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A phase-averaged global reaction model for cellular detonations

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Detonations in gases have a time-varying cellular structure. In the present paper, we develop and test a phase-averaged reaction rate model for cellular detonations, extending the ideas of Lalchandani [1]. We model the distribution of ignition times in the cellular cycle. This distribution serves as a phase-averaged reaction rate model in a coarse-grained description of detonations. To arrive at this closure, we first model the lead shock dynamics in detonations using the recent model suggested by Radulescu [2], whereby the lead shock dynamics are controlled by the pulsed, nearly constant volume energy addition at the end of each cell. The corresponding exponentially decaying shocks permit us to determine the distribution of shock strengths in a cell, which in turn give us the time history of ignition for fluid particles traversing the lead shock. Two different models are developed: ignition conditioned by the shock state distribution and ignition conditioned only by the rapid consumption of non-reactive pockets at the end of a cell. These models are then used to assess their impact on modeling detonations with global lateral flow divergence.

References

[1] Sarthak Lalchandani. Modelling of quasi steady detonations with inert confinement. Master's thesis, University of Ottawa, 2022.

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