The Royal Academy of Engineering

Research Fellowship

The Tribological Investigation of Modern Automotive Engines for Improved Fuel Economy and Lowered Emissions

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ABSTRACT

The global issues to be tackled today and both in and for the future are the continued drive towards resource utilization, conservation and continued quality of life. With the number of cars in the world predicted to increase 50% by the year 2020 there is an increasing awareness that we are running these cars, both their lubrication and fuelling, on oil which is a finite resource. This has resulted in governmental legislation, technology requirements, and consumer pressure on the automotive industry to produce lubricants that have longer drain intervals and higher performance. This however must be achieved within ever tightening compositional constraints, such as reduced phosphorus and sulphur as these damage catalytic converters used to treat much of the harmful exhaust emissions. To help design the next generation of lubricants it is therefore necessary to understand the links between oil degradation and its changing chemical, rheological and tribological properties.

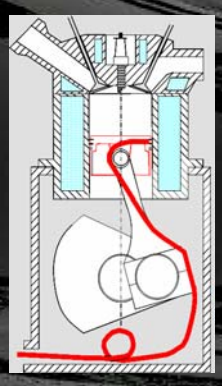
EXPERIMENTAL TECHNIQUES

Mathematical modelling

$$OSF = \left(\frac{P}{V_d}\right) \times \left(\frac{C_e}{V_s}\right)$$

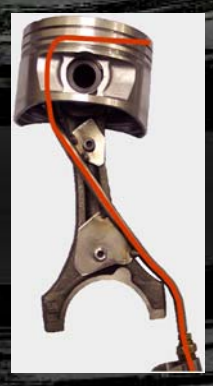
P = Power output (W)
V_d = Volume displaced by cylinder (m^3)
C_e = Number of engine combustion cycles
V_s = Volume of oil in sump (m^3)

Top Ring Zone (TRZ) Sampling



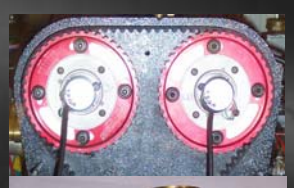
Oil sampled through hole at back of top piston ring. Pushed along pipe as a mist due to combustion chamber pressure.

Pipe taken out of engine along connecting rod, round an axial constraint and out to sample vials.



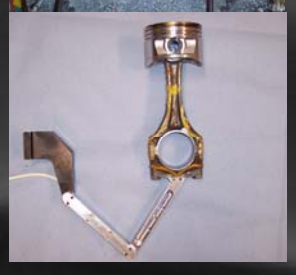
Friction measurement

Valve train pulley torque tranducers



Strain gauged connecting rod

Grasshopper linkage for data retrieval



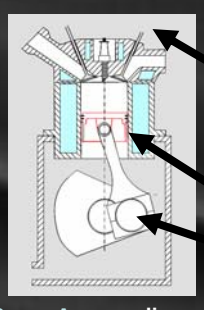
Instrumented piston

Inter-ring pressure

Top ring zone temperature

Piston temperatures

Split supply, temperature controlled, three sump system



Sump A

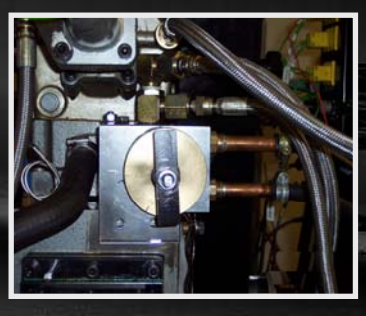
Supplies Valve train

Sump B + C

Supplies Piston Assembly and Crankshaft

Sump A – supplies valve train with fully formulated oil
Sump B – supplies piston assembly and crankshaft with test oil 1
Sump C – supplies piston assembly and crankshaft with test oil 2

Oil supply change valve



Supply of oil from sump B to sump C can be changed while the engine is running

PROJECT SUMMARY

Project is:
- interdisciplinary and adventurous
- experimental, numerical and analytical research

Looking at how lubricating oil:
- degrades in the ring pack
- affects friction and wear in the engine
- impacts on fuel economy, engine life and oil drain intervals

Fired engine tests for:
- extracting degraded oil from sump and Top Ring Zone (TRZ)
- inter ring gas pressures
- blow-by gas levels
- ring zone temperatures
- friction of degraded oils

Extracted sump and TRZ oil are characterised using:
- chemical analysis
- rheological testing
- tribological tests

Results of tribological tests investigated using:
- advanced surface analysis techniques
- 2D and 3D surface metrology

EPSRC Engineering and Physical Sciences Research Council

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