Vortex Shedding Suppression within a Supersonic Rectangular Nozzle using Active and Passive Flow Control

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A modern variable cycle turbofan engine is the culmination of decades of work towards novel engine architecture. These adaptive engines can significantly increase the efficiency of the propulsion unit via the implementation of an addition unheated third stream which insulates the aircraft, allowing the unit to operate at a higher temperature for a longer time period. When placing this three-stream engine within an airframe and using a rectangular nozzle, the complexity increases further, as do the benefits. Rectangular nozzles, when paired with an aft-deck plate, are of high interest for defense applications as a rectangular nozzle has a small radar cross-section, and the aft-deck plate redirects acoustic emissions away from the ground. The interest in these complex engine configurations, with their clear benefits to the field of aviation, makes research efforts desirable. At Syracuse University a two-stream, single sided expansion rectangular nozzle is used as a platform to study modern variable cycle engines. The traditional core and fan flow are assumed to be fully mixed upstream of the nozzle, which is modeled by a primary stream at Mach $= 1.6$. The bypass stream, the third stream in a variable cycle engine, is sonic in the model. Between these two flows, is a splitter plate which lets the two flows mix slightly downstream of the nozzle throat. The blunt trailing edge of the splitter plate, however, generates a strong high frequency vortex shedding instability which propagates downstream interacting with shock wave formation, and generating acoustics. Reducing the formation of these vortices, and thus diminishing their undesirable effects, is the focus of the present work.

In addition to the nominal nozzle characterization, three control methods implemented at the trailing edge of the splitter plate are investigated using far field acoustics, time-resolved schlieren and shadowgraph imaging, and particle image velocimetry. An active control method which uses an array of parallel jet actuators (Mach $= 0.5$) embedded within the splitter plate to disrupt the vortex formation, is fed from a separate reservoir. A passive bleed control method, which retains the parallel actuator geometry from the active control method, bleeds from the primary stream via a spanwise slit (width 0.1 mm) to power the array. And a geometric passive case, which carves a sinusoidal wave into the trailing edge of the splitter plate to generate counter rotating vortices which inhibits the instability from forming. This control method was studied previously and is included as a point of comparison to the two novel control methods. This study aims to show that all three methods of control are effective in attenuating the effects of the splitter plate trailing edge instability.

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