Use of the CDS database service by the UCL Internal Combustion Engines Group - Martin Davy

The internal combustion (IC) engine is expected by most industry observers to retain its position as the dominant prime mover for automotive applications for many years to come. Accordingly, there is a strong industrial need for improved IC engine technologies providing simultaneous improvements in fuel economy and exhaust emissions. Many researchers see the ability to provide reliable quantitative, crank-angle resolved, measurements of the local air-fuel ratio (AFR) distribution within the engine cylinder as prerequisite to the successful development of these improved combustion systems.

The past decade has seen laser-induced fluorescence (LIF) techniques assume a significant role in AFR measurement in IC engines. The technique is non-intrusive. Typically, a fluorescent marker compound (seeded within an optically transparent base fuel) is excited in the UV-spectral region and information regarding the local AFR is inferred from the resulting fluorescence signal. However, quantification of the results is non-trivial, and the accuracy of the technique is dependent on the ability of the fluorescent marker co-evaporate with the carrier fuel. A blend of isooctane (B.P. 102 ºC) and 3-pentanone (B.P. 99 ºC) has been widely adopted in the field, and quantitative AFR measurements obtained using this blend are common in the literature.

Recently however, researchers from the Internal Combustion Engines Research Group at University College London (UCL) — in collaboration with researchers at Sandia National Laboratories in the US — have demonstrated that the 3-pentanone / isooctane mixture is non-ideal, and that (despite their similar boiling points) 3-pentanone is preferentially evaporated from the blend [1]. This result represents a non-negligible source of error that is unaccounted for in any published IC Engine/LIF study known to researchers from either group. Hence, one of the primary aims of UCL's continuing research on instrumentation and measurement techniques for IC engines is the development of truly co-evaporative fluorescent tracer/fuel blends suitable for quantitative LIF studies in engines.

The DETHERM thermophysical properties database that has recently become available to UK researchers through the Daresbury CDS database service has proven to be an essential resource in this work. Most fluorescent tracer/fuel blends contain both polar and non-polar components and do not form ideal mixtures. Hence, the evaporation characteristics of candidate blends are strongly influenced by the relative concentrations of the individual components within the mixture and may be adjusted accordingly. The large number of possible fuel/tracer compositions precludes the wholly experimental approach. Thus, the methodology applied by the UCL research group has been that of an extensive numerical modelling program, investigating the evaporative behaviour and physical properties of a range of candidate binary, ternary and quartenary blends, backed by the experimental investigation of selected candidate blends

The vapour-liquid equilibrium (VLE) modelling techniques in use at UCL are well-established in Chemical Engineering literature. However, the fuel/tracer blends under investigation are much less common. Thus, the validation of model predictions often requires access to rare, or difficult to find data sets. The DETHERM database, which claims to contain more than 95 % of VLE data published world-wide, has been essential in the investigation of a wide range of systems we have encountered in our research. This research continues, with the goal of improving the accuracy of AFR measurements in spark-ignition IC engines, thereby aiding the development of cleaner more fuel efficient combustion systems. The Daresbury service, and in particular the DETHERM database that is available through Daresbury, is a vital tool in this research.

[1] Davy, M., Williams, P., Han, D., Steeper, R. (2002): "Evaporation characteristics of the 3-pentanone/isooctane binary system", Submitted to Experiments in Fluids.