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:

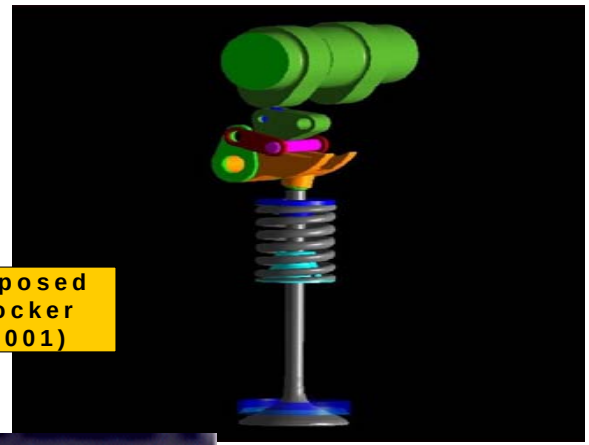
- Using a VVT with a high degree of flexibility
- Managing the coolant temperature

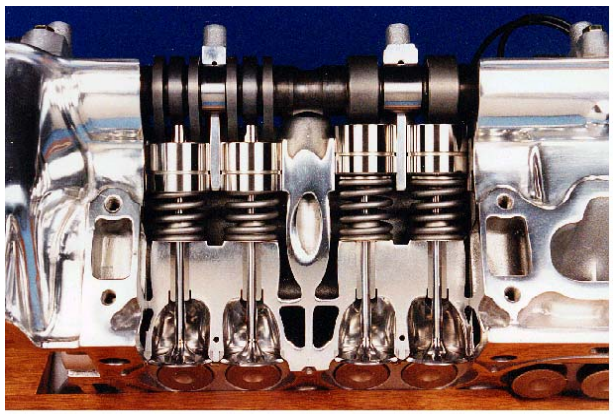
VVT Systems/Mechanical Variable Valve Train

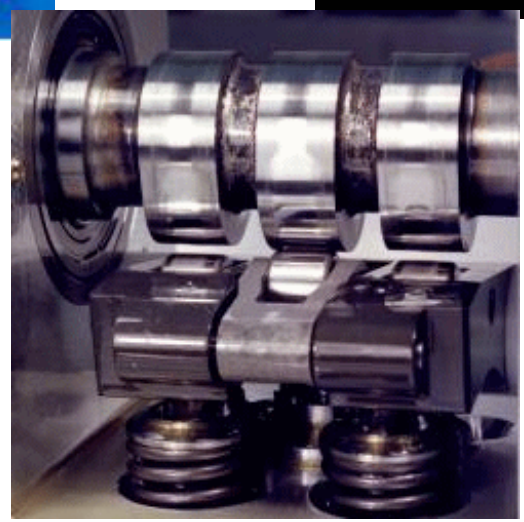
Available low cost VVT options with a very good cost / benefit ratio:

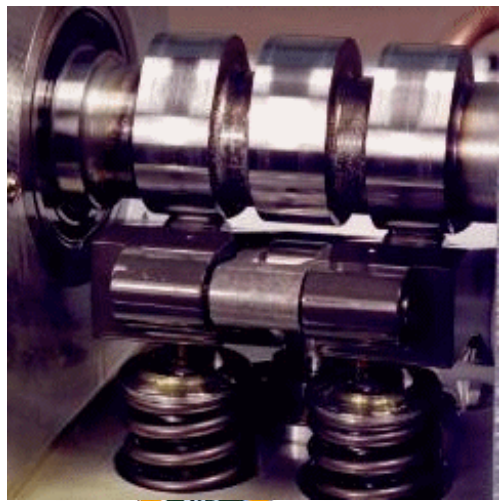
- *Two-positional cam profile switching mechanisms and phaser*

- *Opposed rocker*



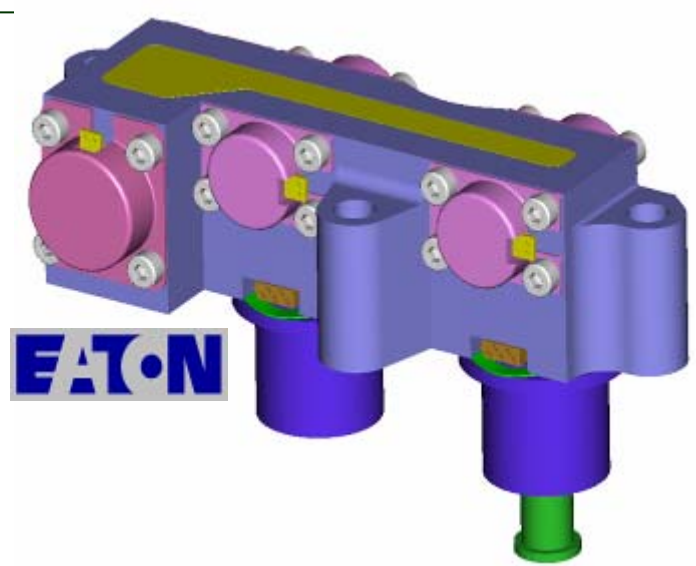


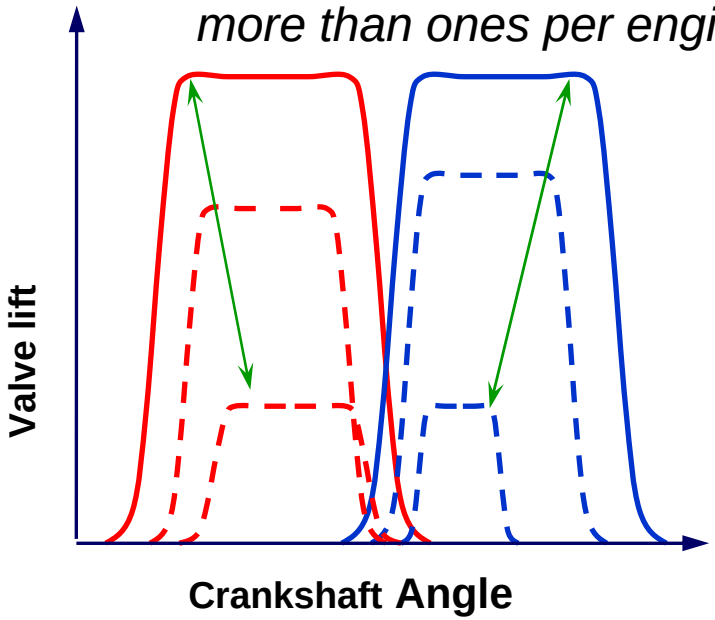




VVT Systems/Fully Variable Valve Train

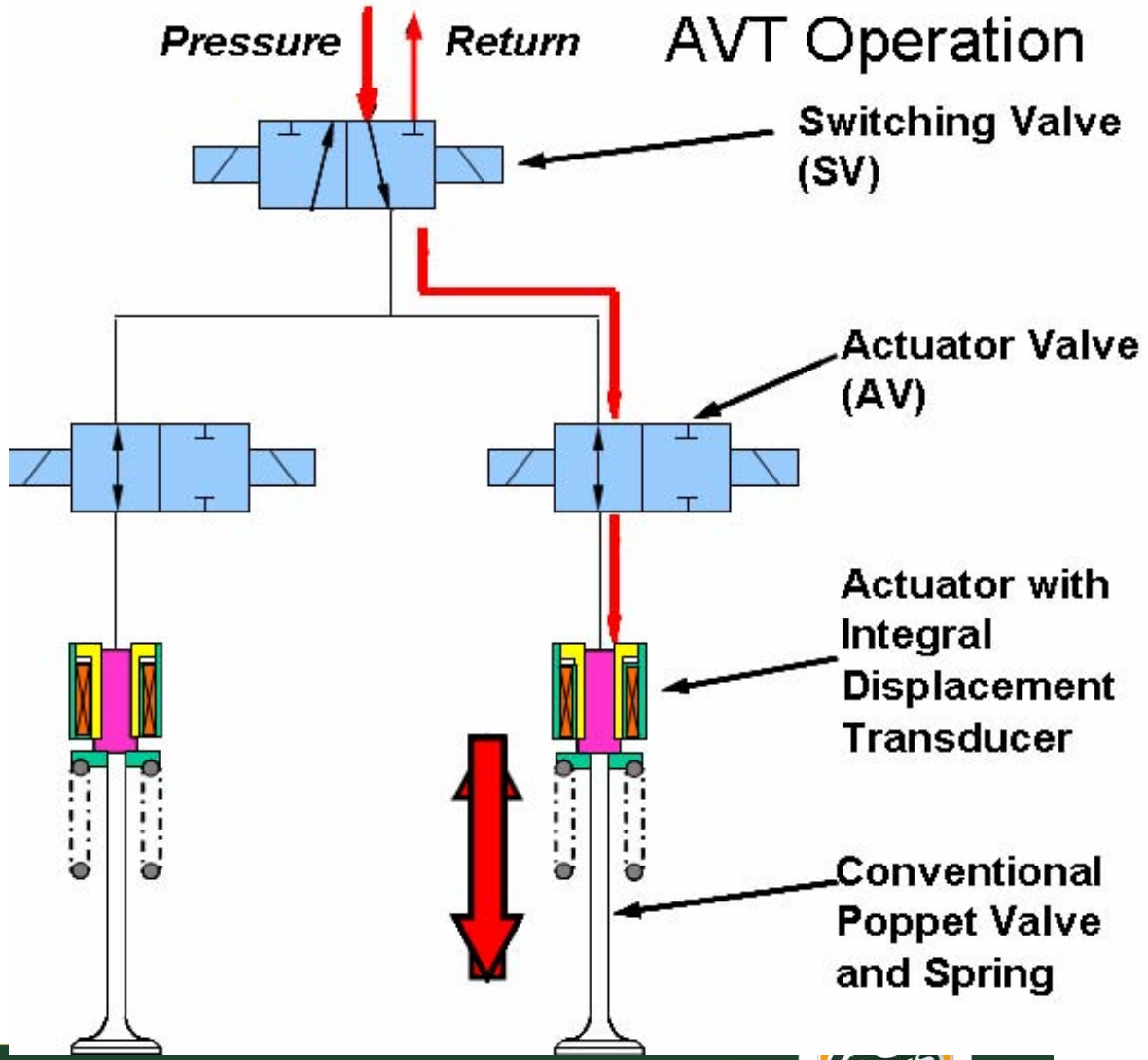
- Fully variable valve train-Lotus AVT™:
  - *Electro-hydraulic valve system with full flexible control over valve timing, lift and velocity*
  - *Capability to run different valve profiles (polynomial, trapezoidal or triangular) and to open/close valves more than ones per engine cycles.*



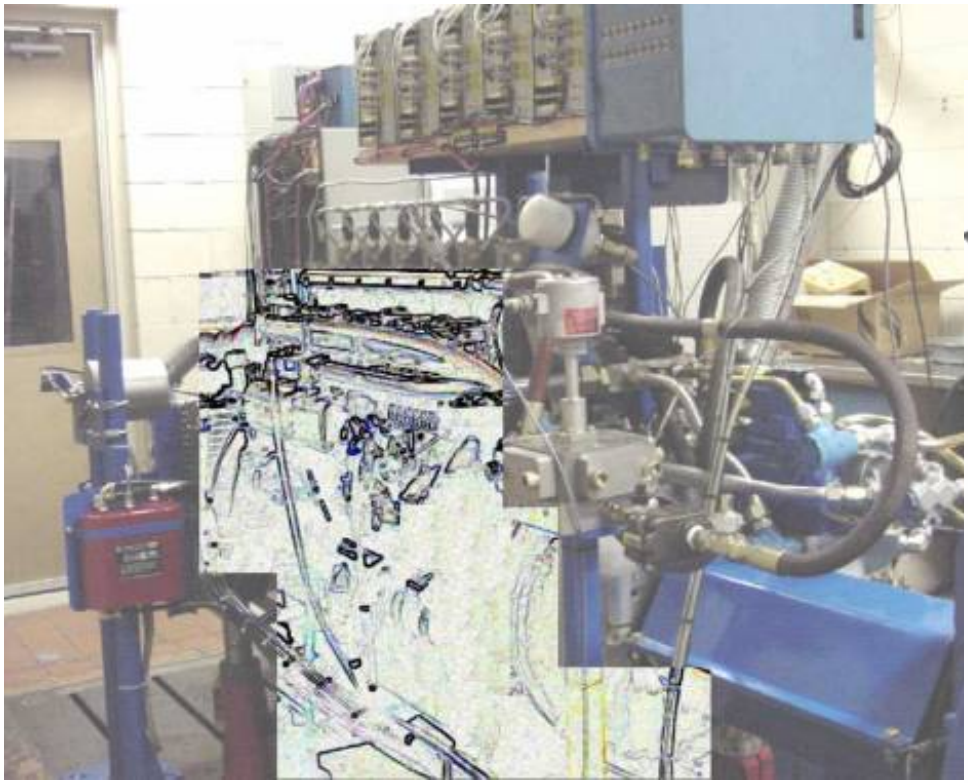


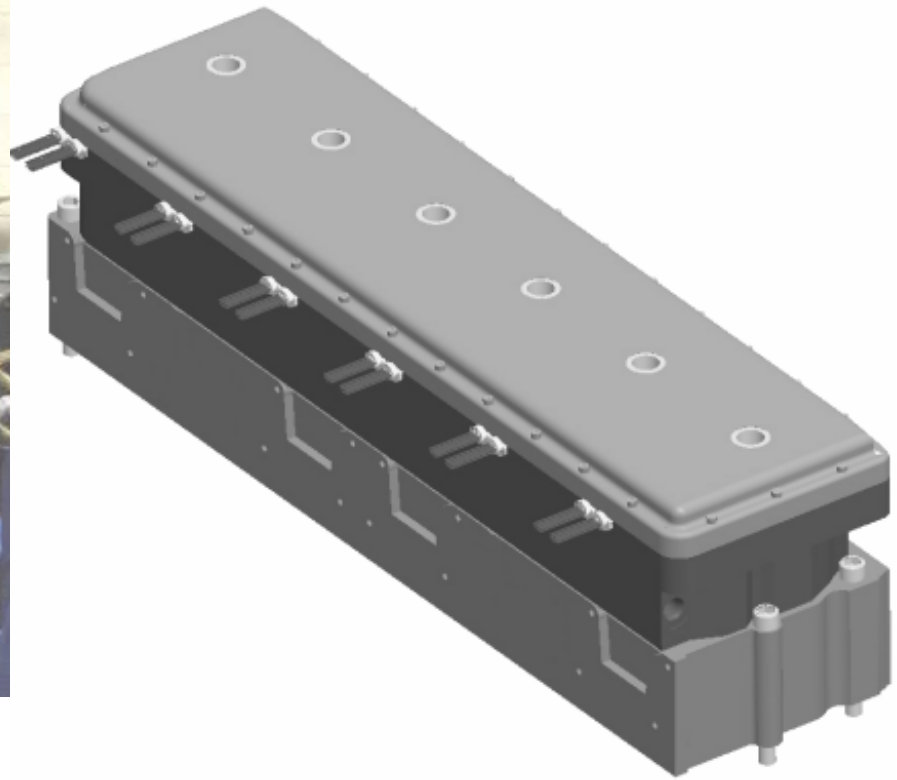
VVT Systems/Production AVT

Packaging

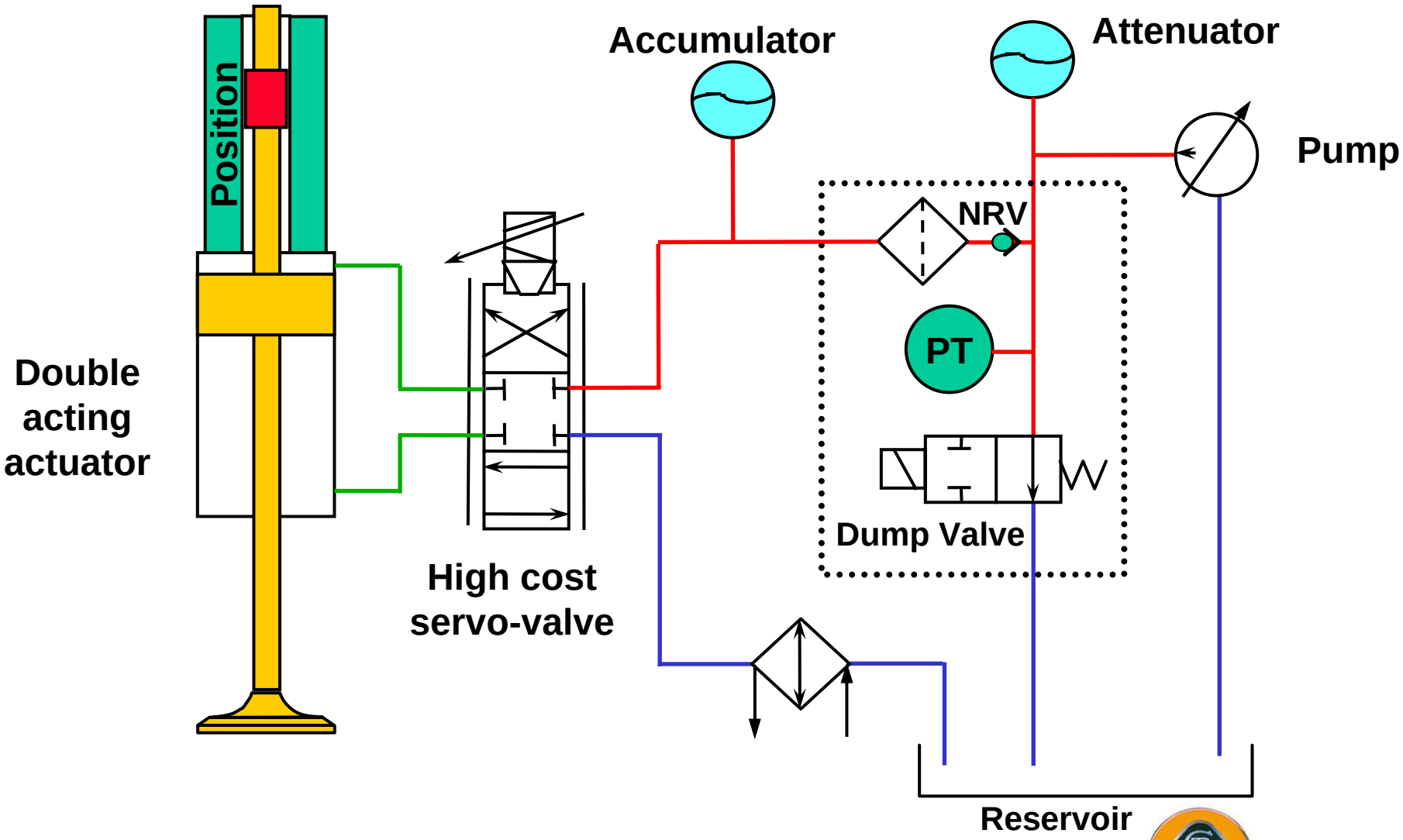


Production AVT/HDD engine with AVT on Test Bed

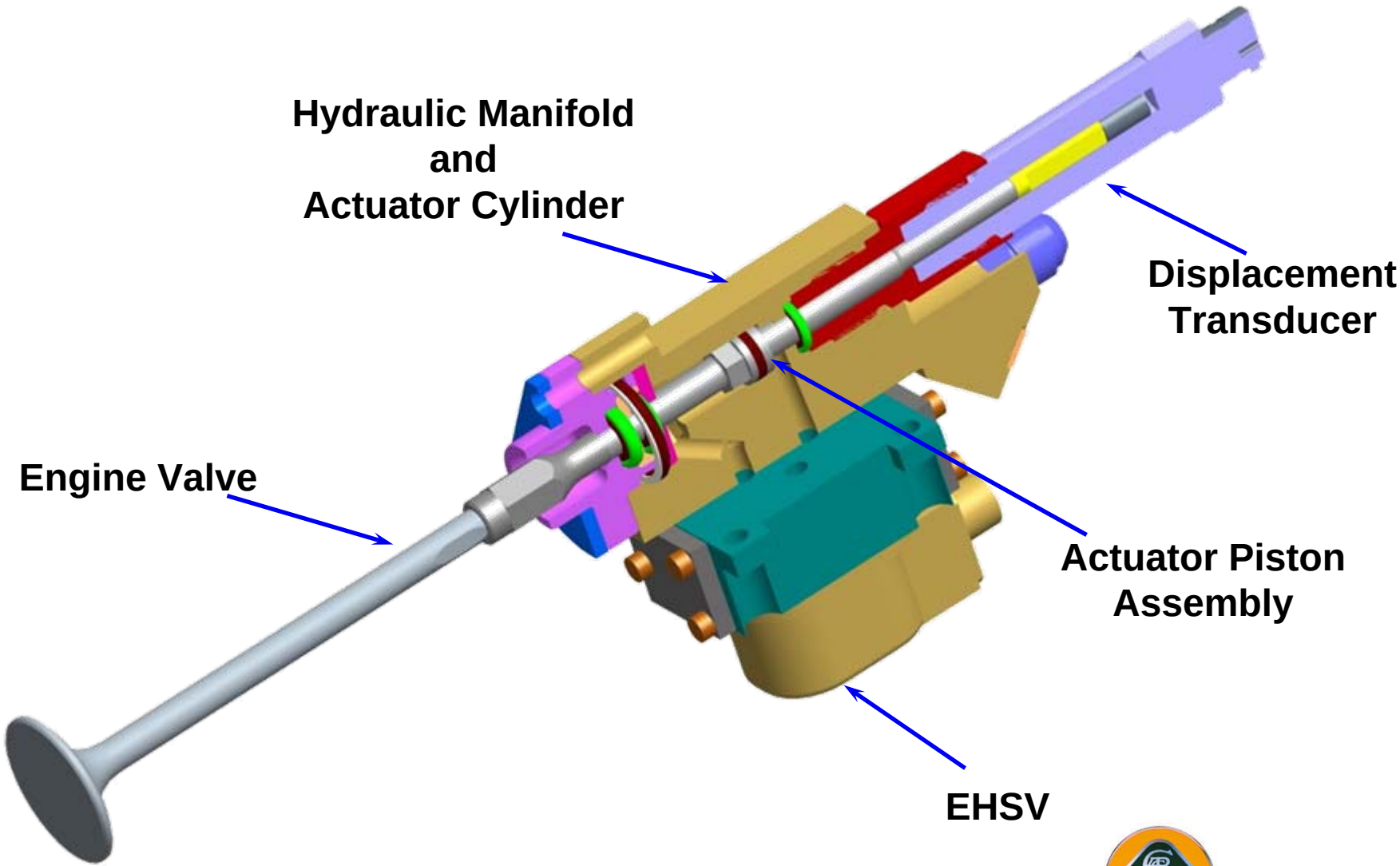




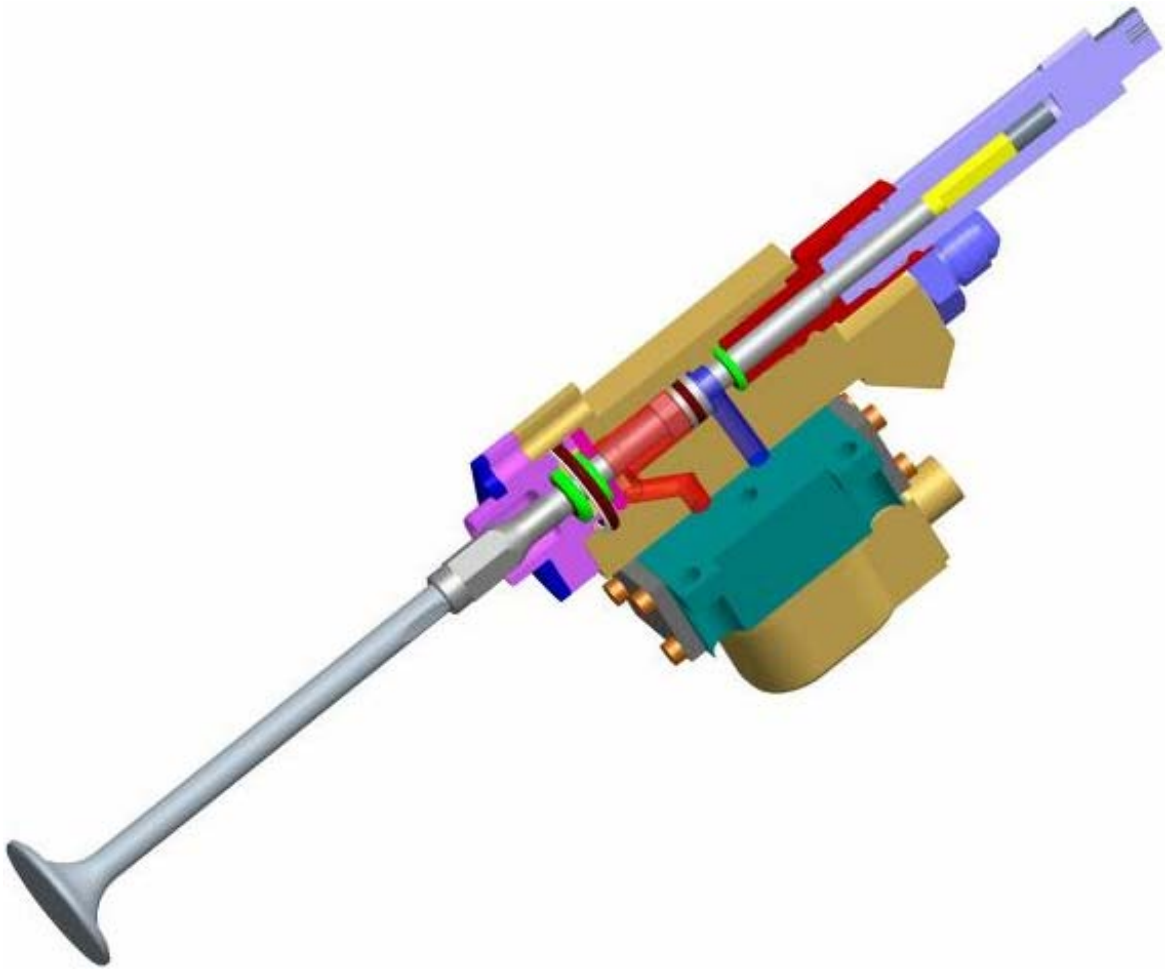
VVT systems/Research AVT



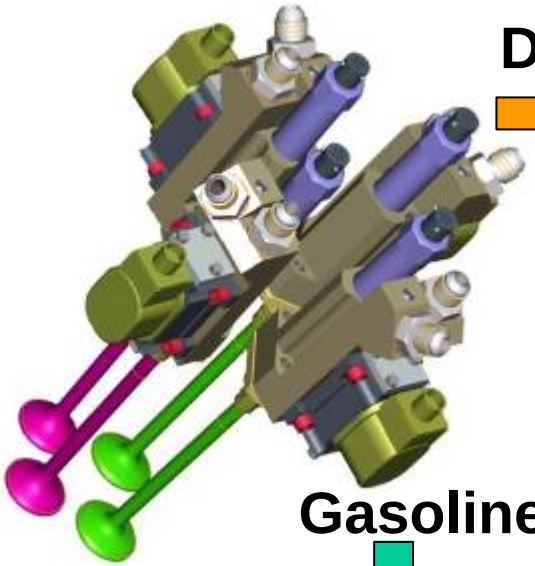
Research AVT/Main Components



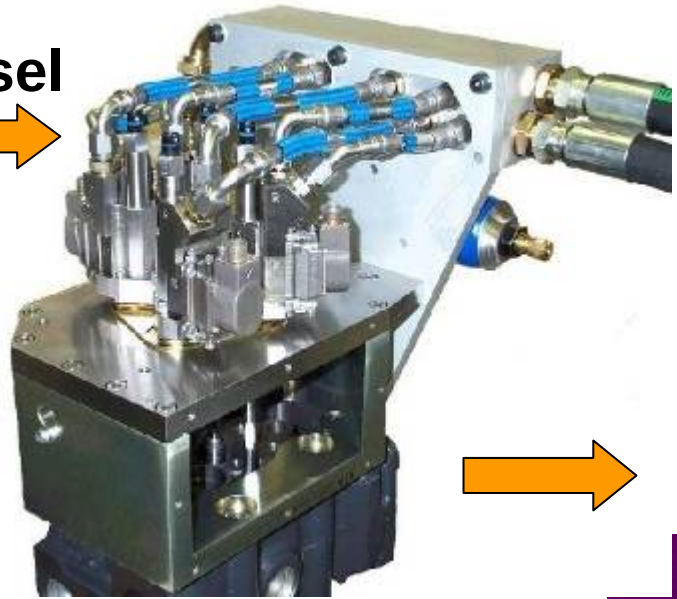
Research AVT/Actuator Oooperation

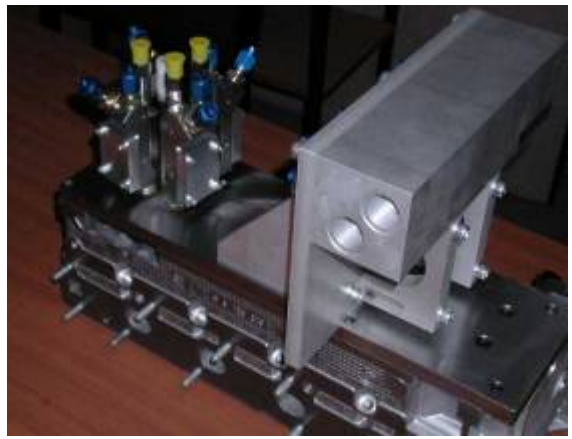


Research AVT/Packaging&assembly

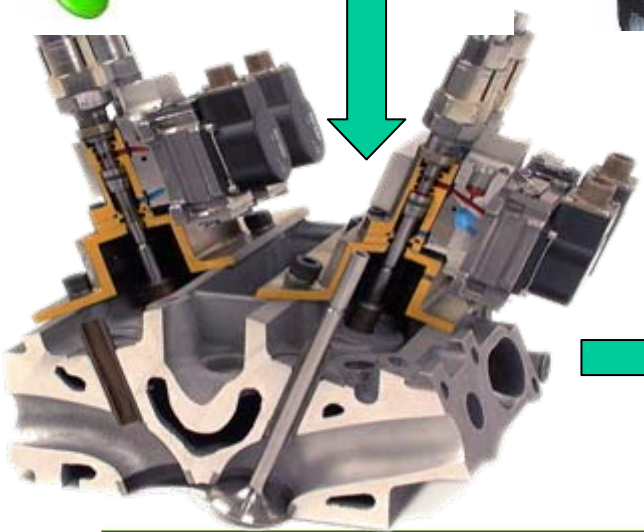


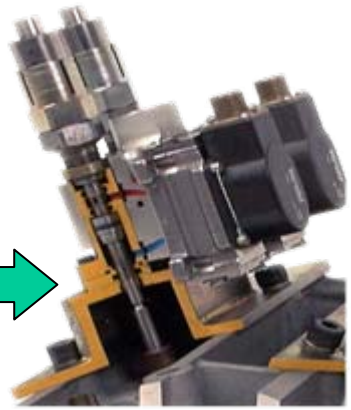
Diesel

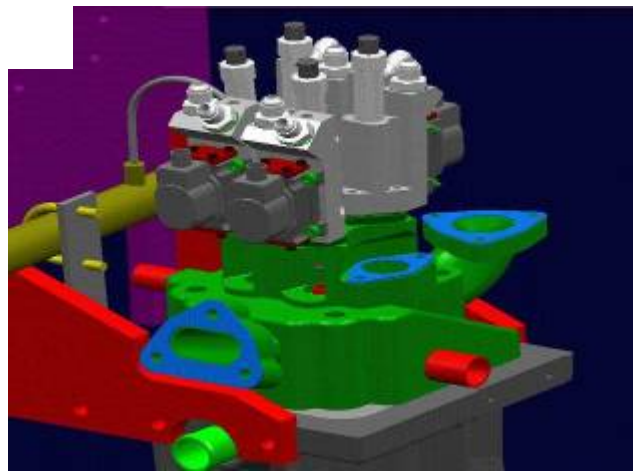




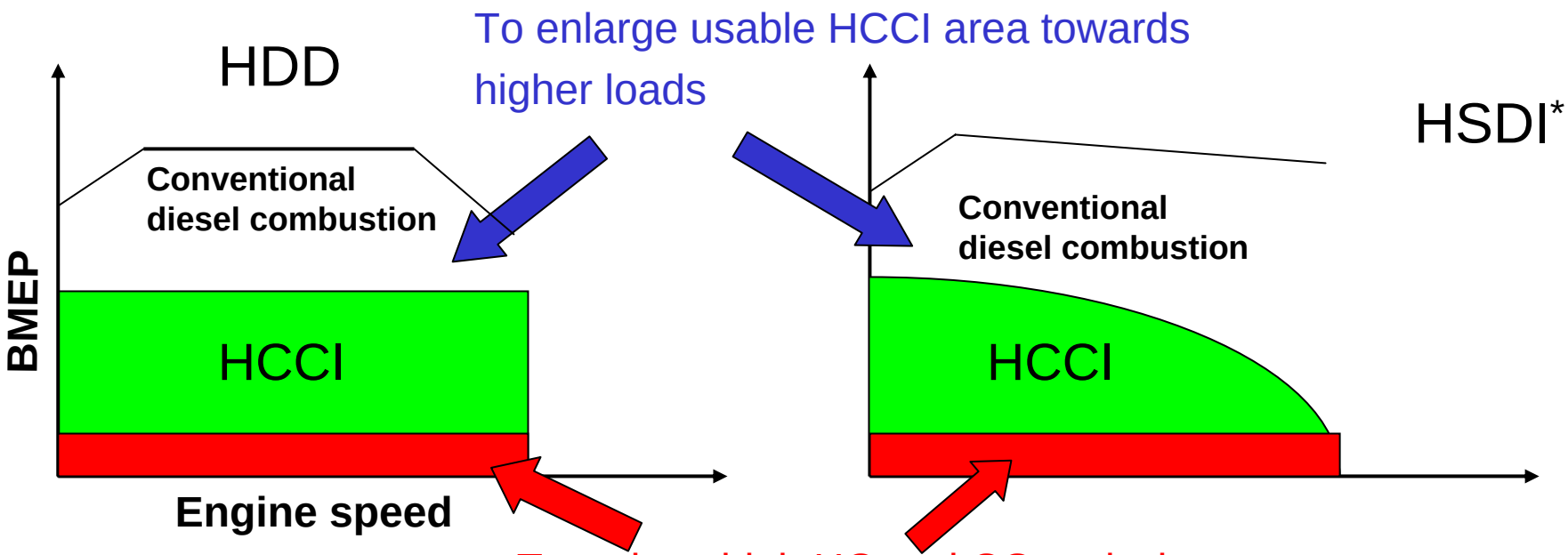
Gasoline







Range Extension & Low Load Emissions Reduction

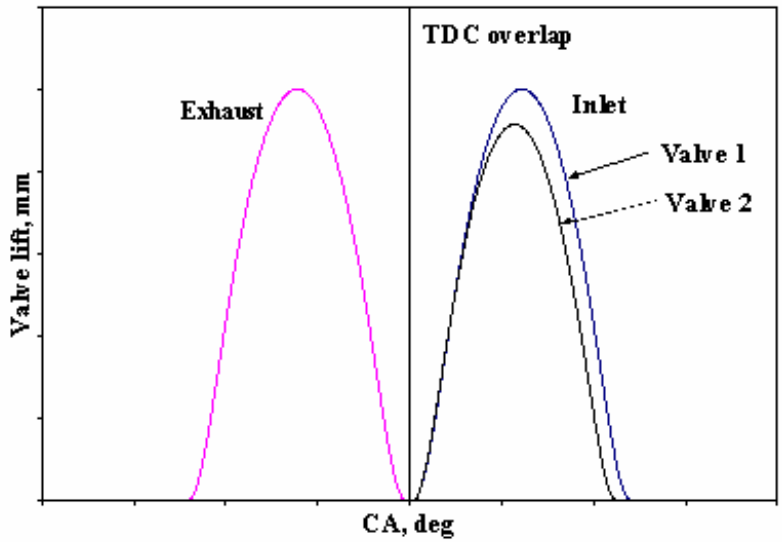


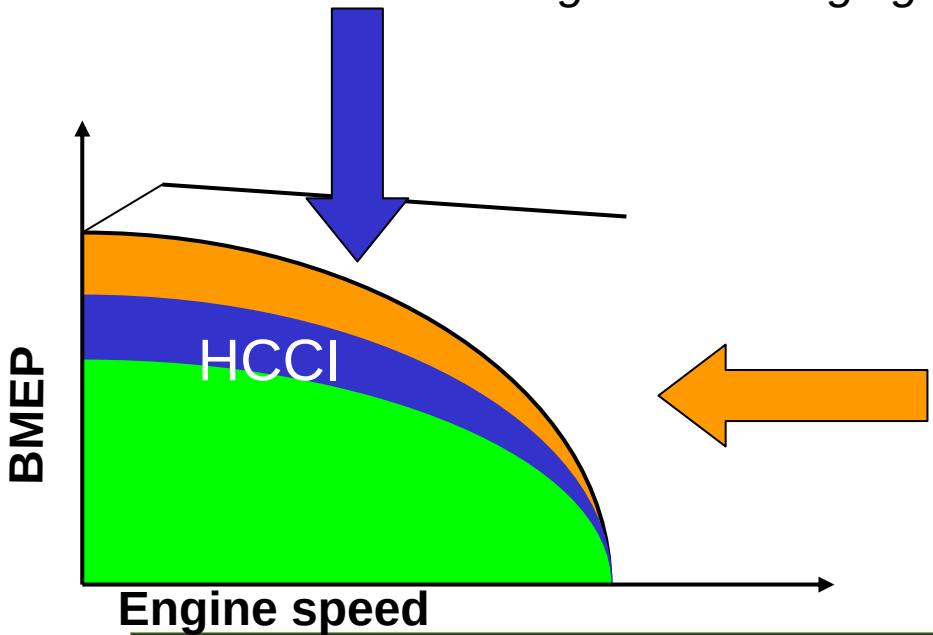
Approaches:
-Lotus AVT
-Managing the coolant temperature

*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*





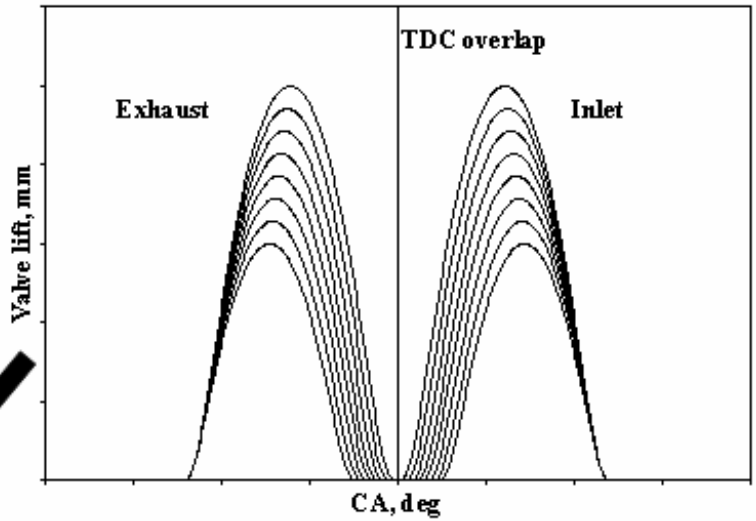
- **Tcoolant reduction**
  - *from 95 ^{o}C to 65 ^{o}C*

Emissions Reduction/Low Loads

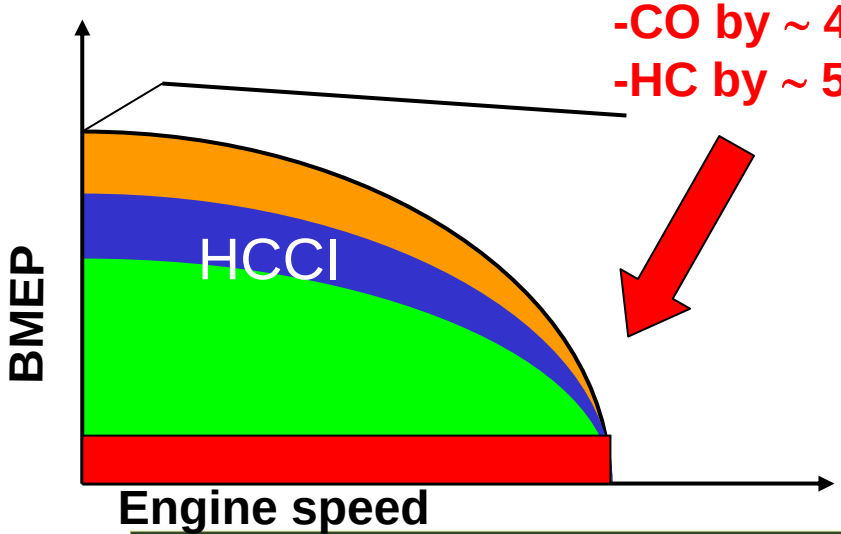
- **Lotus AVT (results supplied by IFP and Renault)**

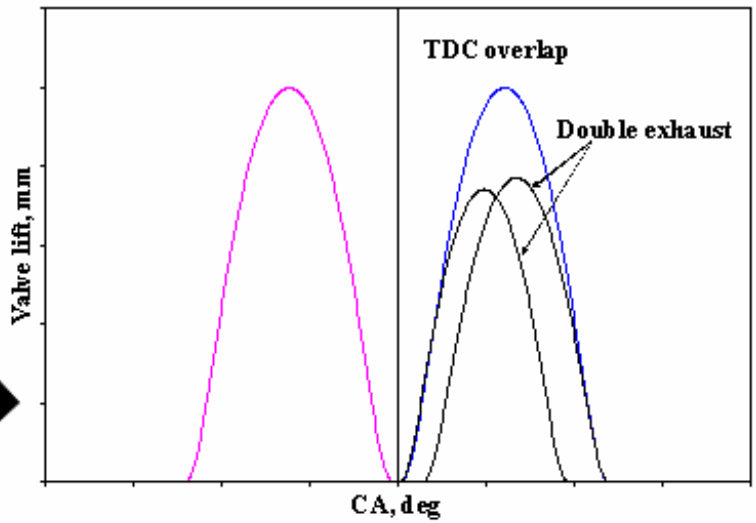
  Various valve strategies used:

  - Recompression (EEVC&LIVO)
  - Re-breathing, i.e. Double exhau opening



Emissions reduct
-CO by ~ 40%
-HC by ~ 50 %





Pneumatic Hybridisation/Air-Hybrid

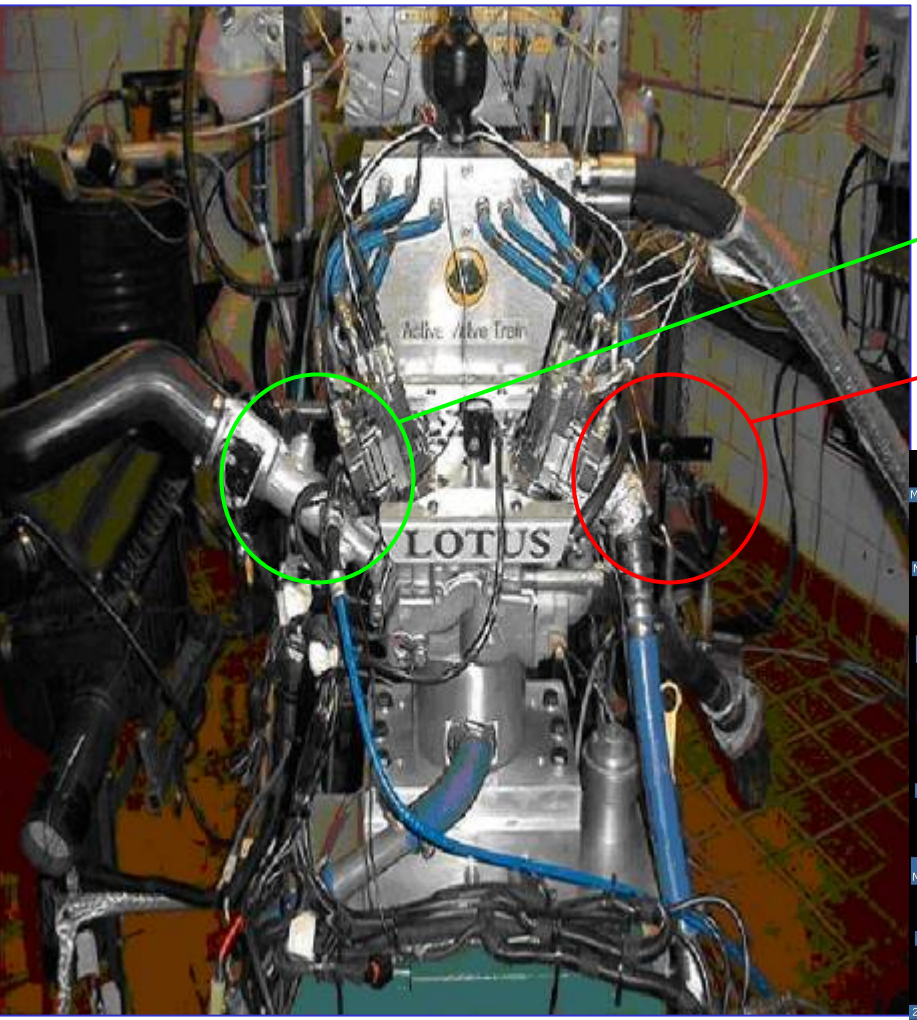
Targets:

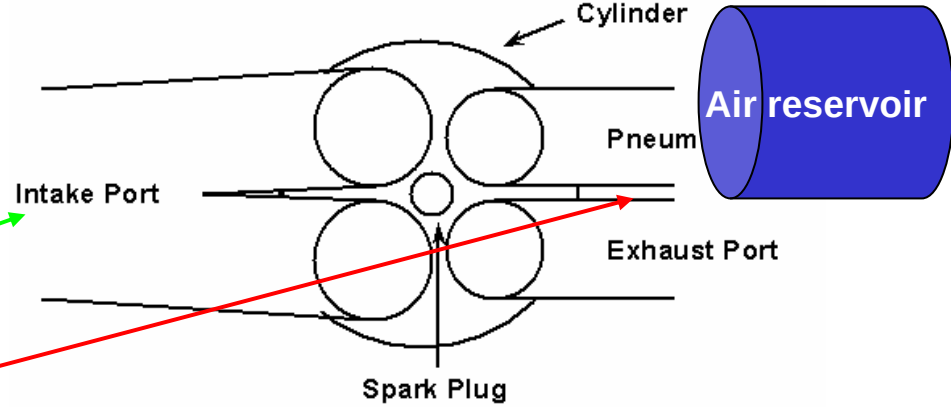
- Reducing engine braking losses by recovering braking energy
- Store that energy and later transform into positive work, e.g. use it to drive engine from the standstill

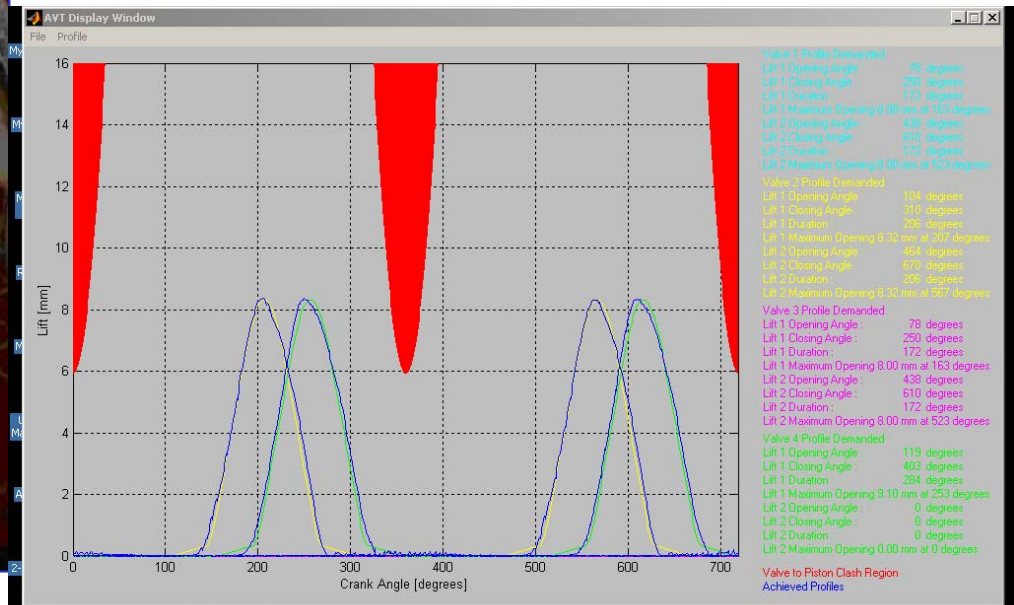
Approach:

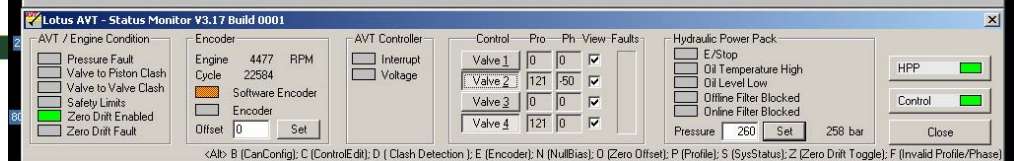
- A *pneumatic* hybrid which pumps air to a receiver during vehicle
- braking and uses the engine as an air motor to launch the vehicle

Pneumatic Hybridisation /Experimental Set-up





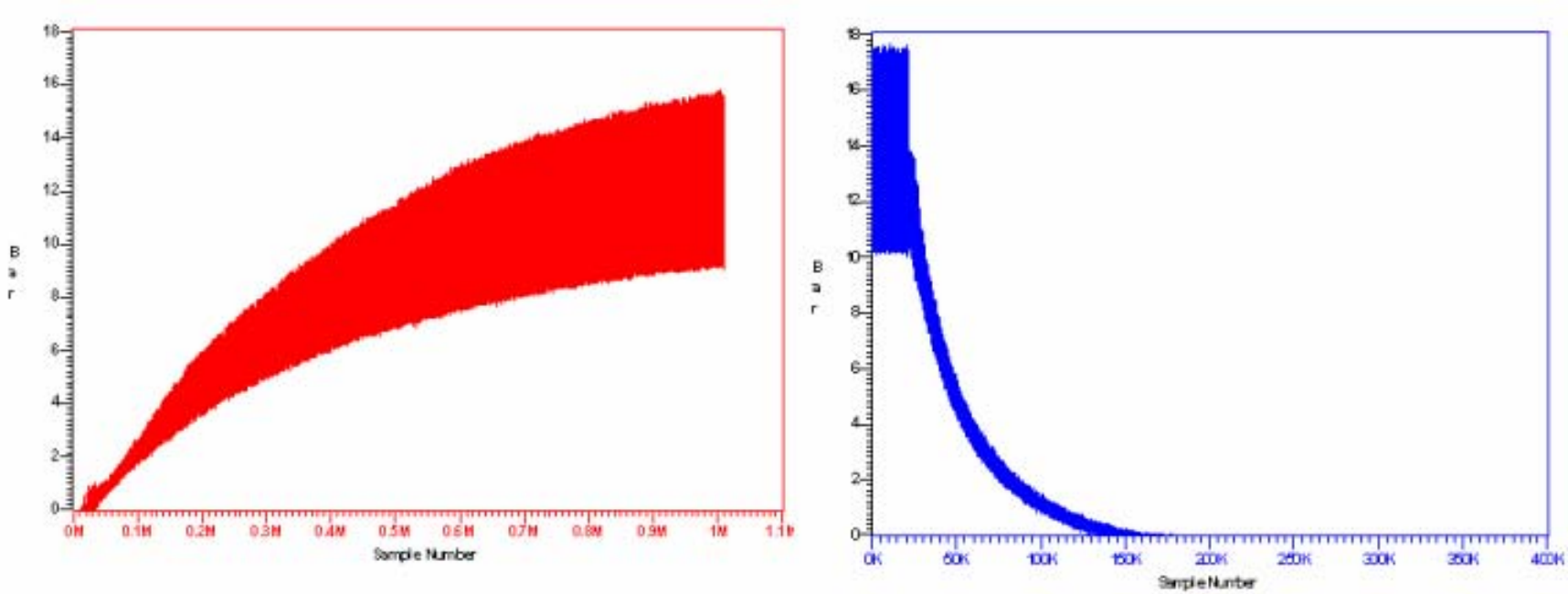




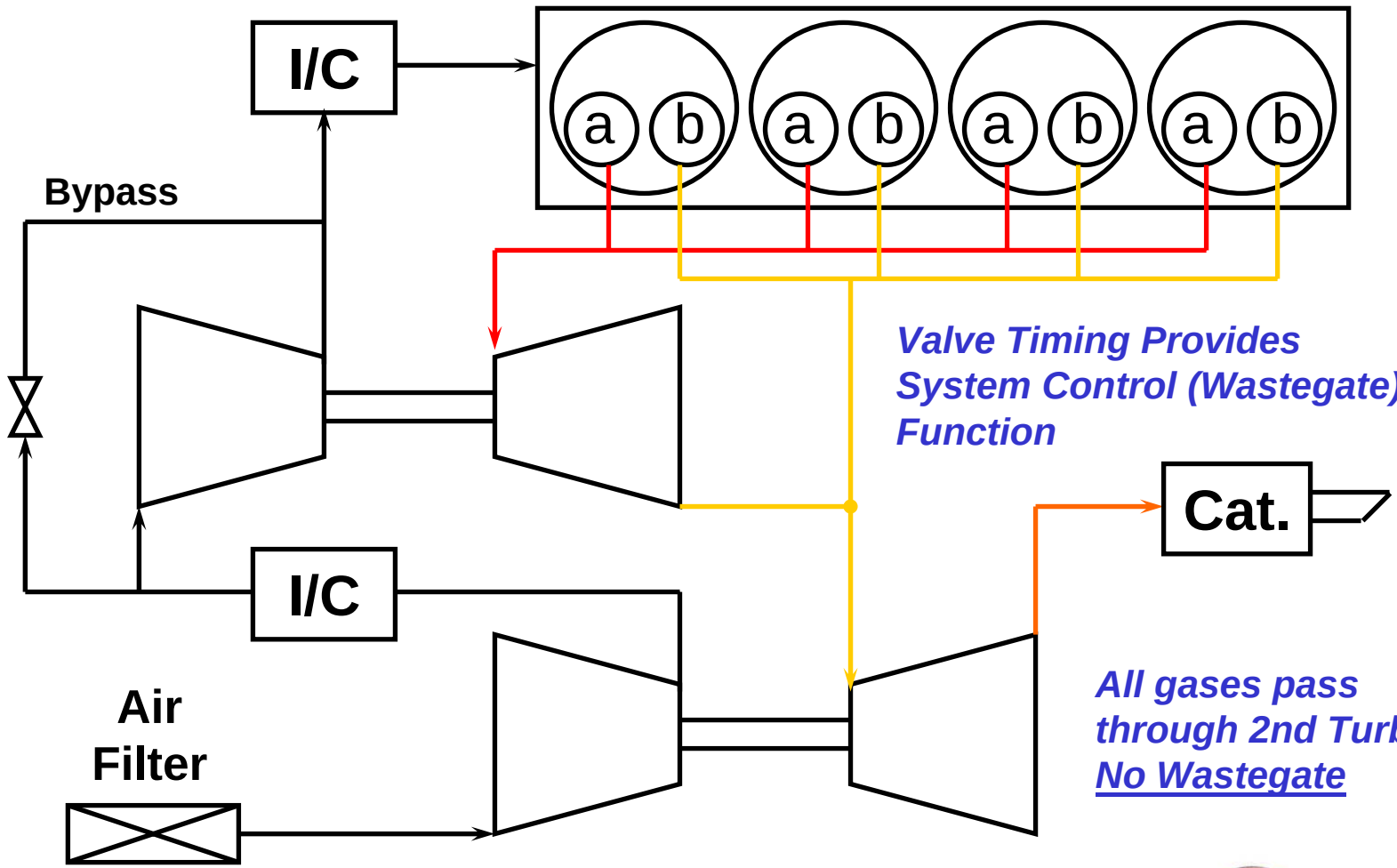
Lotus Engineering

Pneumatic Hybridisation/Results

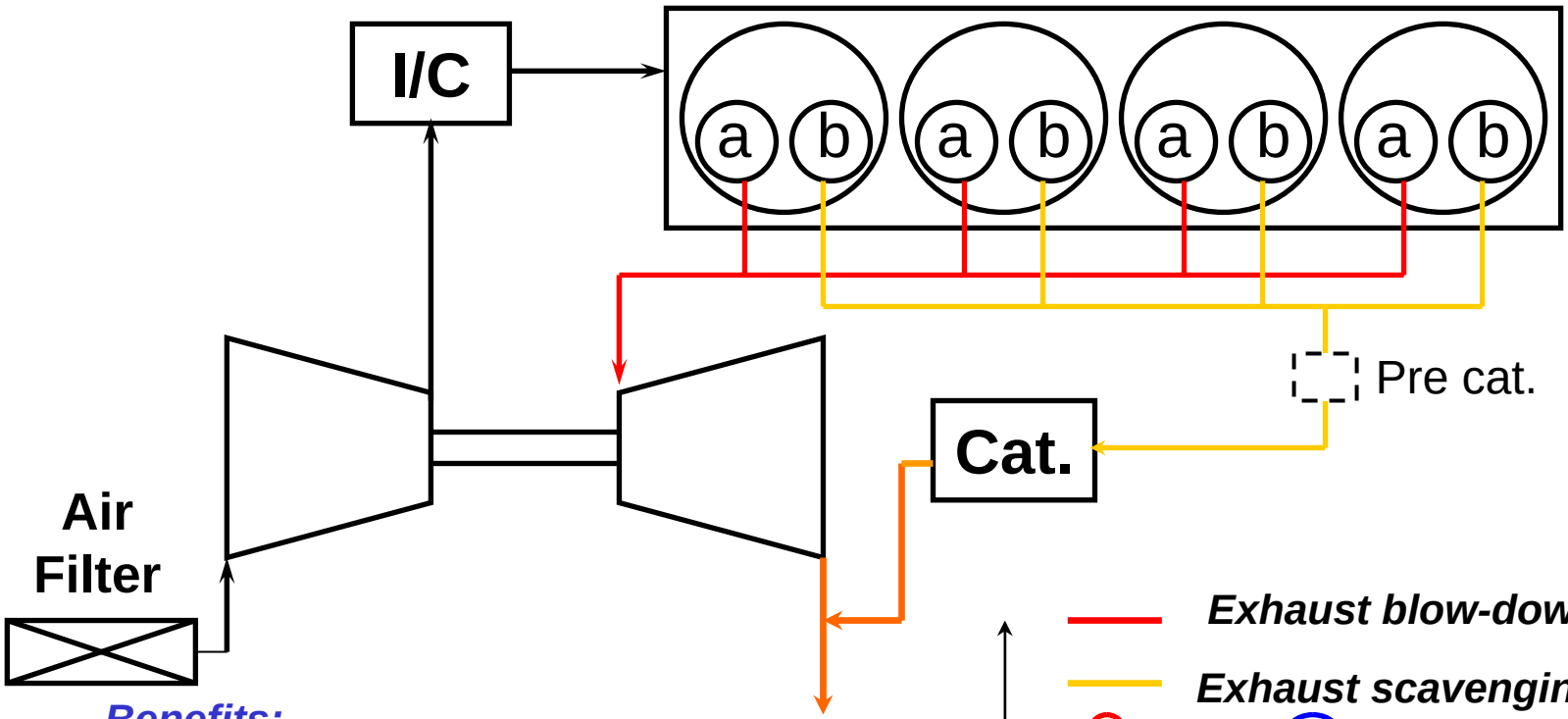
- A two-litre 4-cylinder engine charges a 30 litre reservoir to 22 bar in 12 secs with the engine driven at 5000 rev/min (85% achieved in 6 secs)
- Available motor torque drops rapidly - from 35 to 0 Nm in 8 secs (two-stroke @ 1000 rev/min)

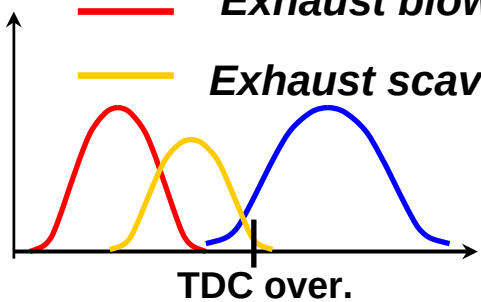


Advanced turbocharging/2-Stage Series System



Advanced Turbocharging/Divided Exhaust Period



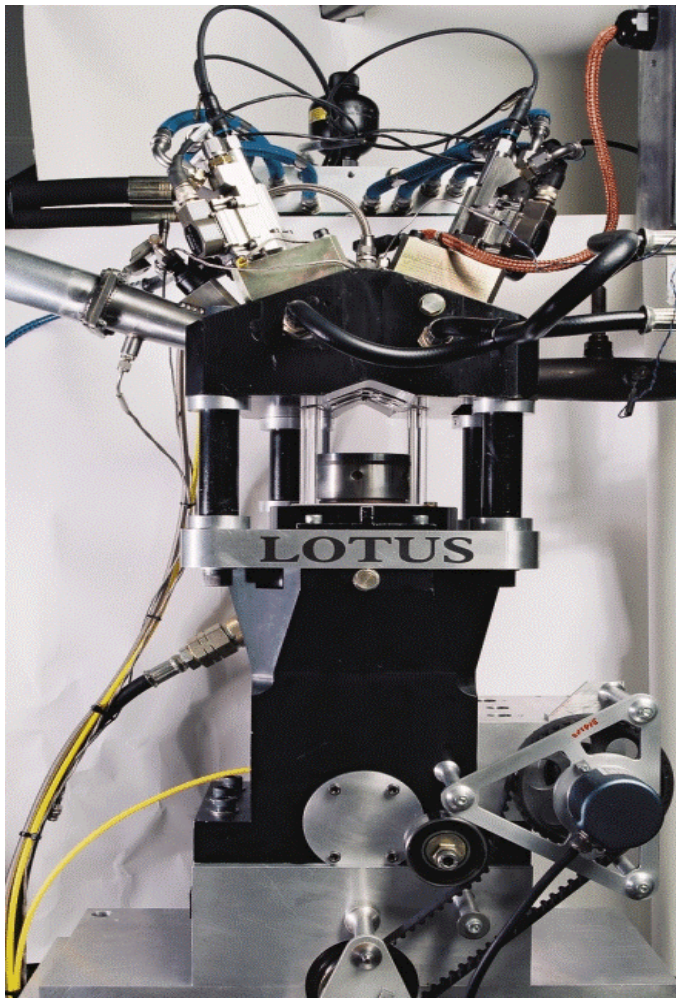


Benefits:

- ***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