#00519

INJECTOR WALL HEAT TRANSFER QUANTIFICATION IN SUPERCRITICAL NITROGEN INJECTION

1. SPACECRAFT PROPULSION
1.03. Advanced spacecraft propulsion systems

L. Magalhães [1], A. Silva [1], J. Barata [1].
University Of Beira Interior - Covilhã (Portugal)

Introduction

Pressure and temperature increase in combustion chambers of Liquid Rocket Engines (LRE's), while enhancing injection and combustion efficiencies, leads to both fuels and oxidizers to exceed their critical point conditions, entering the domain of supercritical fluid flows. Over the past 20 years, many physical models are developed for the simulation of supercritical nitrogen injection, which is validated with the experimental data from [1] and [2]. However, regardless of the sophistication employed in RANS, LES [3] or DNS-based [4] approaches, unrealistic top hat density profiles appear in the computations, which have in common the consideration of adiabatic injector walls.

The present work has the objective of quantifying the influence of injector wall heat transfer for the considered experimental conditions, contributing for a more accurate representation of the physical phenomena in LRE's combustion chambers. For this purpose, a RANS-based approach is followed combining the accuracy of a multiparameter equation of state for nitrogen with an incompressible, but variable density approach description of the mixing conditions.

Discussion

Figure 1 depicts a comparison of the results obtained for the centerline density decay for case 4 from [1]. The injector diameter normalizes the axial distance from the injector. In this figure, the origin corresponds to the entrance of the combustion chamber. For the case of the adiabatic injector walls, it can be observed a potential core until $x/D = 7.5$, as opposed to what is depicted in the same figure for the experimental data. Experimentally no core is predicted, and the axial density starts to decrease as soon as the beginning of the combustion chamber. If, on the other hand, the isothermal injector is considered, it can be seen that no top hat profile appears, and the numerical results closely replicate the experimental behavior of the jet.

Conclusion

It is shown that injector heat transfer phenomena actively changes the topology of the jet mixing, contributing to improved performance of numerical solvers.

Bibliography

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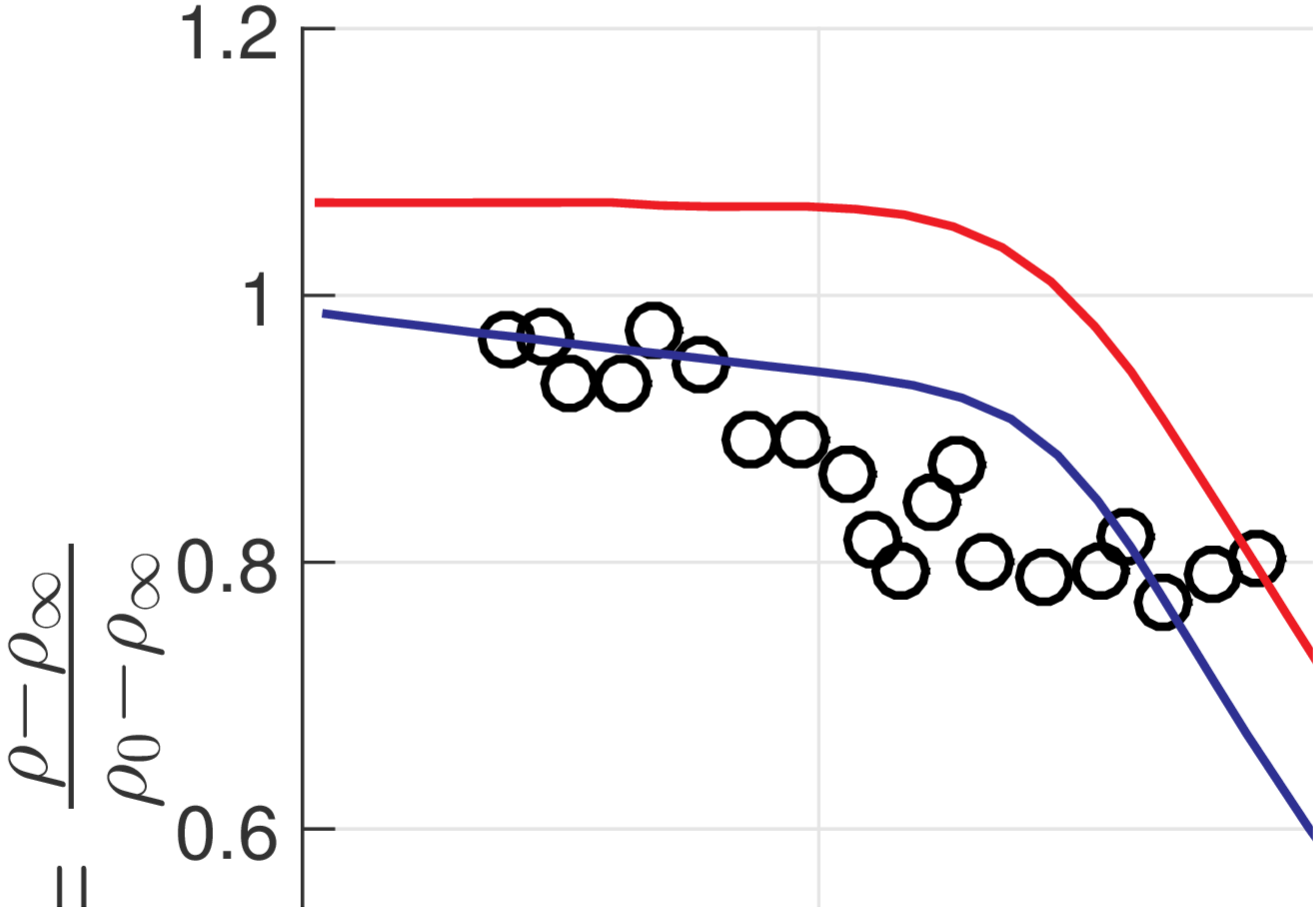
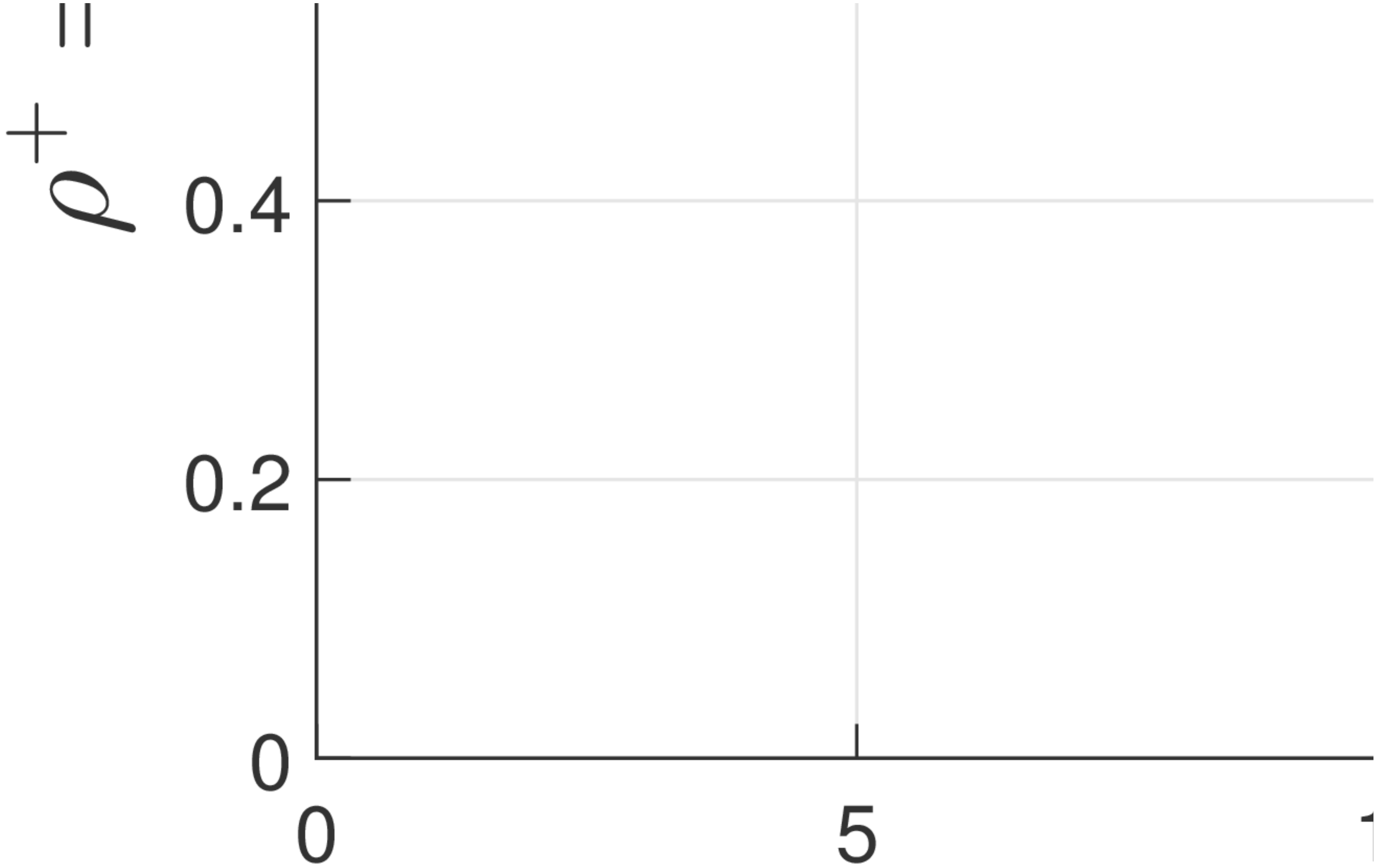
Injector heat transfer influence.

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