PROBABILITY DENSITY FUNCTION MODELLING FOR TURBULENT FUEL SPRAY EVAPORATION

E.S. Richardson* and Q. Jeand'heur*
e.s.richardson@soton.ac.uk
*University of Southampton, Faculty of Engineering and the Environment, University Road, Southampton, SO17 1BJ, UK

We present improved modelling of spray evaporation for the gas-phase transported-Probability Density Function (t-PDF) method. Evaporation models for the t-PDF need to specify not only the amount of liquid evaporated, but also the region of composition-space where the vapour is released. The common assumption of liquid-vapour equilibrium surrounding evaporating droplets implies that evaporation takes place at the saturated vapour composition, and the vapour then diffuses into the gas phase. Therefore the t-PDF modelling must introduce vapour in a manner which ensures the composition remains *bounded* by the saturation condition, and transport the vapour across composition-space in a manner which corresponds to the mixing rates and to the *localness* seen in the diffusion process around evaporating droplets. The two t-PDF evaporation models in common usage [1] fail to enforce boundedness and localness, and we propose new modelling which can satisfy both of these criteria.

PDF model predictions are evaluated by comparison with asymptotic solutions for evaporating sprays [2]. In contrast with previous models, by applying evaporation source terms and mixing rules which enforce boundedness and localness, the new modelling is able to match the vapour-PDF for a range of spray evaporation regimes.

Simulations of n-heptane spray auto-ignition are used to investigate the sensitivity of spray combustion predictions to the details of the t-PDF evaporation modelling. It is found that the t-PDF predictions of ignition timing and pollutant formation are sensitive to the PDF evaporation models, depending on the regime of spray evaporation. We conclude that the new evaporation modelling should be adopted for t-PDF simulations of spray-fuelled engines.

References

[1] Haworth, D. C.,"Progress in probability density function methods for turbulent reacting flows", *Prog. Energy and Combust. Sci.* 36: 168-259 (2010).

[2] Klimenko, A.Y., Bilger, R.W., "Conditional moment closure for turbulent combustion", *Prog. Energy and Combust. Sci.* 25: 595-687 (1999).