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FLUIDIC CONTROL OF TRANSITION IN DUAL BELL LAUNCHER NOZZLE

Abstract

Altitude adaptive rocket nozzles are highly attractive in the current space launcher technology moment which is characterized by extensive demand for an efficient and cost and environment friendly alternative to the present rocket staging designs. Dual bell rocket nozzle, as one of the most analyzed altitude-compensating nozzle concepts, incorporates 2 expansion wall profiles, base and extension, linked via contour inflection zone in-between. Such a rocket engine nozzle concept provides a very wide operation envelope that enables suppression of additional rocket staging.

Dual bell nozzle designs have emerged in the early 1950ies and have been in investigation and adaptation ever since. Stumbling stone in dual bell nozzle configurations represents the sensitivity to flow instabilities during the normal and especially transition regime at the inflection contour zone. This issue has received large amount of attention and has been extensively analyzed in European facilities as German DLR, CNES, Italian institutes.
Common approach in dealing with the transition in the dual bell nozzle often considers a careful design of the inflection zone. However until now only limited results have been obtained by alteration of inflection contour geometric designing.

Controlled secondary injection in the nozzle that the current study considers, proposes a fluidic alternative control of the transition. Fluidic injection in the inflection zone induces the boundary-layer thickening to fully controlled separation as a response to introduced adverse-pressure-gradient.
Dual bell sub-scale rocket nozzle is experimentally investigated in hypersonic test facility of CNRS institute ICARE. Fast schlieren, parietal pressure probing and force balance measurements data have been treated and confronted to the original and derived parameters of numerical simulations. After validation the numerical simulations are expanded with the wide range of full scale models. Effective modes of fluidic injection application are reviewed from the analyzed experimental and numerical results and optimization principles are given. The study shows that simple fluidic injection concept in dual bell launcher nozzle can substantially affect its reliability and jet sustainability during the transition regime.