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# Unravelling engine combustion using large-scale computations

## Abstract

Global imperatives to reduce emissions of greenhouse gases, to improve urban air quality, and to adapt to new fuel sources are driving continuing developments in reciprocating engines, in terms of fuel economy, emissions, and fuel flexibility. In the medium- to heavy-duty engine sector, these efforts are mostly focussed on compression-ignition (CI) engines, the performance of which is underpinned by remarkably complex, interacting phenomena of sprays, turbulence, mixing, combustion chemistry, and heat transfer. In this talk, I will discuss efforts in my group and our collaborators over the last few years to unravel aspects of this complexity using large-scale computations, principally direct numerical simulations (DNS). With continuing progress in supercomputing capability, it is now possible to carry out DNS in engine-relevant thermochemical conditions and with turbulence parameters that overlap with those long considered relevant in laboratory flame studies. In my talk I will firstly discuss a series of DNS studies that investigated the processes of autoignition and combustion. These studies reveal the significant complexity of these processes, involving important effects of both low- and high-temperature chemical pathways, and involving interactions of several combustion modes including cool flames, ignition kernels, partially premixed edge-flames, lean- and rich- premixed flames, and a diffusion flame. Secondly I will discuss efforts to use these DNS and laboratory experiments to help develop practically applicable models of combustion, which can be used in the engine design process.

## Short Bio

**Evatt Hawkes** is a Professor at the University of New South Wales, Sydney (UNSW). His group applies high fidelity computational fluid dynamics models to turbulent, reacting flows that underpin the performance of combustion and solar energy systems. His work at the nexus of big data and engineering applications is usually carried out with the aid of large-scale supercomputing resources with a view to making fundamental and practical advances in problems of industrial relevance in transportation, power generation, and other energy systems. Much of his work involves interaction with industry, with experimental researchers, and with international collaborators at universities and laboratories around the globe.

Prior to joining UNSW in 2007, Professor Hawkes graduated from University of Cambridge with a Ph.D. in 2001 and subsequently worked as a post-doc at the Combustion Research Facility of Sandia National Laboratories from 2002-2007. Professor Hawkes serves as Associate Editor of Proceedings of the Combustion Institute, as Advisory Editor of Flow, Turbulence and Combustion, and previously served as co-chair for the Turbulent Flames colloquium at the 36$^{th}$ International Symposium on Combustion. Professor Hawkes' contributions and leadership in turbulent combustion modelling have been recognised most notably by the award of an Australian Research Council Future Fellowship in 2011, and in 2018 by his election as one of the inaugural class of Fellows of the Combustion Institute.