Engine Tribology in Daily Life

Malcolm Fox[1,2] and Martin Priest[1], (1) School of Mechanical Engineering,
University of Bradford, BD7 1DP UK, (2) Nylacast Ltd., Leicester LE4 9LN UK

I/c engines will be part of 'daily life' to 2050, as sole or hybrid prime movers. The targets are 50% reduced emissions and 100% increased fuel efficiency. Many engineering disciplines contribute to 'light weighting', increased thermodynamic efficiency, reduced Cd values and more efficient tyres. Internal engine friction from in-bore components is a major energy loss from 'fuel tank' to 'road wheel'

Conventional wisdom was that the lubricant at the piston/bore interface was the same composition as the sump but at a higher temperature. However, a standing lubricant ring was demonstrated in the piston ring zone; later, sampling inter-ring gas found very degraded lubricant. Analyses of bore wall lubricant samples at top ring reversal from diesel engines showed extensive degradation. Degradation of bore wall samples was so extensive that different grades could not be differentiated. Lubricant internal sampling from the ring pack gave insights into degradation of additives and base oil components, improving commercial lubricant formulations. Samples from the second ring groove, intermediate land, top ring groove and crown land showed progressive degradation of base oil and additives components at different rates as lubricant is transported up the piston face. Sequential degradation of ZDDP through several intermediates was shown to lead to the alkyl sulphide as final product.

Continuous gas and oil sampling transport rates plateaued between 40-75% engine of the speed range for varying loads. Ring pack design changes showed differing oil and gas rates, reducing hydrocarbon emissions without increased wear. An engine lubricant transport model based on two, interconnected, Continuous Flow Stirred Reactors, was developed, with the Sump as a large reactor in equilibrium with a much smaller reactor, the Ring Zone. Relative rates of additive and base oil degradation were measured. The concept of a *'residence time'* for a lubricant particle in the Ring zone was developed as a measure of how the ring pack controlled lubricant flow, measured for both small and large diesel engines and at different sampling positions within the ring pack.

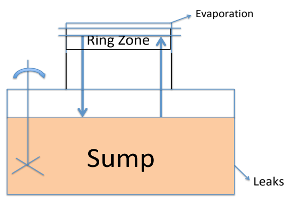

Figure 1. Lubricant Transport Model Between the Engine Sump and the Ring Zone

'Laser-Induced Fluoresence' measured lubricant film thickness in the ring zone for new and used lubricants, finding significant differences between them. 'In-Bore' friction loss measurements showed reductions by added friction modifier to a petrol engine fuel. Alternation between plain fuel and fuel containing individual organics gave up to 4% reduced fuel consumption. Different friction reduction effectiveness was found between organic types and individual within those groups. This effect reduces ring zone friction of domestic and transport, to reduce consumption, in every day life.

References:

1. Saville, S B, Gainey, F D, Cupples, S D, Fox M F & Picken D J, SAE Technical Paper, SAE 881586,
2. Bagshaw, J, Fox M F, Jones, C J, Picken, D J and Seare, K D R, Tribology International, 30, 1997.