Journal of Zhejiang University-SCIENCE A

國防科学技術大学
National University of Defense Technology

Mode transition process in a typical strut-based scramjet combustor based on a parametric study

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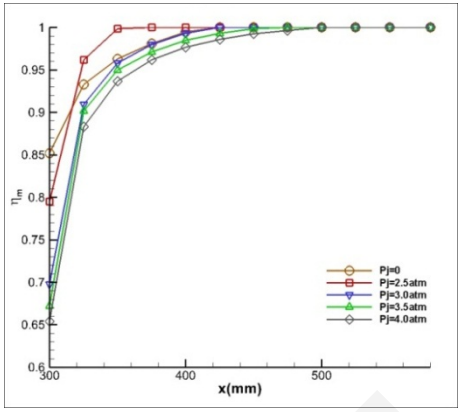
Key words: Scramjet; Mode transition; Strut; Cavity; Combustion performance

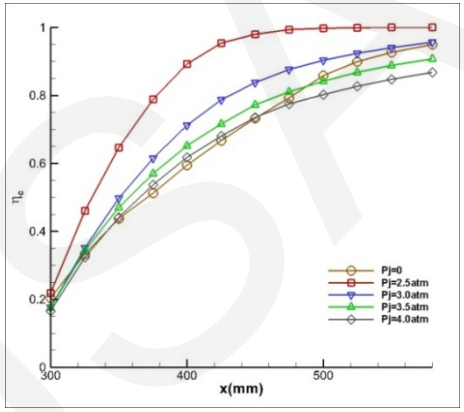
Cite this as: Lei Liao, Li Yan, Wei Huang, Lang-quan Li, 2018. Mode transition process in a typical strut-based scramjet combustor based on a parametric study. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 19(6):431-451. https://doi.org/10.1631/jzus.A1700617

Strut-based combustor

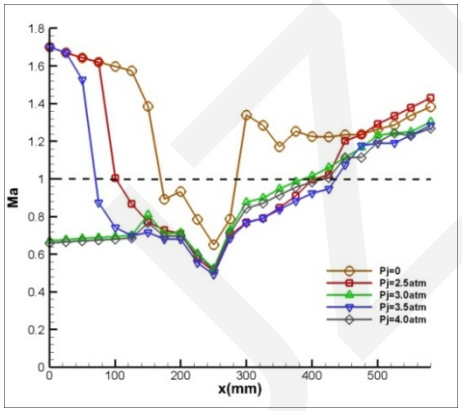
(1) Inlet Mach number of 1.7



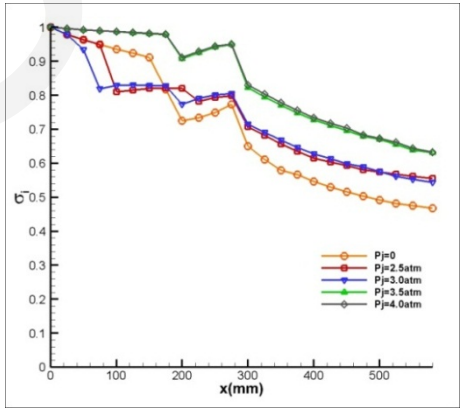
(a) Mixing efficiency



(b) Combustion efficiency



(c) Mass-weighted Mach number

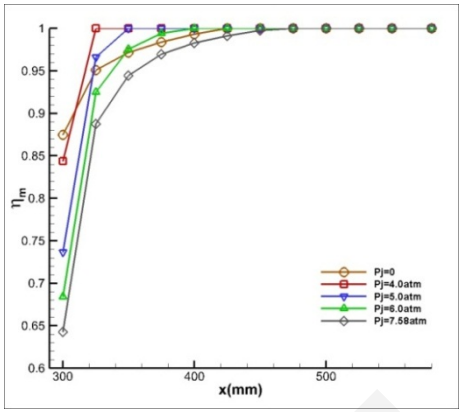


(d) Total pressure recovery

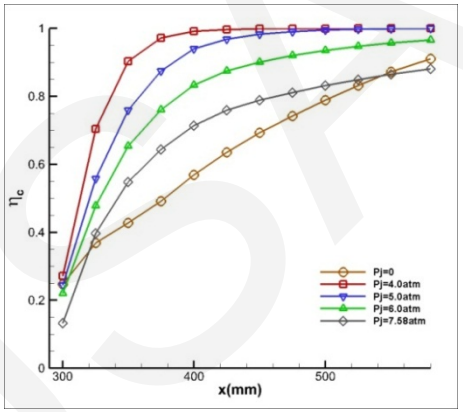
Comparison of combustion performance at different wall-injection pressures when the main flow enters at Ma 1.7.

Strut-based combustor

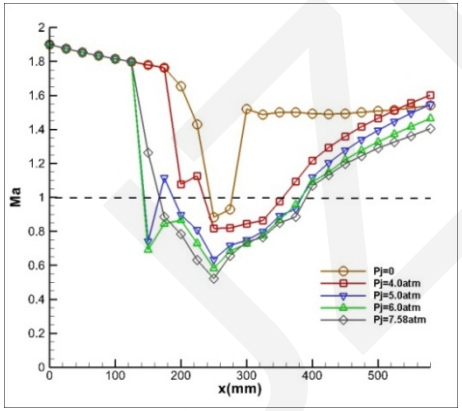
(2) Inlet Mach number of 1.9



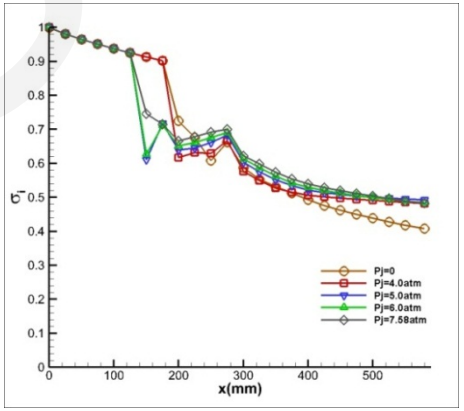
(a) Mixing efficiency



(b) Combustion efficiency



(c) Mass-weighted Mach number

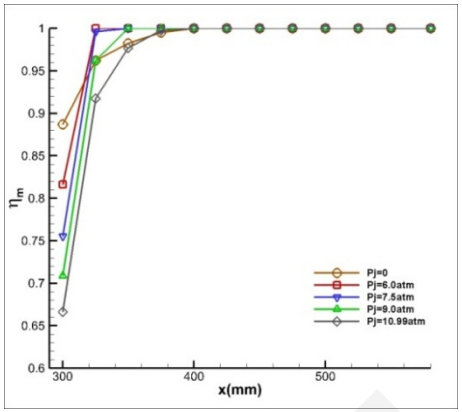


(d) Total pressure recovery

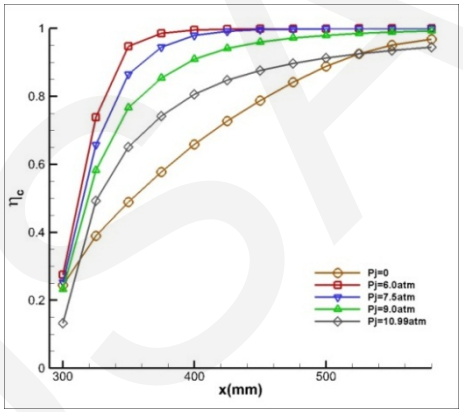
Comparison of combustion performance at different wall-injection pressures when the main flow enters at Ma 1.9.

Strut-based combustor

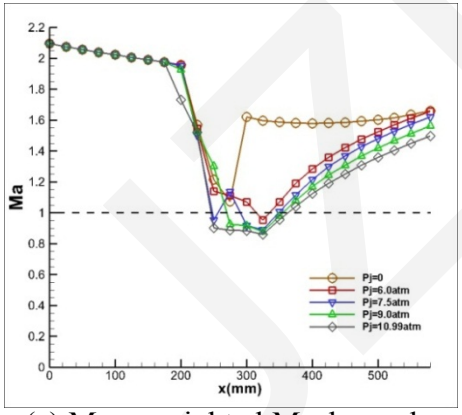
(3) Inlet Mach number of 2.1



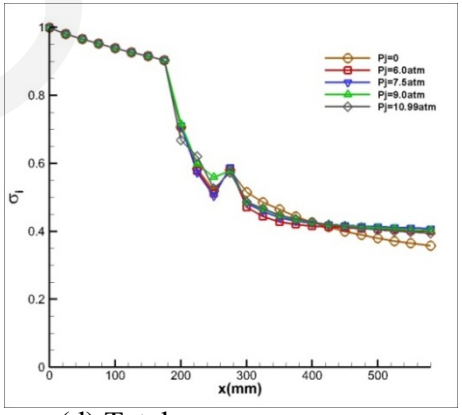
(a) Mixing efficiency



(b) Combustion efficiency



(c) Mass-weighted Mach number

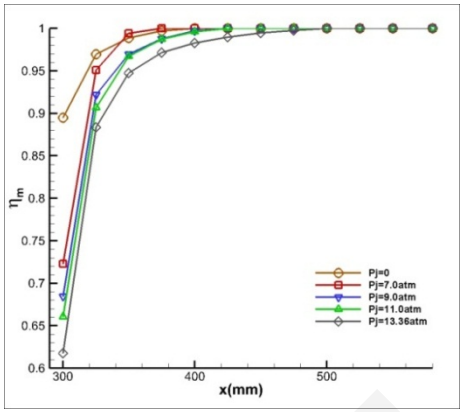


(d) Total pressure recovery

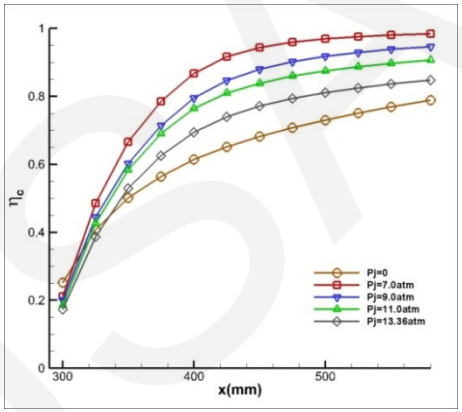
Comparison of combustion performance at different wall-injection pressures when the main flow enters at Ma 2.1.

Strut-based combustor

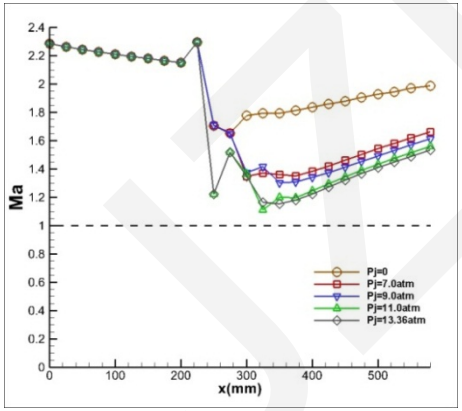
(4) Inlet Mach number of 2.3



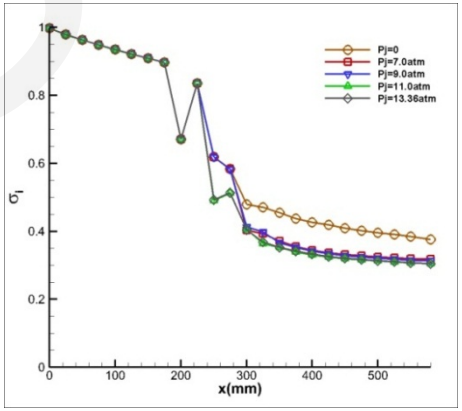
(a) Mixing efficiency



(b) Combustion efficiency



(c) Mass-weighted Mach number

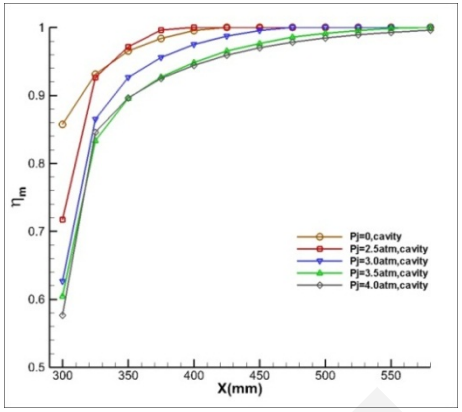


(d) Total pressure recovery

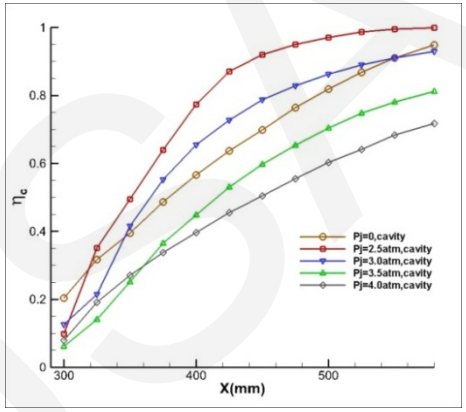
Comparison of combustion performance at different wall-injection pressures when the main flow enters at Ma 2.3.

Strut-cavity combustor

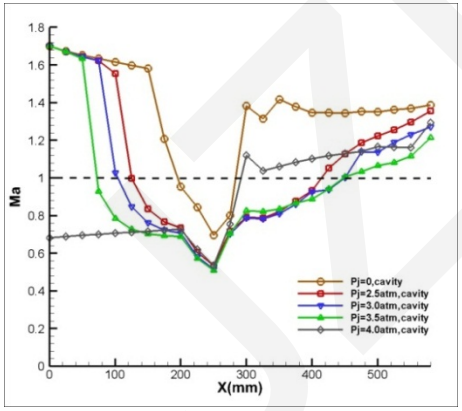
(1) Inlet Mach number of 1.7



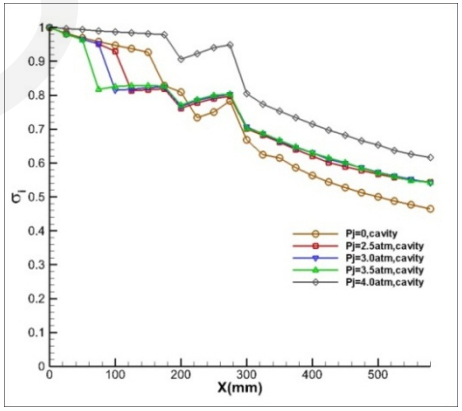
(a) Mixing efficiency



(b) Combustion efficiency



(c) Mass-weighted Mach number

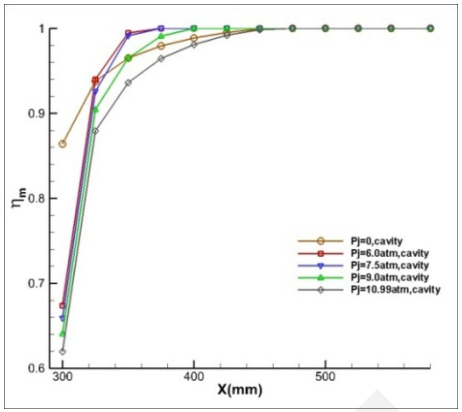


(d) Total pressure recovery

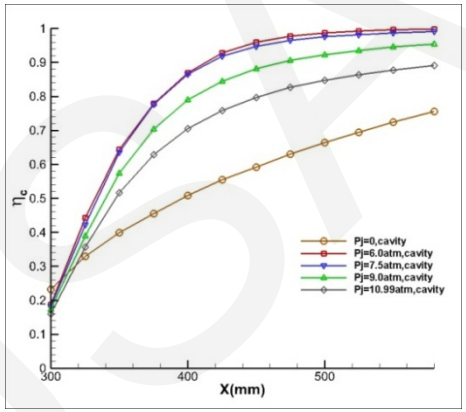
Comparison of combustion performance using a strut-cavity combustor at different wall-injection pressures when the main flow enters at Ma 1.7.

Strut-cavity combustor

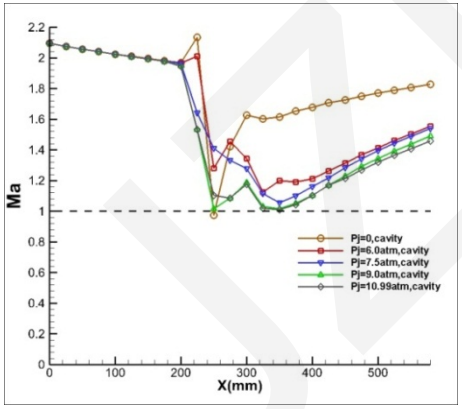
(2) Inlet Mach number of 2.1



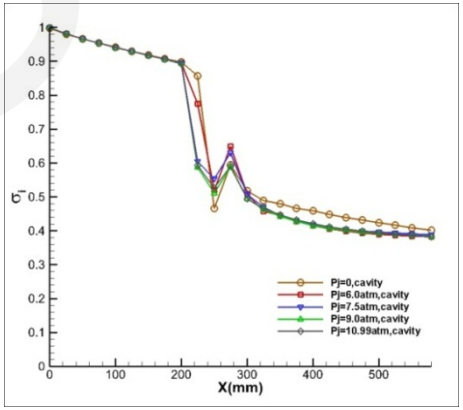
(a) Mixing efficiency



(b) Combustion efficiency



(c) Mass-weighted Mach number



(d) Total pressure recovery

Comparison of combustion performance using a strut-cavity combustor at different wall-injection pressures when the main flow enters at Ma 2.1.

Conclusion

In this study, the influence of wall-injection pressure on a typical strut-based dual-mode scramjet combustor was investigated numerically, and the effect of typical cavities evaluated qualitatively. By comparing the Mach number contours and wave structures, mixing and combustion efficiency, 1-D mass weighted average Mach number and total pressure recovery, we have come to the following conclusions:

- The wall-injection pressure has a great influence on the flow field structures, especially the ram-to-scram mode transition and the combustion performance. A high wall-injection pressure will cause some problems: in the ramjet mode, it might push the pre-combustion shock waves out of the isolator, while in scramjet mode, the combustor is likely to suffer huge energy loss because of the high wall-injection pressure. For all the cases studied, a wall-injection pressure of about half of the strut-injection pressure seems to be the best.

- The cavity adopted in this study would prevent the pre-combustion shock waves from pushing out of the isolator and help to stabilize the flow field, but it would decrease the mixing and combustion efficiency. Clearly, there is great scope for further investigation of the optimization of the strut-cavity combination. At the same time, a cavity has been shown to reduce the transition time from the scram mode to the ram mode, implying that a combustor with a cavity is beneficial for the scram mode.

Related publications

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[2] Huang W, Yan L, Tan J G. Survey on the mode transition technique in combined cycle propulsion systems. Aerospace Science and Technology, 2014, 39: 685-691

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