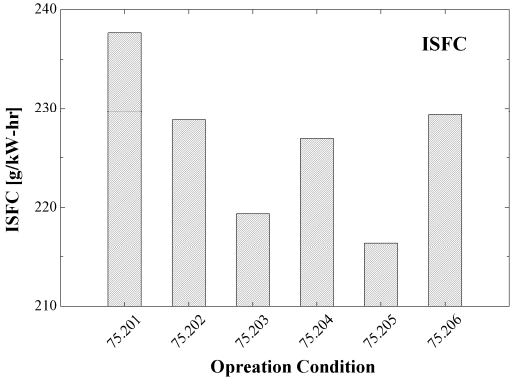












QLC

7. Summary

- The MVCO fuel injector provides adaptive spray penetration, variable spray angles, variable spray patterns and SMD, is flexible for different modes of combustion and operating conditions;
- Dual-Mode Adaptive PCCI (D-MAP) diesel combustion has significant potential for near-future engine emission control, it has intrinsic advantage of thermal efficiency;
- The MVCO injector and Dual-Mode Adaptive PCCI (D-MAP) have significant potentials to cut the cost of after-treatment (especially for NOx) to meet future emission regulations;

QLC

Thank You !

Contact: Deyang Hou

281-793-2792

- ***Clean Environment and Energy***
  - ***for Our Next Generation***
    - ***and Generations to Come!***

QLC