Research Abstract

Multi-scale modeling of detonation formation

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Keyword: detonation formation; ignition modes; stratified fuel

Background:

Recently, due to the increasing concerns on energy sustainability and global warming, the development of high efficiency and low emission internal combustion engines, such as the homogeneous charge compression ignition (HCCI) engines[1][2], the reactivity controlled compression ignition (RCCI) engines[3], and the new pressure gain detonation engines[4][5], has drawn great attention. These engines often operate at high pressure, ultra-lean, and elevated temperature conditions with both thermal and compositional stratifications. However, several technical challenges remain unsolved, especially those about understanding the combustion regimes and detonation formations at the extreme conditions [6].

So far, a number of numerical and experimental researches have been done[7][8][9][10] but most of them cast their attention on initial temperature distributions[11][12][13], while only few focused on fuel stratification effect[14], let alone the coupling effect between thermal and fuel stratification.

Current work:

Detonation initiation and ignition wave propagation in concentration stratified n-heptane/air mixtures with and without temperature gradient are numerically modeled. We employ adaptive simulation of unsteady reactive flow(ASURF+)[15][16] code with a third-order weighted essentially non-oscillatory(WENO) scheme. In addition, the correlated adaptive chemistry and transport (CO-DACT) method[17][18] coupled with the hybrid multi-timescale (HMTS) method[19] in a one-dimensional planar constant volume chamber is adopted to improve calculation efficiency.

Future work:

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In the future, there are two main lines for my research. First, a high-performance algorithm combining HMTS method and G-scheme [20] based on parallel computation needs to be developed. Consequently, the current research can be extended to two dimensional or three dimensional cases with more complicated geometries. Second, a more thorough investigation on detonation formation is needed: for chemistry part, the effect of low temperature mechanism and high temperature mechanism is not fully understood; for transport, the effect of turbulence needs to be further studied.

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