Requirements for the Valve Train and Technologies for Enabling HCCI Over the Entire Operating Range

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Overview of Presentation

- Requirements for the valve train system in diesel HCCI engines
- Applications of various VVT systems
- Strategies for enabling HCCI operation over entire engine operating range and reducing CO and HC emissions at low loads
- Pneumatic hybridisation (air-hybrid)
- Advanced turbocharging
- Observations & Conclusions
Diesel HCCI Engines/Requirements for the Valve Train

Challenges:

• Enlarging HCCI operational area towards higher loads, i.e. reducing a high rate of heat release
• Reducing excessive CO and HC emission at low loads
• Obtaining smooth transition in ‘hybrid’ CI-HCCI engines
• Keeping existing engine geometry unchanged

Approach:

• Using a VVT with a high degree of flexibility
• Managing the coolant temperature
VVT Systems/Mechanical Variable Valve Train

Available low cost VVT options with a very good cost / benefit ratio:

- Two-positional cam profile switching mechanisms and phaser
- Opposed rocker

Opposed Rocker (2001)
VVT Systems/Fully Variable Valve Train

- Fully variable valve train-Lotus AVT™:
  - Electro-hydraulic valve system with full flexible control over valve timing, lift and velocity
  - Capability to run different valve profiles (polynomial, trapezoidal or triangular) and to open/close valves more than ones per engine cycles.
VVT Systems/Production AVT

Packaging

AVT Operation

Switching Valve (SV)

Actuator Valve (AV)

Actuator with Integral Displacement Transducer

Conventional Poppet Valve and Spring

Pressure

Return

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Change the rules

20/09/2005
Production AVT/HDD engine with AVT on Test Bed
VVT systems/Research AVT

Double acting actuator

High cost servo-valve

Accumulator

Attenuator

Pump

NRV

PT

Dump Valve

Reservoir
Research AVT/Main Components

Hydraulic Manifold and Actuator Cylinder

Displacement Transducer

Engine Valve

Actuator Piston Assembly

EHHSV

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Change the rules
Research AVT/Actuator Ooperation
Research AVT/Packaging&assembly

Diesel

Gasoline

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Change the rules
Range Extension & Low Load Emissions Reduction

To enlarge usable HCCI area towards higher loads

To reduce high HC and CO emissions at low loads

Approaches:
- Lotus AVT
- Managing the coolant temperature

*SPACE LIGHT PROJECTS EU FINANCED THAT INCLUDED: IFP, RENAULT, OPEL, CRT, POL. DI MILANO, BRUNEL UNIV. AND LOTUS ENGINEERING
Range Extension/High Loads

- Lotus AVT (results supplied by IFP and Renault)
  - *Changing effective compression ratio-ECR by EIVC or LIVC*
  - *Improving internal dynamic control (asymmetric valve profiles)*
  - *Advanced 2-stage turbocharging*

- Tcoolant reduction
  - *from 95 °C to 65 °C*
Emissions Reduction/Low Loads

- Lotus AVT (results supplied by IFP and Renault)
  
  Various valve strategies used:
  - Recompression (EEVC&LIVO)
  - Re-breathing, i.e. Double exhaust opening

  Emissions reduct
  - CO by ~ 40%
  - HC by ~ 50%
Pneumatic Hybridisation/Air-Hybrid

Targets:

• Reducing engine braking losses by recovering braking energy
• Store that energy and later transform into positive work, e.g. use it to drive engine from the standstill

Approach:

• A pneumatic hybrid which pumps air to a receiver during vehicle
• braking and uses the engine as an air motor to launch the vehicle
Pneumatic Hybridisation /Experimental Set-up

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Pneumatic Hybridisation/Results

- A two-litre 4-cylinder engine charges a 30 litre reservoir to 22 bar in 12 secs with the engine driven at 5000 rev/min (85% achieved in 6 secs)
- Available motor torque drops rapidly - from 35 to 0 Nm in 8 secs (two-stroke @ 1000 rev/min)
Advanced turbocharging/2-Stage Series System

Valve Timing Provides System Control (Wastegate) Function

All gases pass through 2nd Turbine: No Wastegate
Advanced Turbocharging/Divided Exhaust Period

Benefits:
- back pressure reduced
- cold start catalyst light-off time reduced
- full load performance enhancement
- pumping losses reduced
- pulse interaction avoided
- fully optimised angle area

Also tested by Elmqvist et al. SAE 2005-01-1150
Advanced Optical Engine/DI&AVT

Used for in-cylinder flow visualisation in HSDI architecture (unfired)
Observations & Conclusions

• AVT System has potentials to increase usable HCCI operation area and reduce emissions at low loads on diesel engines without deteriorating HCCI benefits
• AVT System can be used for pneumatic hybridisation, i.e. to recover braking losses and transform them into a positive work
• AVT System can be applied for advanced turbocharging systems significantly improving cold-start, low and full load regimes
• Using AVT System together with an Optical access engine provides potentials for improving mixing and combustion processes, hence reducing fuel consumption and emissions
Thank You for Listening