Dieseline/multi-fuel Combustion for HCCI Engines

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Presentation Outline

- Research background
- Present objectives
- Research engine setup
- Results and discussion
- Conclusions
- Future prospects

CHARGE/CHASE Project Outline

CHARGE (**C**ontrolled **H**omogeneous **A**uto-ignition **R**eformed **G**as **E**ngine),

2 yrs DTI sponsored, Jag/total funding = £420/840K

concluded 28/04/04

- Facilitate **natural gas** HCCI using fuel reforming

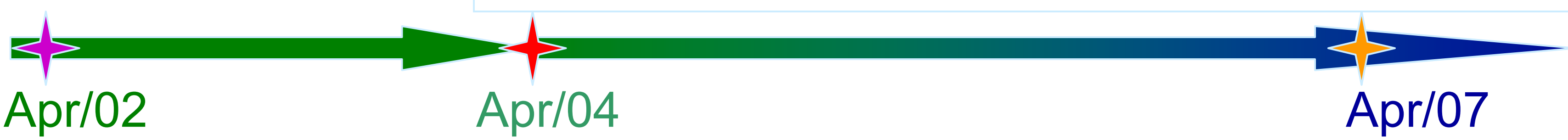
Reviewed by UK EPSRC: "Tending to International Leading"

CHASE (**C**ontrolled **H**omogeneous **A**uto-ignition **S**upercharged **E**ngine)

3 yrs DTI sponsored, Jag/total funding = £720/1,539K)

Kicked-off 28/04/04

- Expand **gasoline** HCCI window



partners:

Jaguar Cars, Birmingham University
Johnson Matthey, MassSpec UK
National Engineering Laboratory
Race Technology

Research Partnership

JAGUAR

LAND ROVER

JM

Project leader, engine and optical work

Reforming catalyst development

Race Technology

NEL

THE UNIVERSITY OF BIRMINGHAM

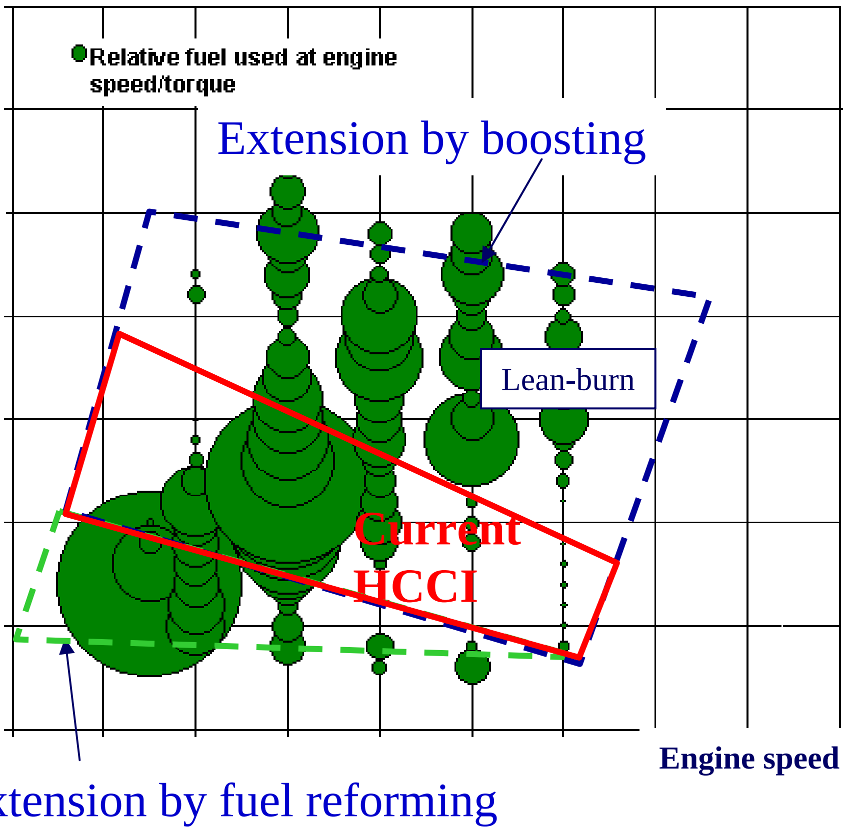
PER ARDUA AD ALTA

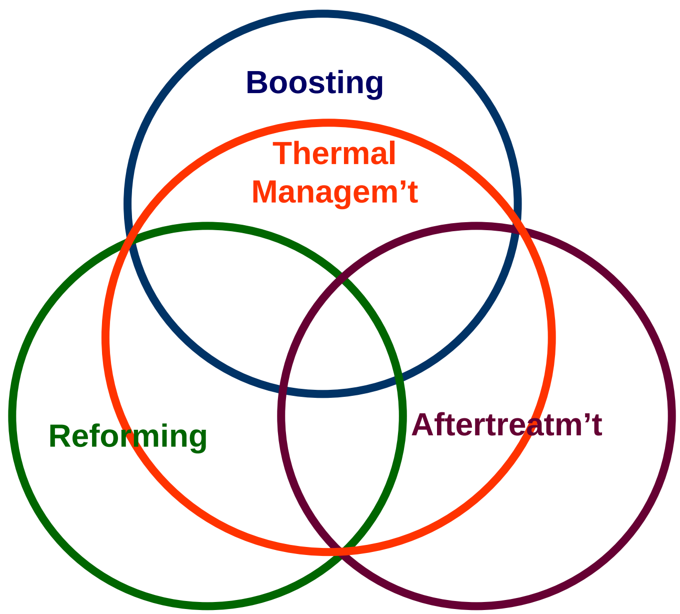
MS UK

Engine and reforming experiment

MS support

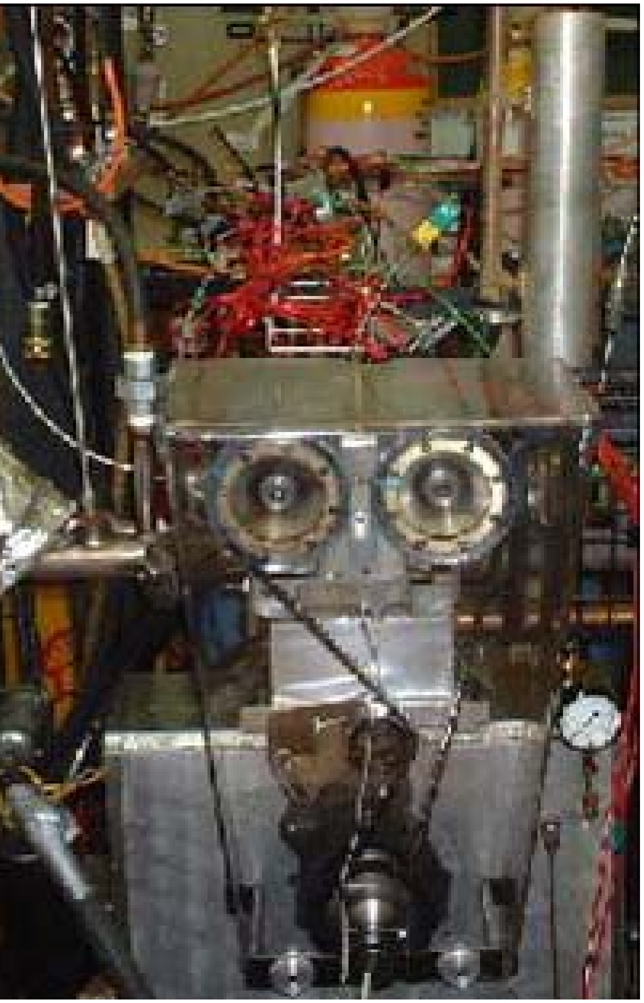
ASE Next Generation (2004-2007)





Main objective – Extend the operating window of Gasoline HCCI using combination of boosting, exhaust gas fuel reforming, and total thermal management.

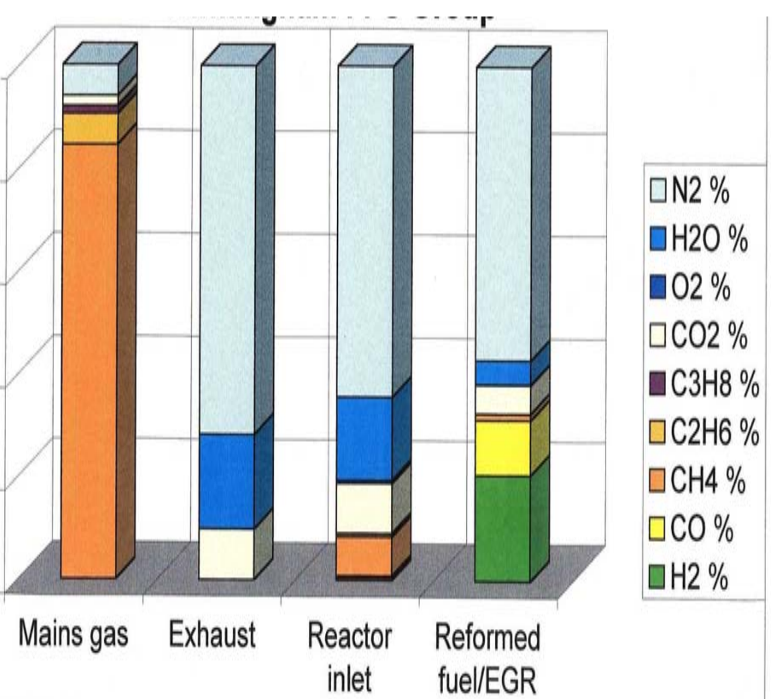
e single cylinder research engine



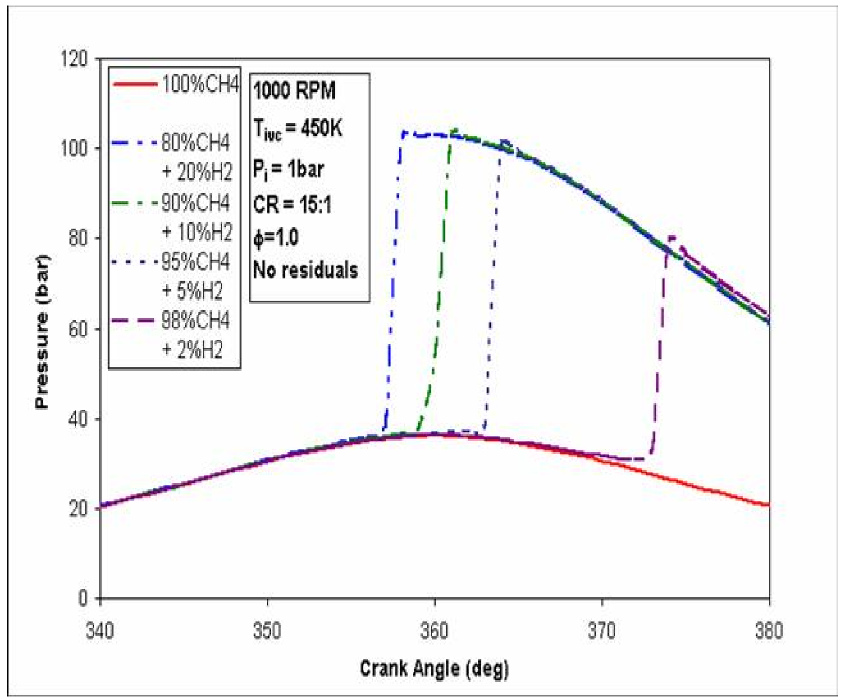
Engine type (Medusa base)	4 - stroke, single cylinder, 4 valve, pent-roof head
Bore x Stroke (mm)	80 x 88.9
Connecting Rod Length (mm)	165
Valve diameters and lift	27.7 / 24.1 mm 3 mm for NVO (8 mm standard)
Geometric Compression Ratio	10.4 for cold NVO (15.0 for heated intake standard valve events)
Fuelling type	liquid port-injected, injection at 3 bar (gauge)

ncept of CHARGE/CHASE (2002-2007)

formed natural gas (test data)

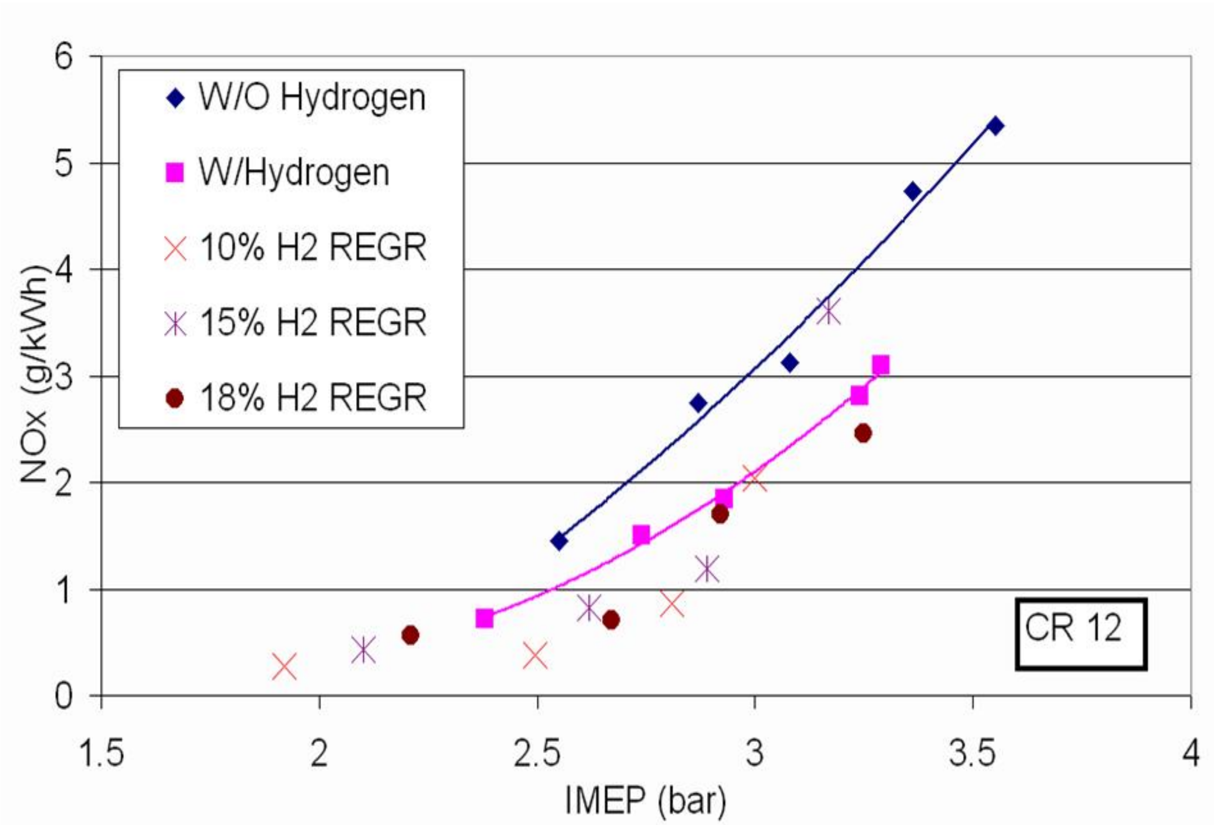


Modelling of the effect of fuel property



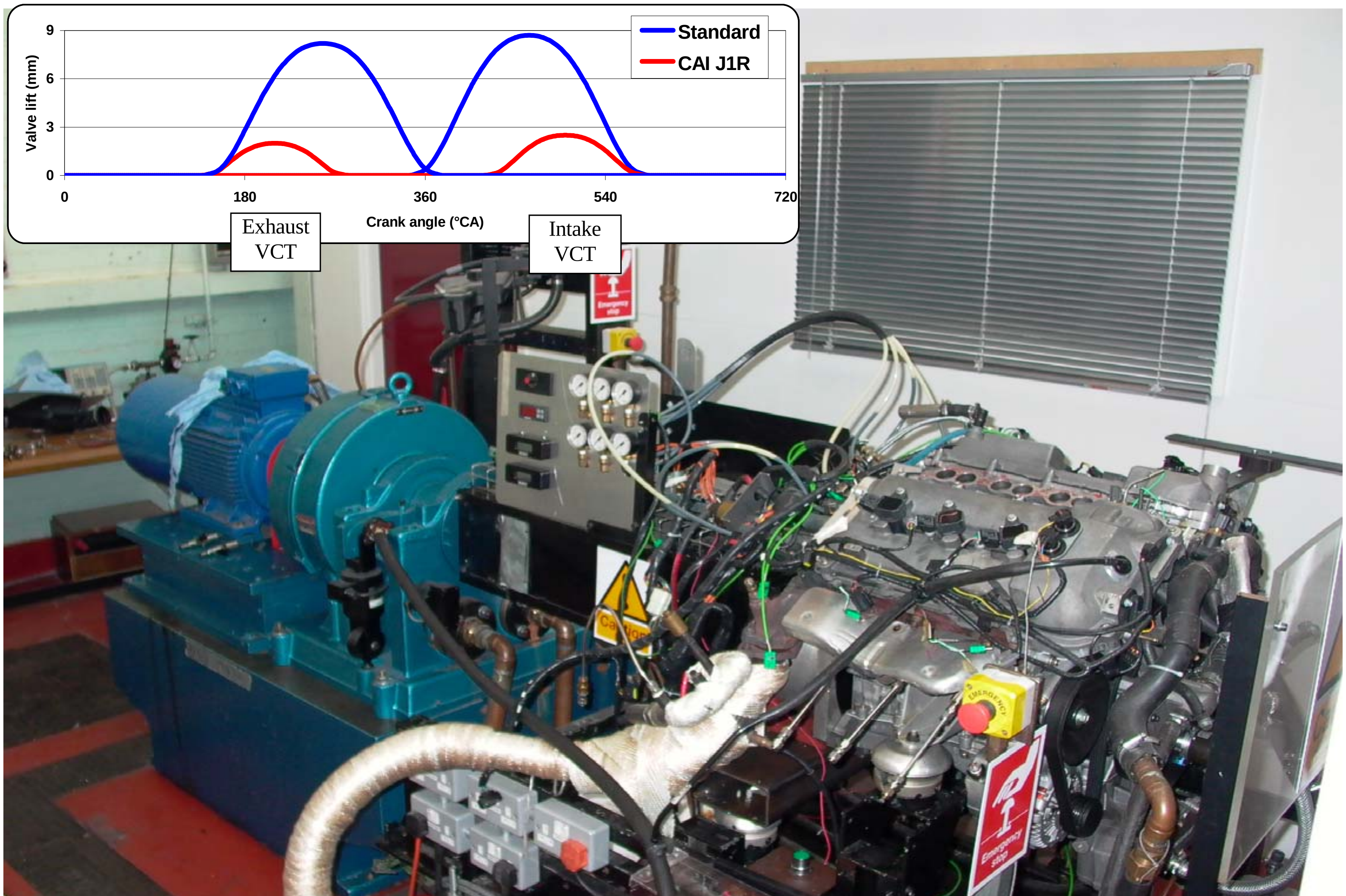
Main objective - Evaluate the effect of fuel composition and control of engine parameters on the auto-ignition process of natural gas in automotive engines

emissions for HCCI – fuel reforming (NG)

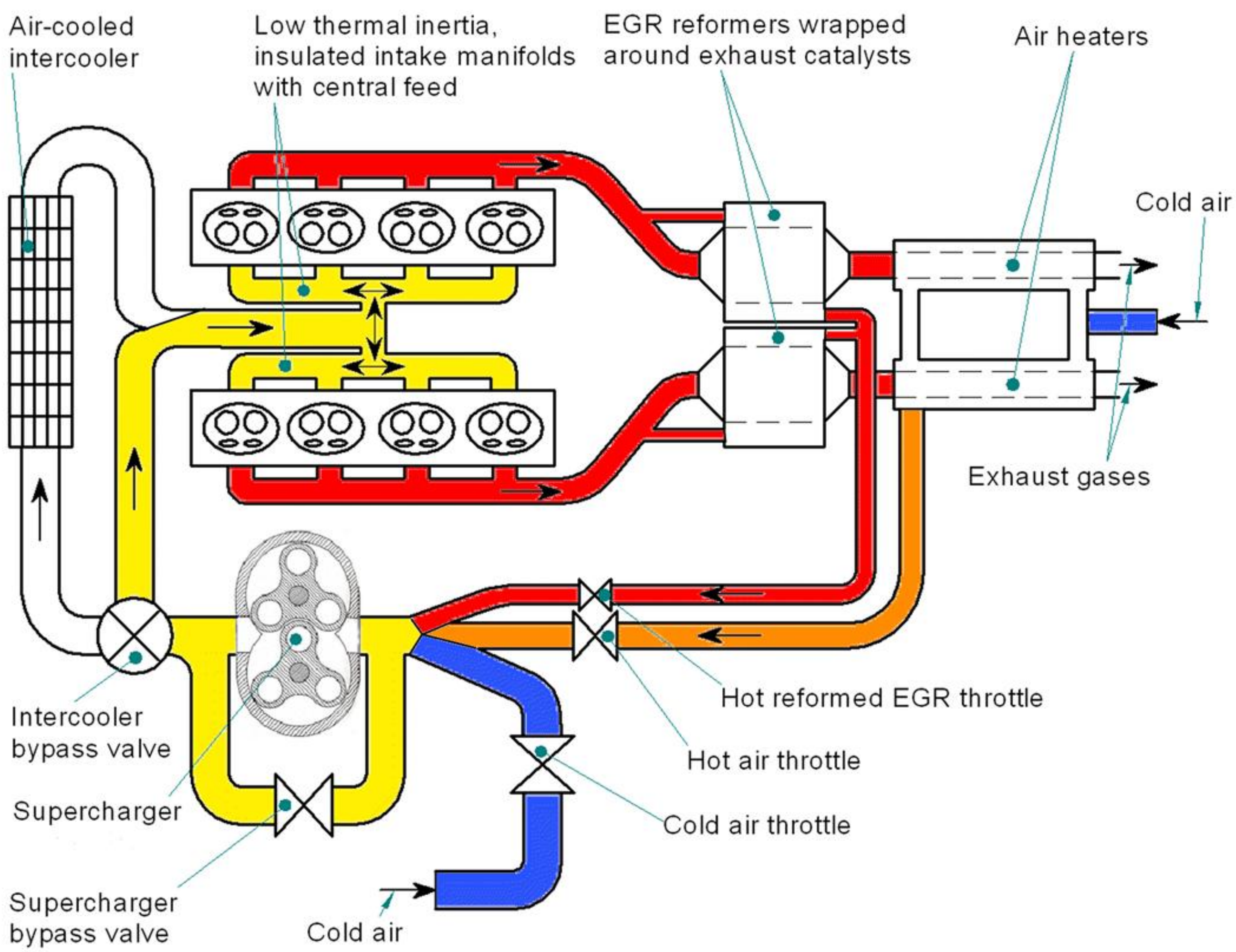


Hydrogen enriched HCCI has a lower NOx emission level and load limit than normal HCCI, with additional effect from reforming

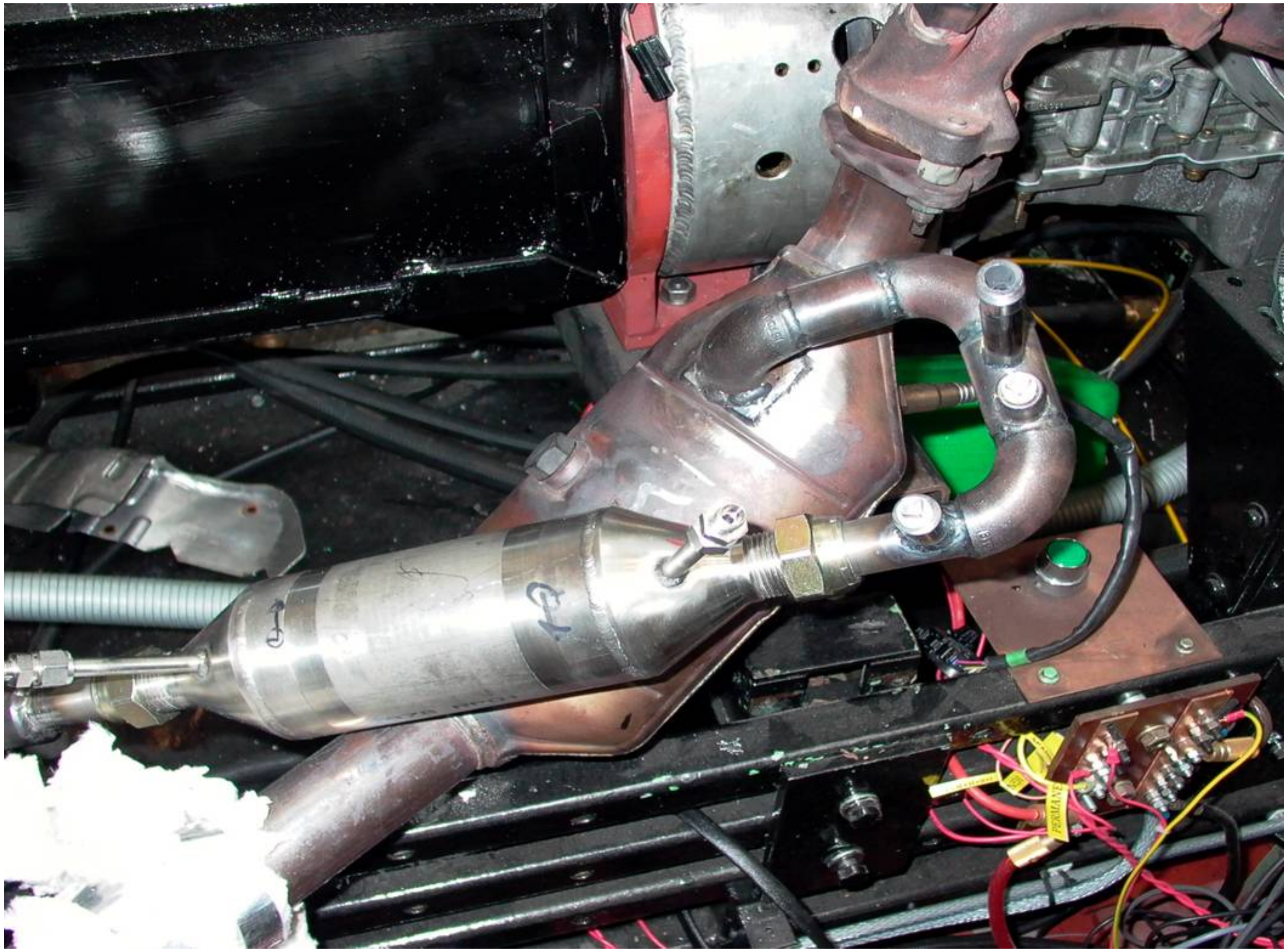
rld 1st dual cam profile switching engine



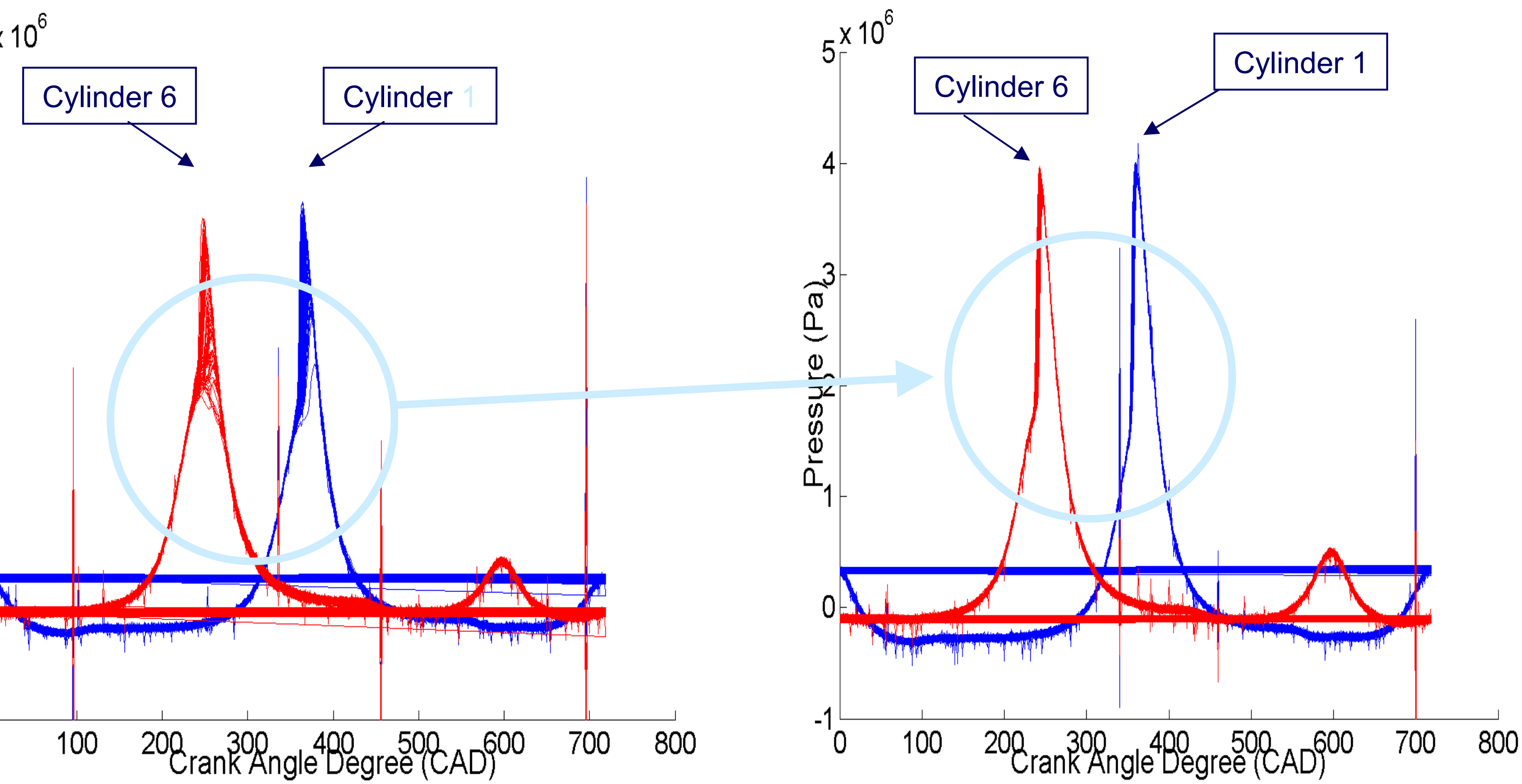
percharged Thermal Management System



ard reformer for the Jaguar AJV6 engine



le-by-cycle & cylinder-to-cylinder variations



Without reformed gas

With on-line reformed gas

eseline' research objectives

Gasoline, diesel and a variety of alternative fuels are all ossible fuels for HCCI combustion but none of them as a ngle fuel has proved to be able to enable a satisfactory berating window.

Gasoline and diesel fuels, the most widely supplied ain fuels, have indeed very different but complimentary roperties. Gasoline, which has high volatility but low nitability, is generally produced as a high octane number el.

The Diesel fuel, on the other hand, has a high cetane umber with larger carbon content and heavier molecular eight with low volatility, is better suited to auto-ignition ut often requires a lower compression ratio.

esent research

to investigate the HCCI combustion behaviour of the mixtures of gasoline and diesel as the two fuels with opposite but complementary properties.

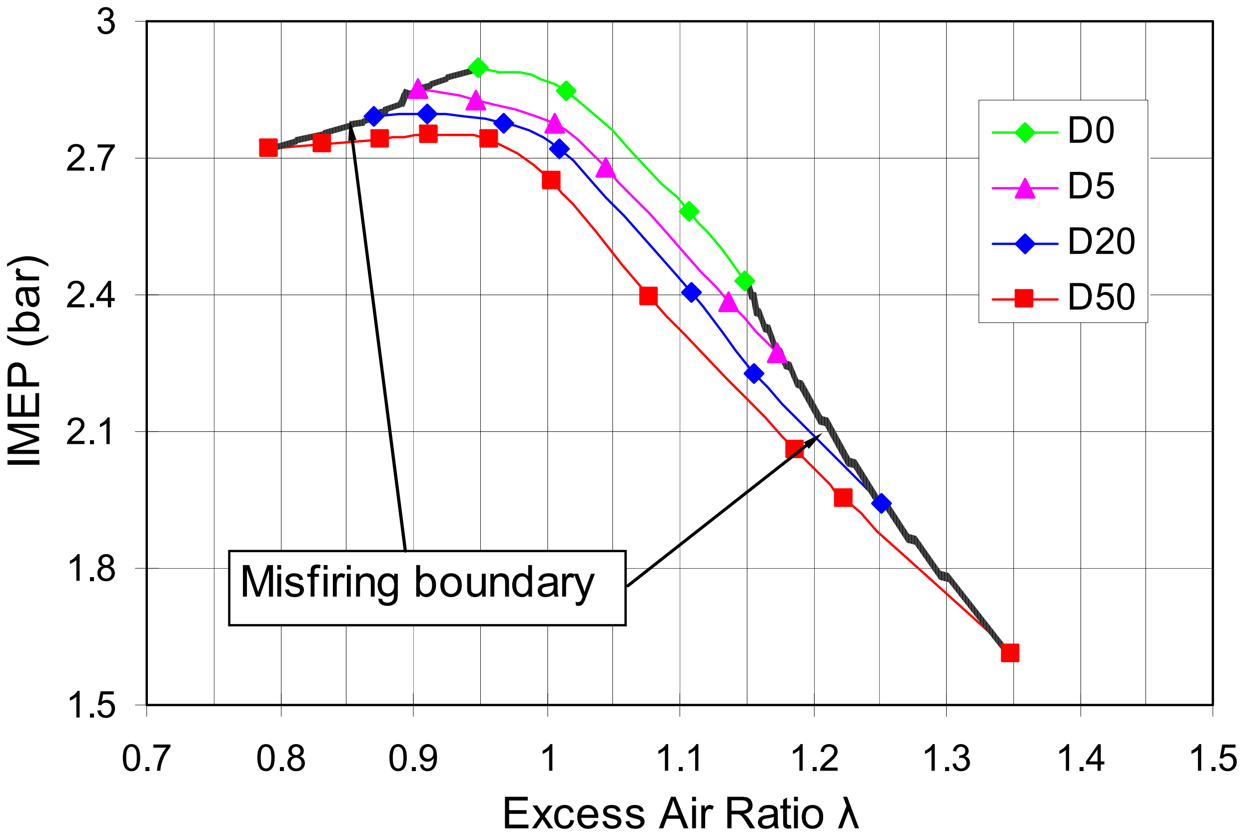
to investigate whether the two fuels can provide a compromise HCCI combustion where the ignitability of charge is improved

to restrain violent knocking so as to operate the engine in a controllable HCCI combustion mode under a moderate compression ratio

st Test matrix

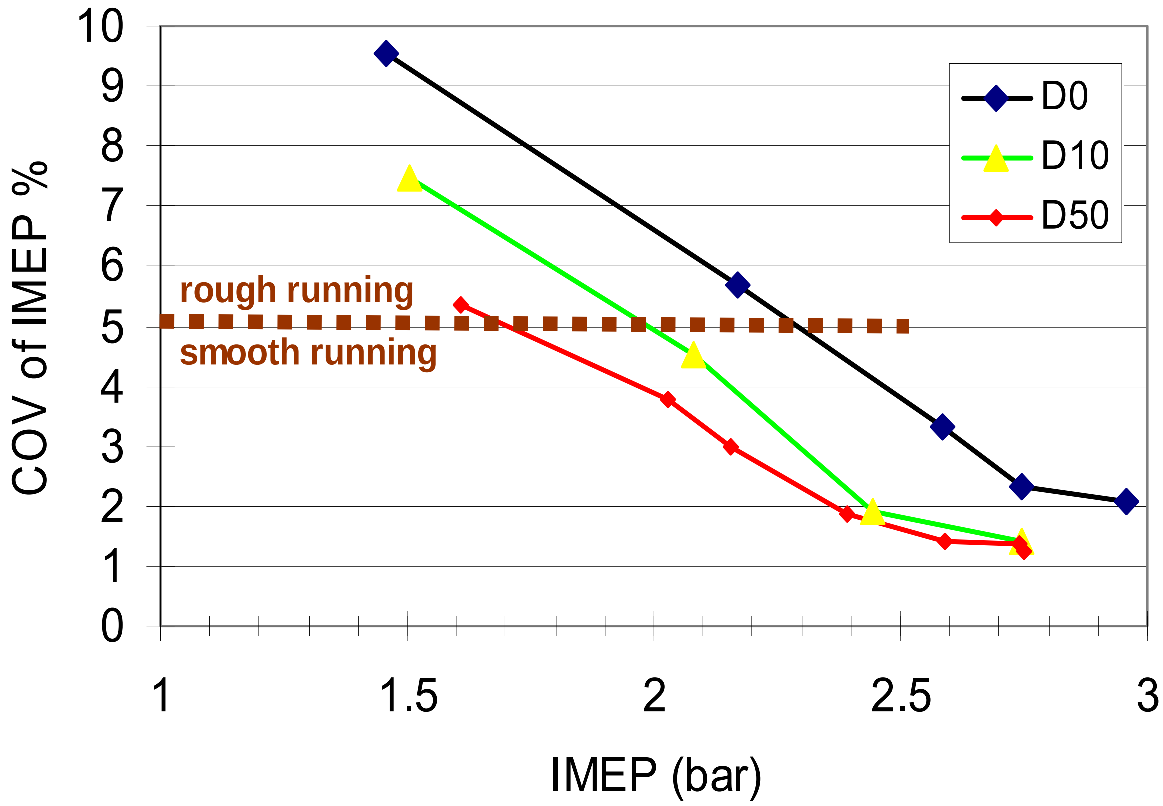
Fuel Designation	D0	D5	D10	D20	D50
Fuel Composition Gasoline : Diesel (by mass)	100:0	95:5	90:10	80:20	50:50
Intake heating (CR=15.0)			√	√	√
NVO (CR=10.4)	√	√	√	√	√

-ratio boundary with EGR trapping



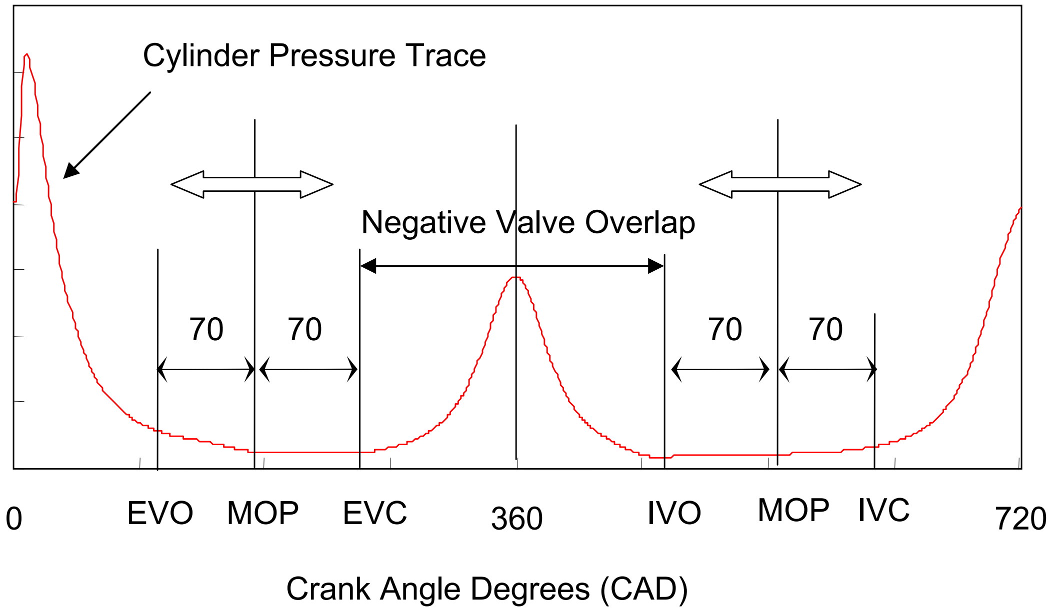
D0 (pure gasoline), D5, D10 and D50, in NVO HCCI mode, CR=10.4, 1500 rpm, unheated intake, low lift cams, NVO = -170 deg.

provement in combustion stability



D0 (pure gasoline), D10 and D50 when engine worked with unheated NVO HCCI mode, CR= 10.4, 1500 rpm.

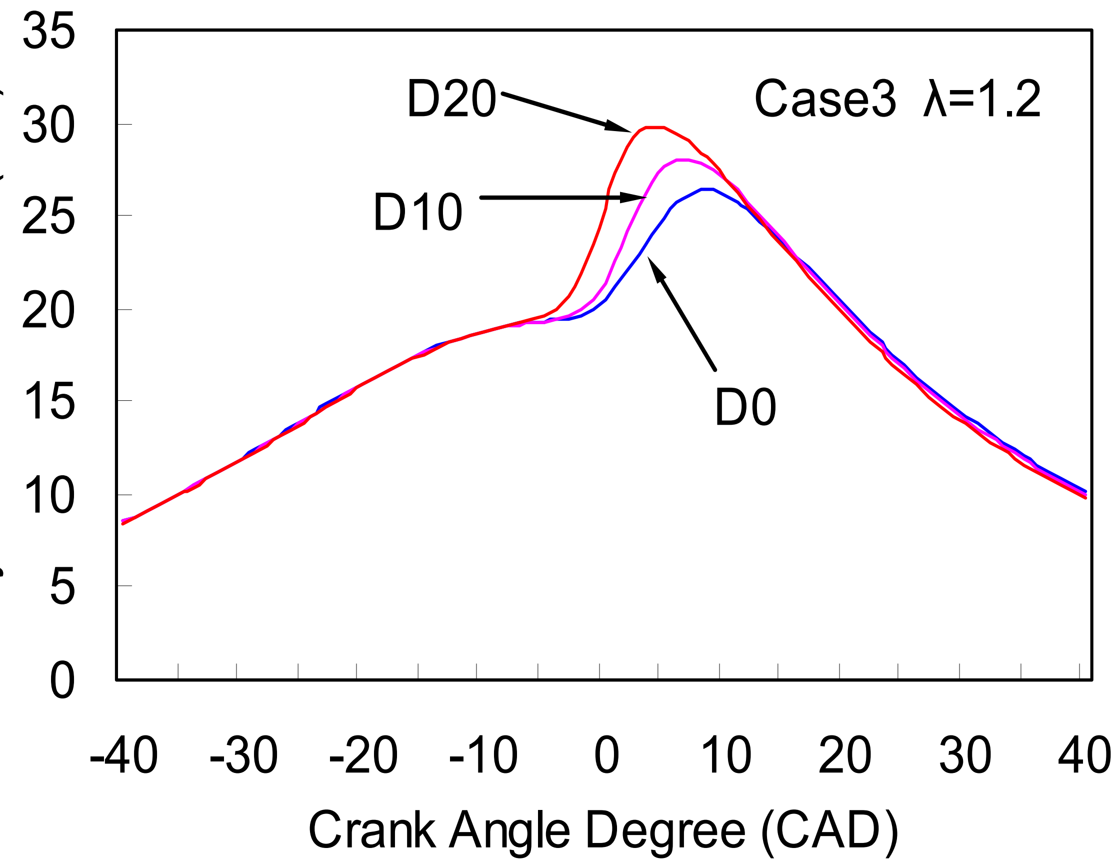
ve timing – case study



- Valve timing used in HCCI engine operated in NVO (negative valve overlap) mode.
- "0" crank angle degrees indicates TDC in the compression / combustion revolution.
- All IV/EV timings are symmetrical w.r.t. TDC

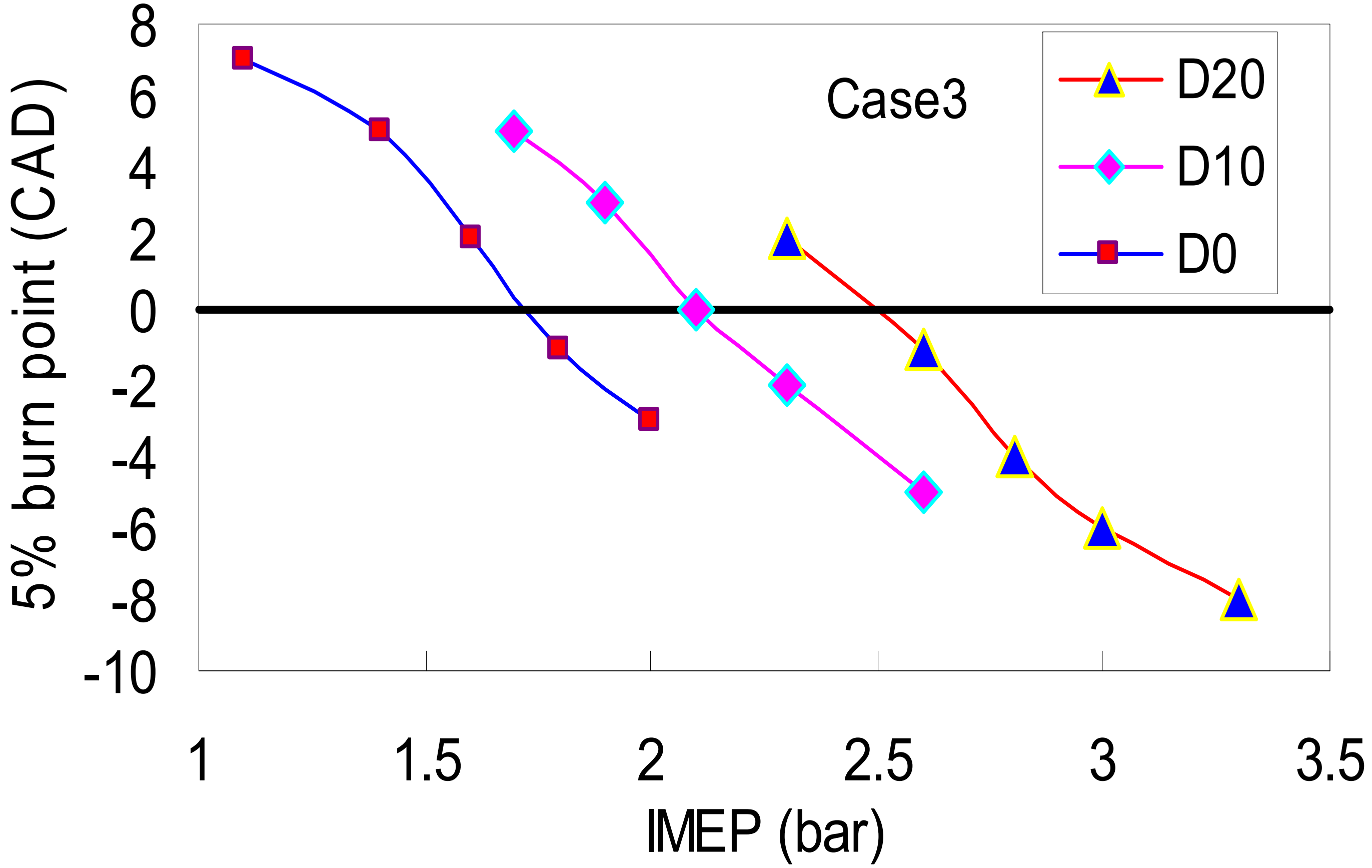
Conditions	Inlet valve MOP (CAD aTDC)	Exhaust valve MOP (CAD bTDC)	Valve Overlap (CAD)
Case 1	130	130	-120
Case 2	140	140	-140
Case 3	150	150	-160
Case 4	160	160	-180
Case 5	170	170	-200

...reasing diesel content, λ = const, NVO = const

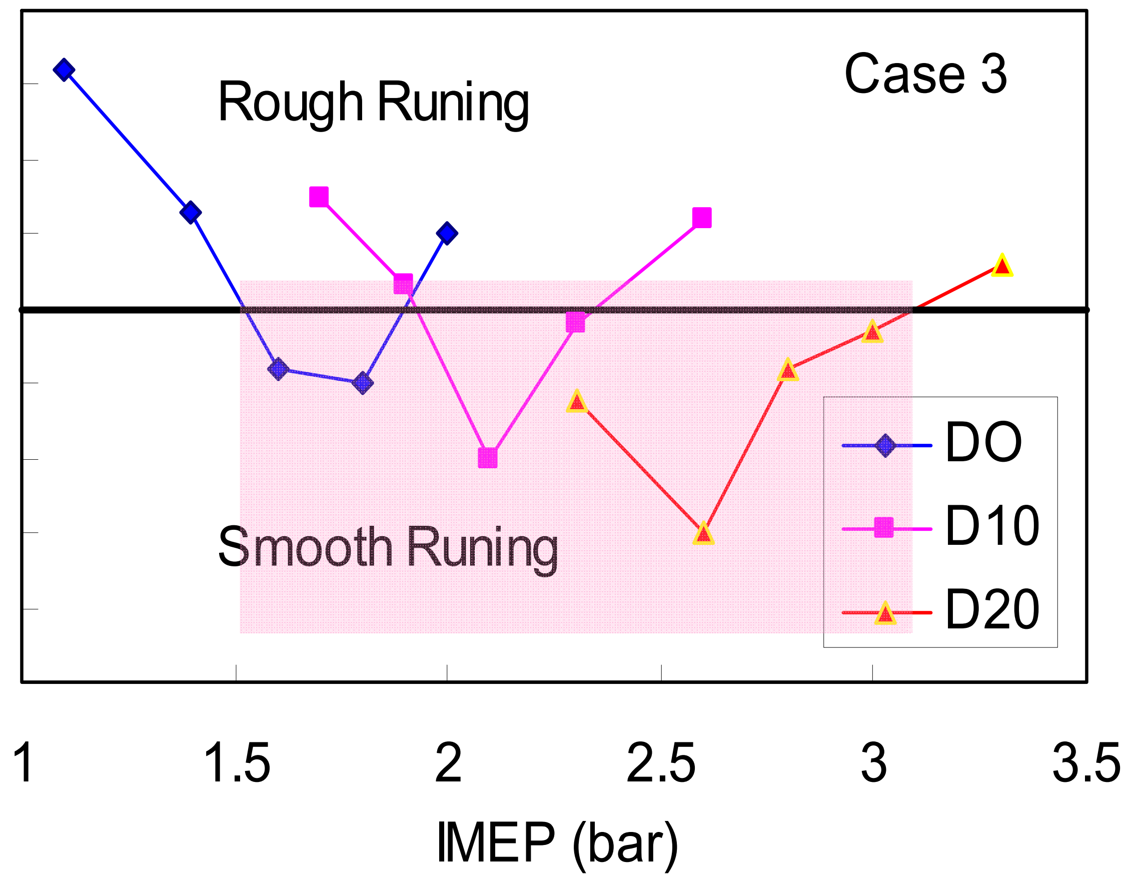


D0, D10, D20 fuels
Case3
NVO = -160 CAD
1500 rpm,
lambda = 1.2

tion advances with increased load and diesel content

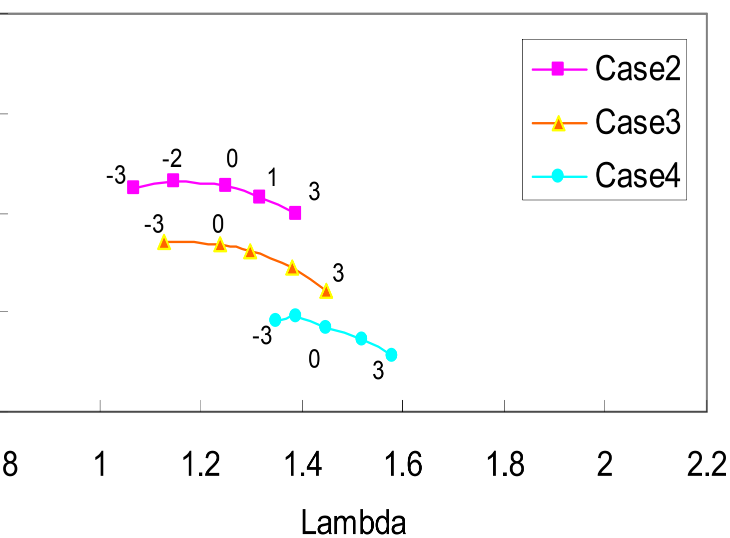


EP boundary with Variable diesel content

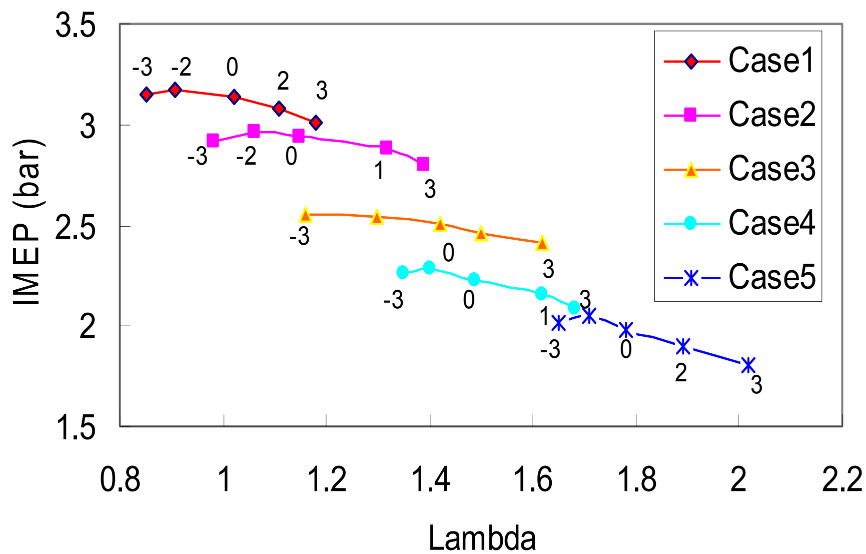


- combustion stability for pure gasoline D0 is poor, particularly at lower loads, this is also due to retarded combustion phasing
- D20 offers a very respectable and acceptable COV below 5% over practically its whole range of IMEP

mparison of load boundary



D0 fuel (gasoline)

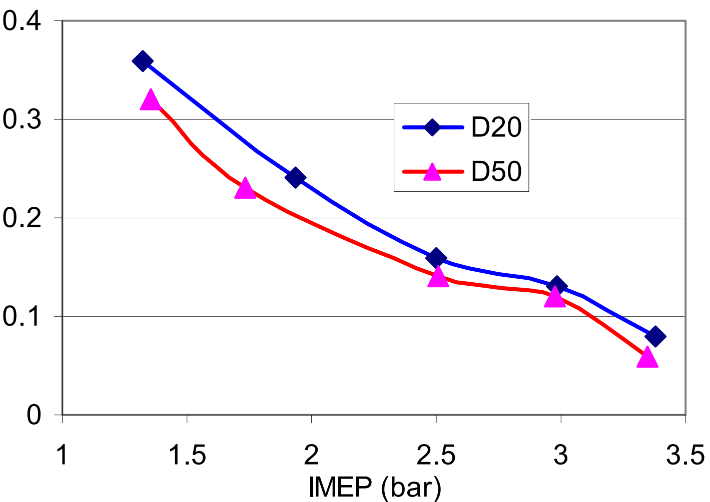


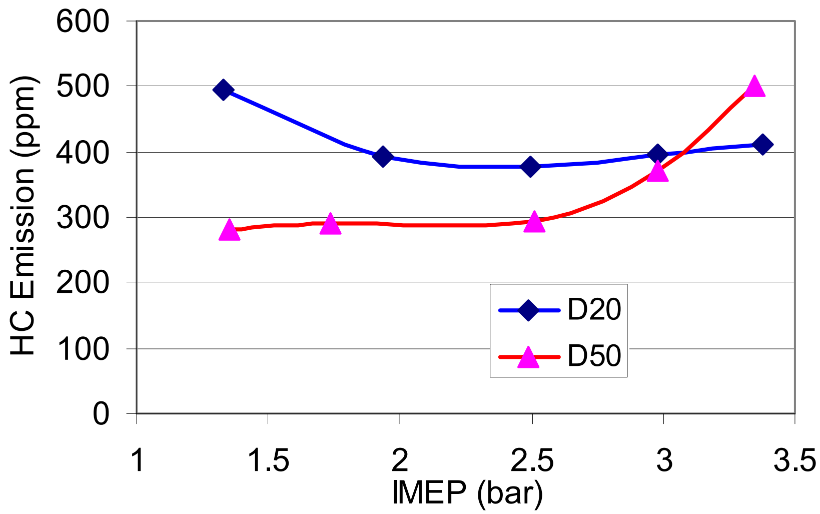
D20 fuel

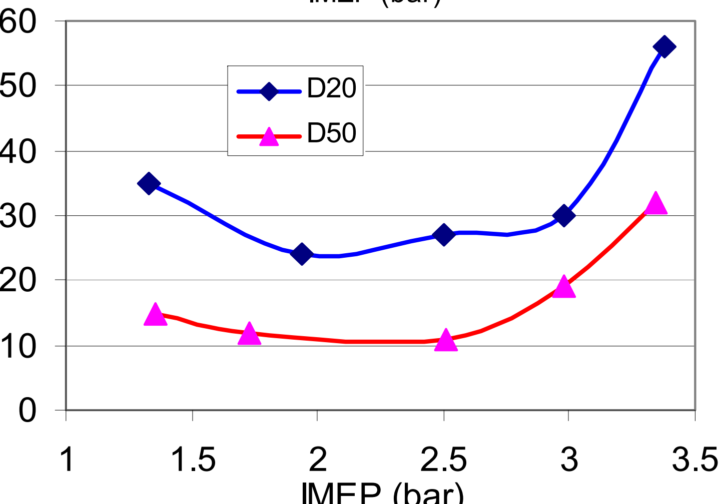
- with D20 fuel, a substantial increase in the upper limit of engine load and a wide ean limit of lambda was achieved compared with D0 fuel.

- diesel fuel addition at the same Case of NVO also enables richer mixtures and higher loads with sustainable combustion

mparison of emissions

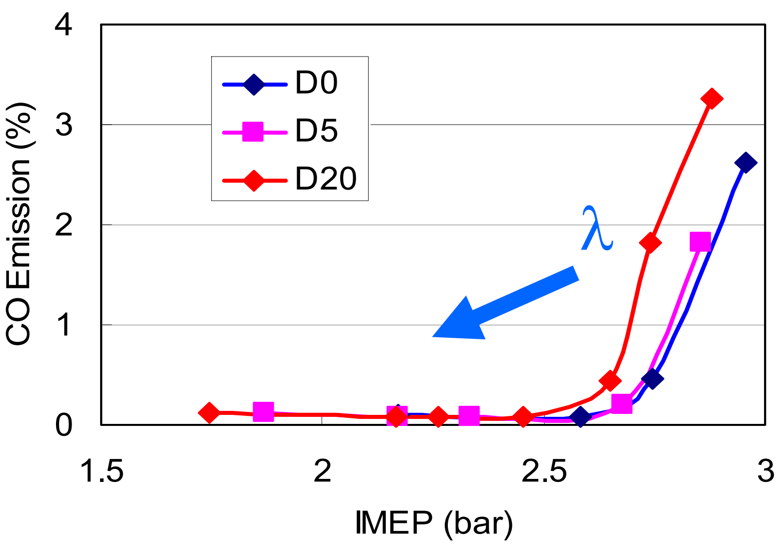


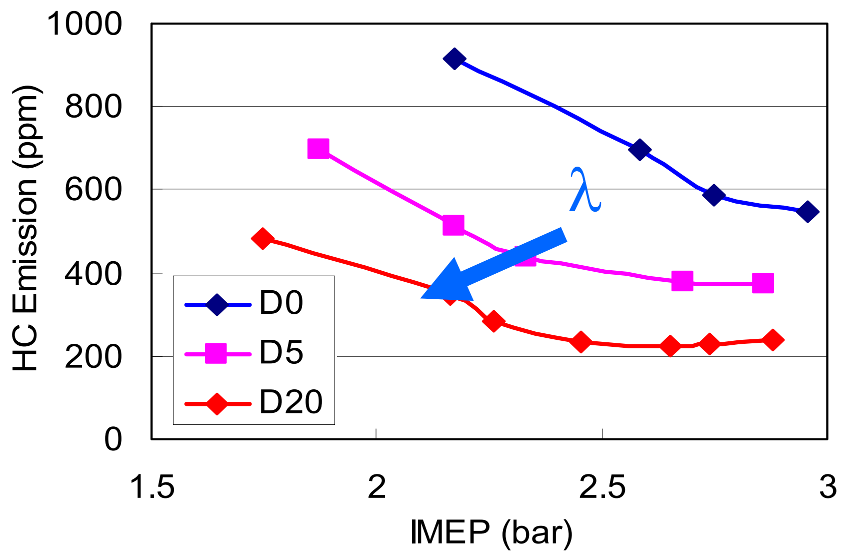


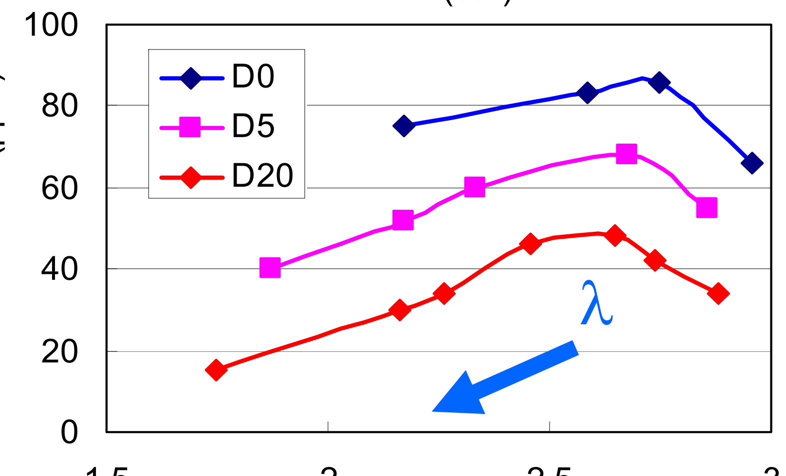


1500 rpm, intake temperature 380 K, intake pressure = 0.1 MPa (abs), CR = 15.0, standard camshaft with positive valve overlap

mparison of emissions with varied λ and load

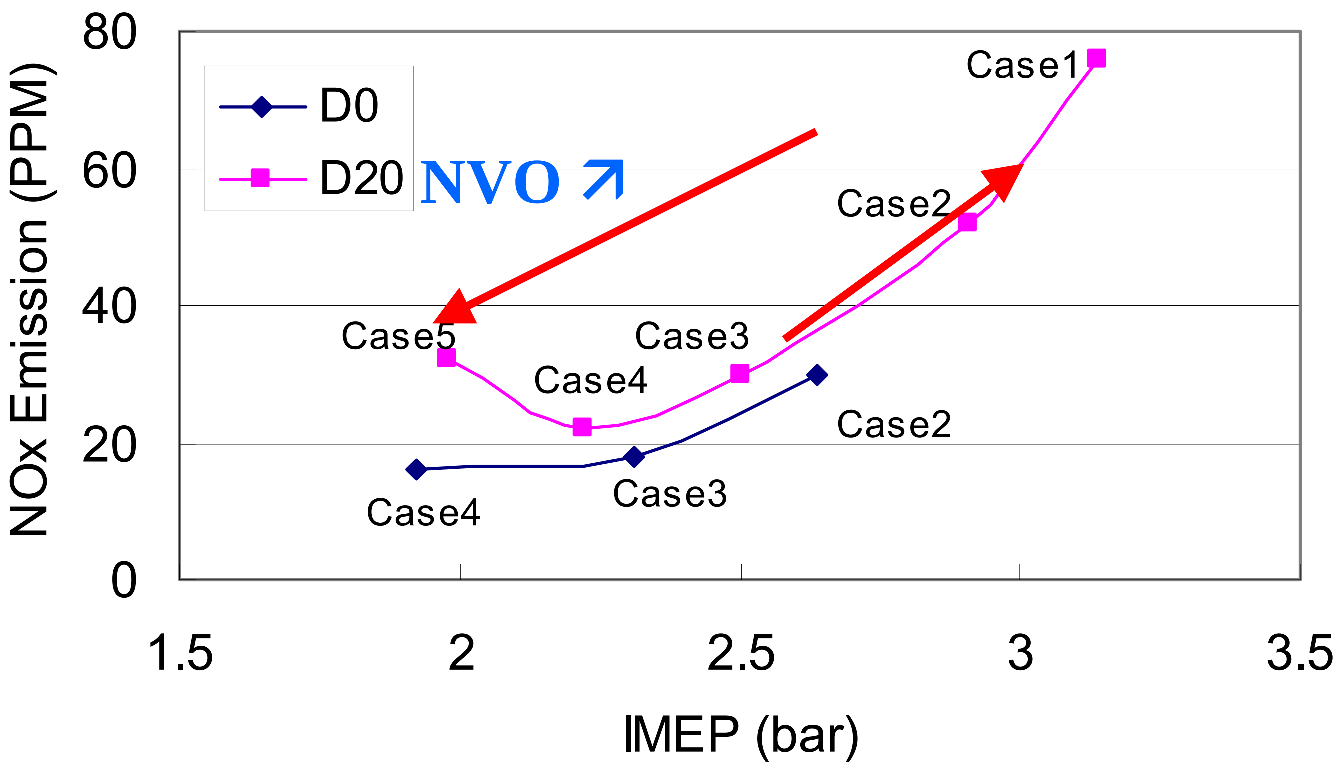






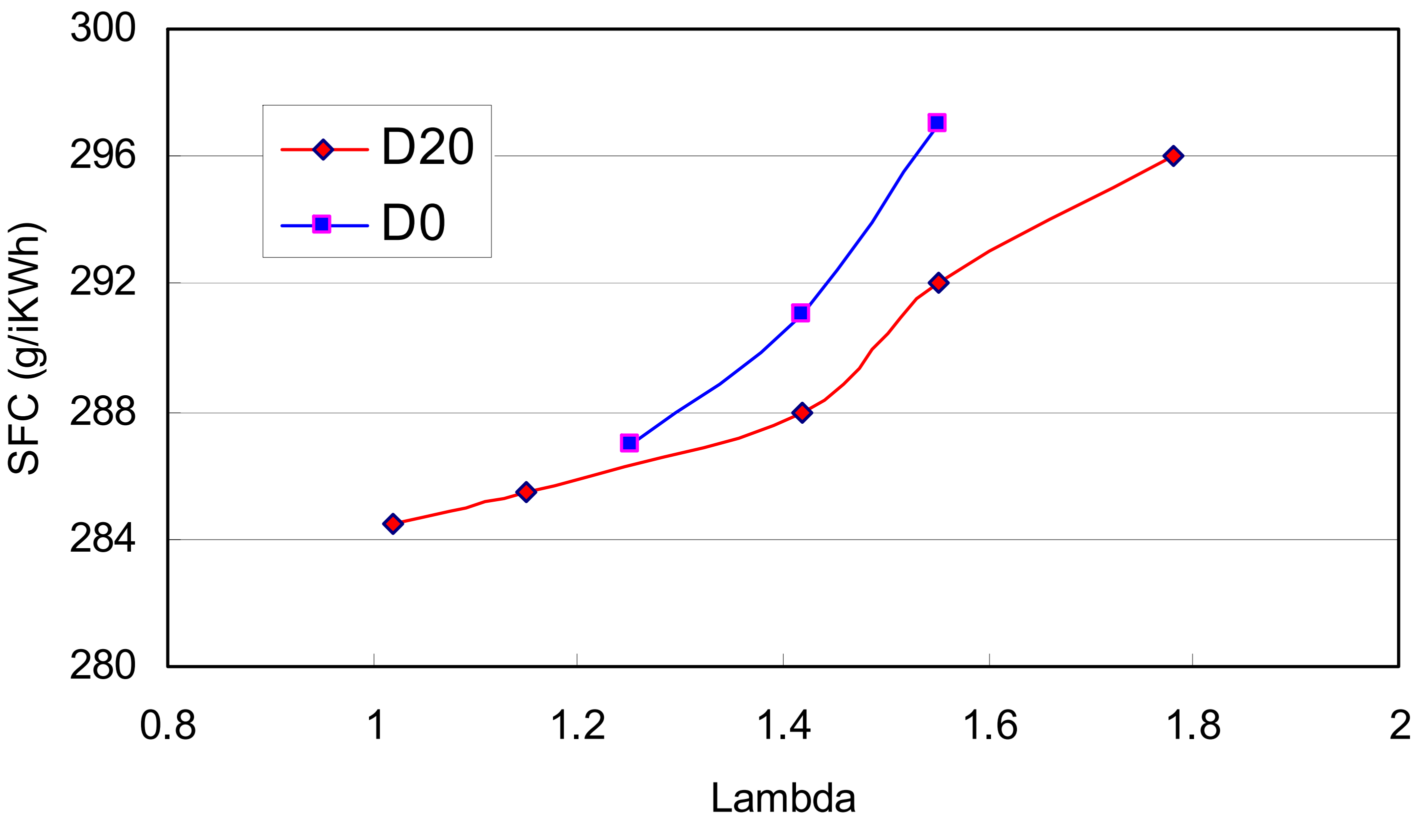
1500 rpm, unheated intake, low lift cams, NVO = -170 deg, varied λ

Ox variation when 5% burn kept at TDC



Case 5 has large NVO, more residual gases in cylinder, higher in-cylinder temperature during the next consecutive cycle. Over-advanced combustion phasing may also be partially responsible for higher NOx

mparison of fuel consumption



1500 rpm, 5% burn at TDC, stable combustion

mmary and conclusions

he blended fuel namely 'dieseline' makes compromised and optimal r to the desired ignition quality, which reduces the dependence of CI on EGR trapping or intake heating.

r 'dieseline' HCCI, the required intake temperature heating can be ered by at least 10 degrees compared with pure gasoline operation. n diesel addition, appropriate engine conditions can be achieved for oline HCCI with EGR trapping for a wide range of CR.

e HCCI operating region for the unheated NVO can be significantly ended into lower IMEP values and the audible knocking is restrained to highest values of λ at high load boundary for the highest mixture peratures. The resulting effects make it possible to reduce the NVO rval required for stable combustion.

e possible scale of NVO was extended by up to 40 CAD, the lean limit of bda can almost reach up to 2.0 when engine is operated with a moderate pression ratio (10.4). However this might cause a CO emission penalty at leanest limit due to lower combustion temperature.

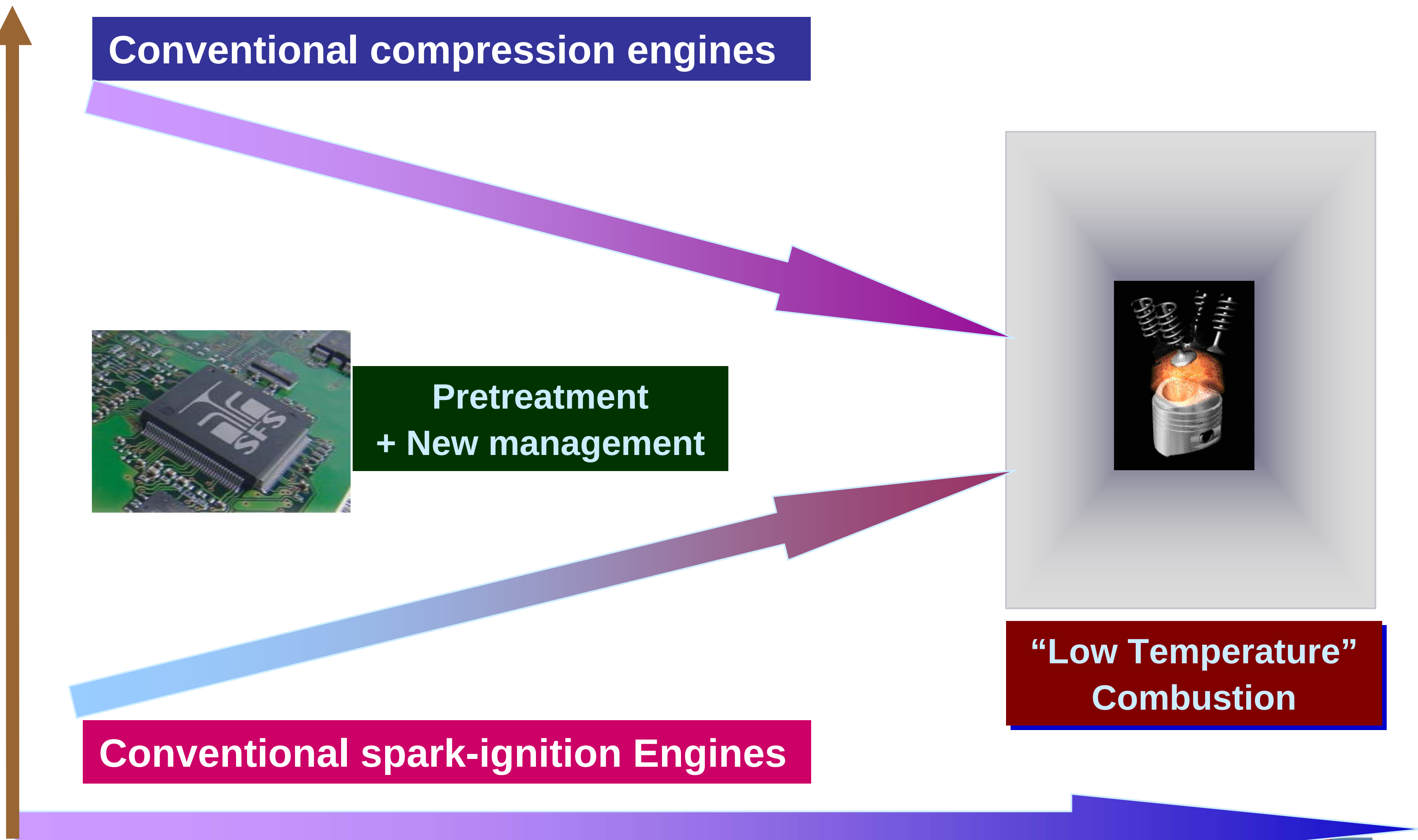
mmary and conclusions

ne indicated specific fuel consumption and CO emissions crease due to decreased pumping losses of recompression and her combustion efficiency.

missions of HC and NOx show an interesting improvement npared with gasoline HCCI with optimized engine operating nditions.

substantial increase in the upper limit of load range will be hieved without intake heating because of higher volumetric ciency resulting from smaller NVO and the presence of less idual gases in cylinder. However this can result in potentially her NOx emissions due to the lower dilution amount present and her combustion temperature.

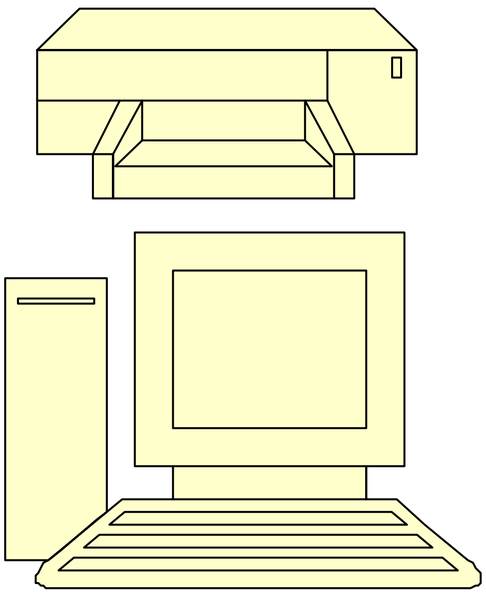
soline and Diesel Engine Technologies are emerging



lti-fuel injection system – the future of new engines?

A computer controlled
our printer can print
ourful pictures using
riginal coloured inks –

f we have 3 different type of
ls, why cant' a CPU controlled
l injection system supply
equired fuel 'colour' (property)
'printing a beautiful picture' – for optimised engine
eration at varied conditions?



Simply, a multi-channel fuel nozzle is required at gas
tions to supply the fuels as for printer cartridges!

cknowledgements

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