Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

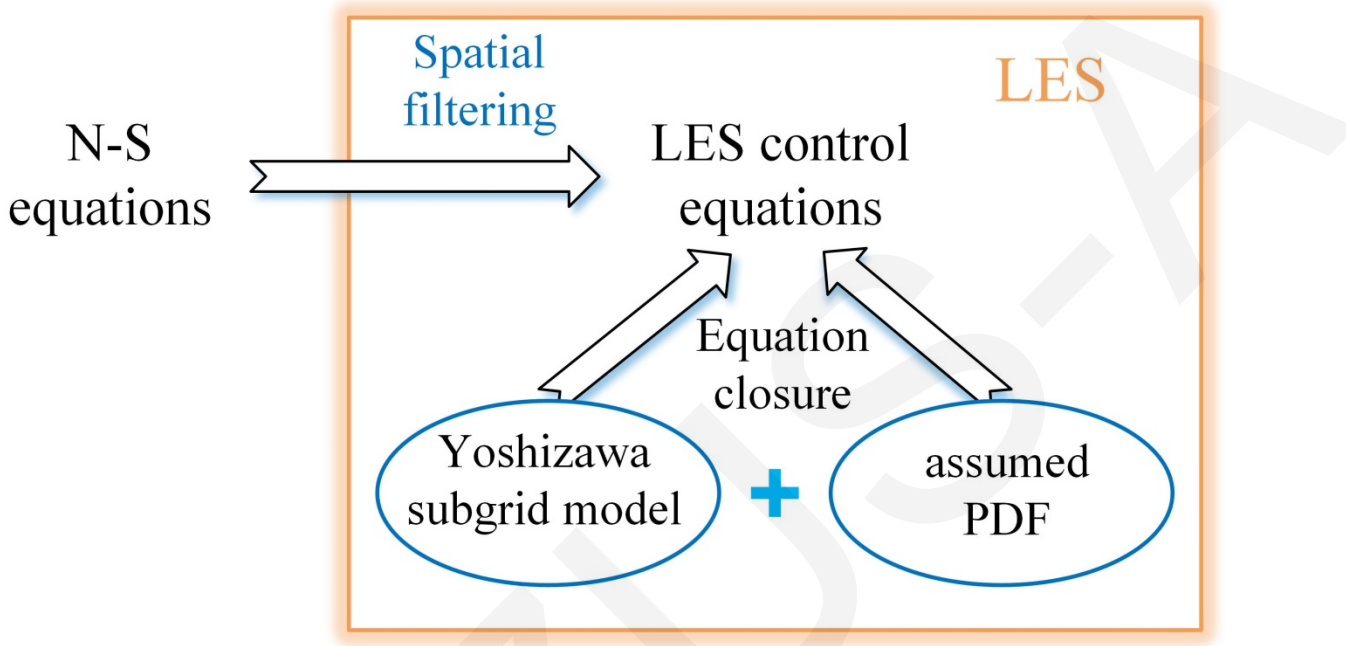
Stabilization mechanisms of lifted flames in a supersonic stepped-wall jet combustor

Jin-cheng ZHANG

Cite this as: Jin-cheng Zhang, Ming-bo Sun, Zhen-guo Wang, Hong-bo Wang, Chao-yang Liu, 2021. Stabilization mechanisms of lifted flames in a supersonic stepped-wall jet combustor. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 22(4):314-330. https://doi.org/10.1631/jzus.A2000087

National University of Defense Technology, China

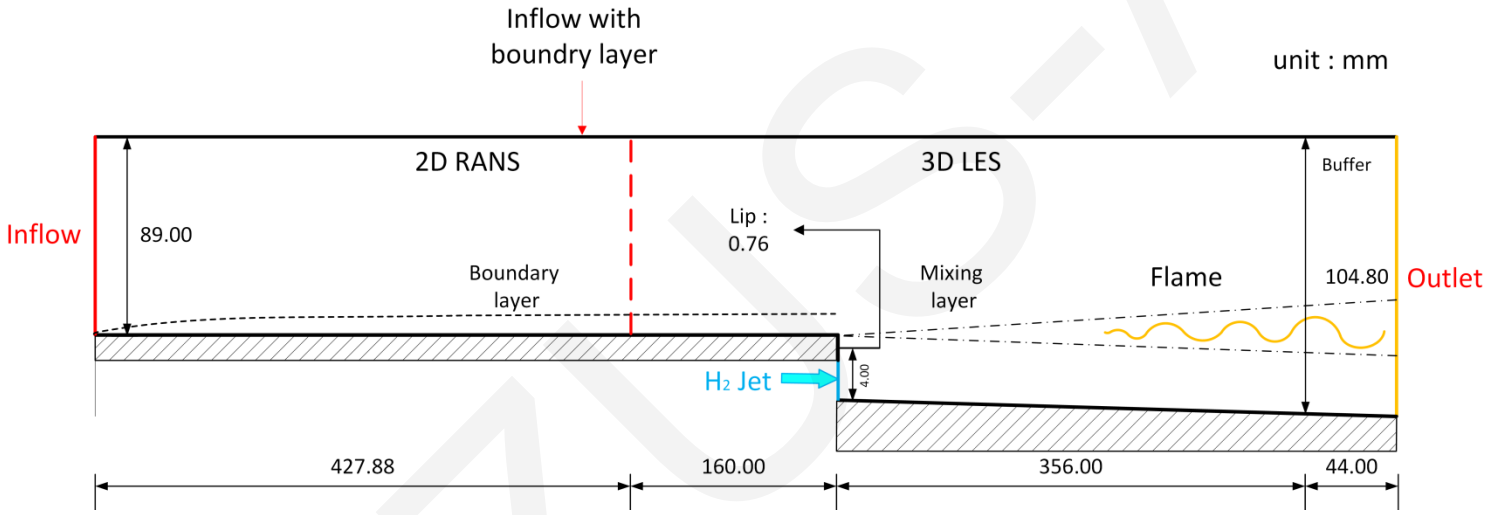
Models and methods



- Our work successfully applied the LES coupled with the assumed PDF to the simulation of the step-wall jet combustion chamber.
- Current work chosen the WENO schemes and the dual time step requires an iterative algorithm to for discretization.

Models and methods

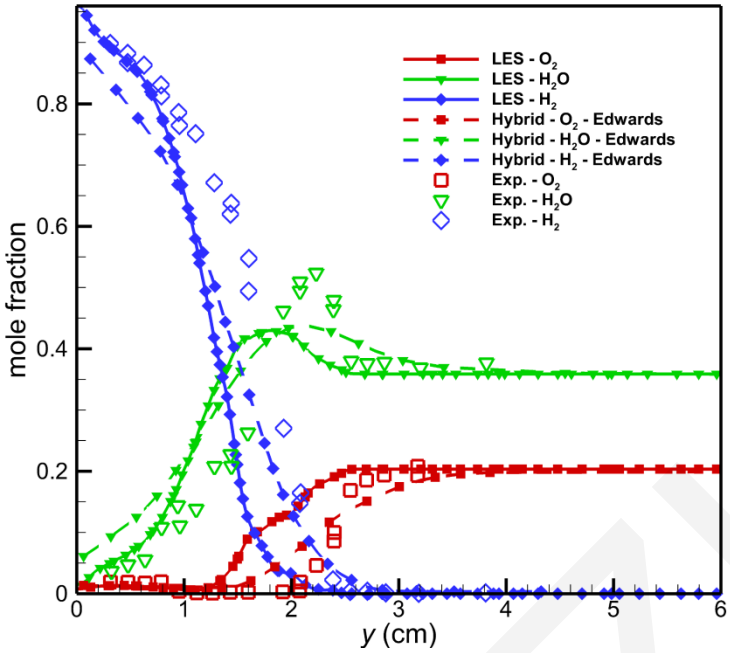
Burrows and Kurkov(1973) experimented with the mixing of inert gases and combustion of vitiated air.



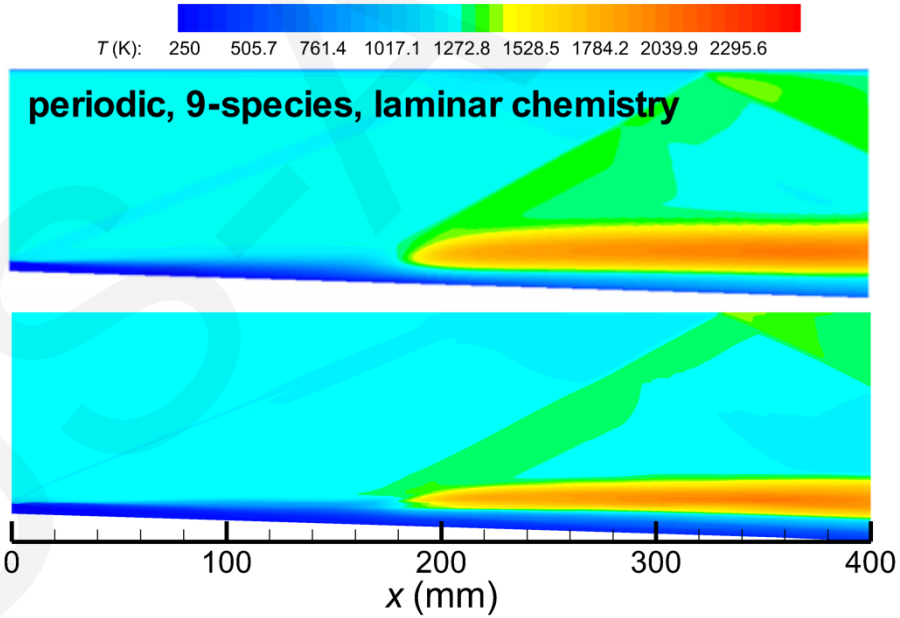
Schematic of the computational domain

- The total temperature, total pressure, and component distribution data obtained during the experiment became the basis of later numerical studies

Validation



Mole fraction profiles at the combustor exit

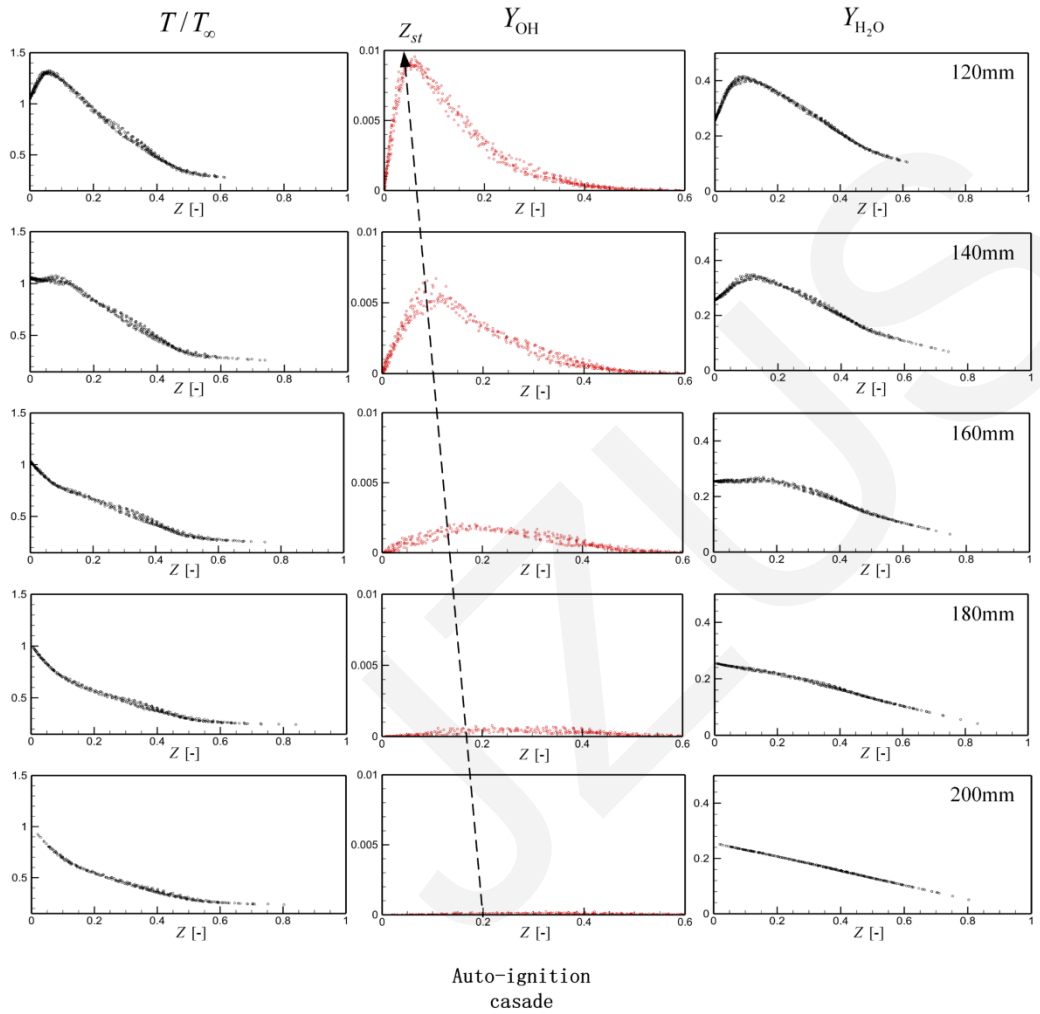


Time-averaged temperature contours obtained by Edwards (2012) (top) and the present work (bottom).

- The simulated results in this paper are credible; furthermore, they support the following discussions.

Results and discussion

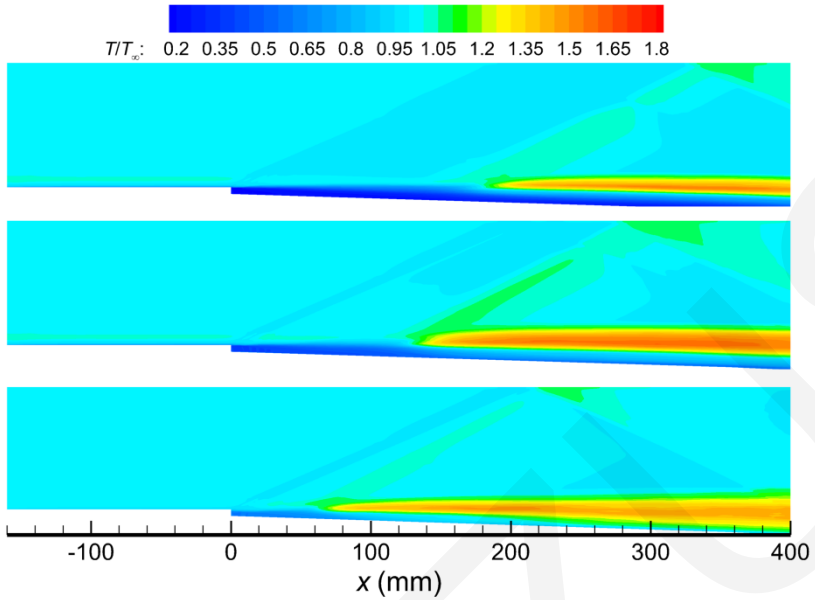
Flame stabilization mechanism



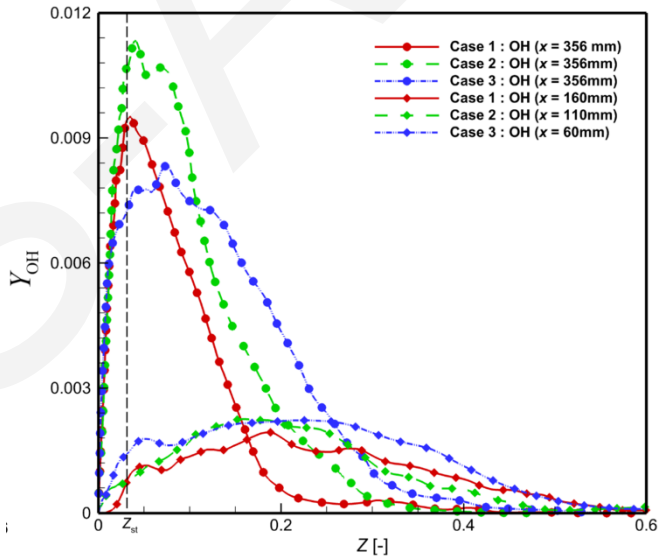
- The ignition cascade continues to provide a flame kernel to form a flame accompanied by a large amount of heat release.
- Reaction heat release induced the shock wave that accelerates the reaction behind the shock to promote flame stabilization.

Results and discussion

Influences of jet total temperature



Time-averaged temperature snapshots for different jet total temperatures



OH mass fraction distributions perpendicular to OH

- The total temperature of the jet caused macroscopic differences in lift-off distances.
- Due to the strong velocity shear and high temperature , the highest total temperature case resulted in a low flame temperature

Conclusions

1. The flame is partially premixed and the diffusion flame is dominant. The autoignition cascade controls the stability of the downstream flame.

2. The higher the total temperature, the smaller the flame lift-off distance.

3. The highest total temperature prevents the completion of the cascade process. Therefore, the flame is mainly fuel-rich and the flame temperature is relatively low .