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NUMERICAL AND EXPERIMENTAL STUDIES OF FLAME STABILIZATION IN A CAVITY STABILIZED RBCC COMBUSTOR

Abstract

A significant challenge in the design of an operational Rocket Based Combined Cycle (RBCC) combustor is to achieve reliable ignition and flame stabilization over a range of operating Mach number. In particular, for hydrocarbon fueled RBCC combustors, flame stabilization is especially of concern due to high-enthalpy rocket chamber exhaust gas, the lower propagation speed and heat release of such system. Designs such as recessed cavity combustor is one of the promising design that appears to be able to achieve flame-holding by generation of subsonic recirculation region that ensure sufficient residence time. Flame-holding characteristic of a laboratory scale RBCC combustor with a wall cavity and back-step in Mach 2-3 preheated crossflow was investigated numerically and experimentally. As for CH radical is well suited to be a reaction marker in high speed flow-field due to its very short lifetime, numerical contour of CH was used to image the reaction zone in RBCC-ramjet mode. Two distinct RBCC combustor stabilization modes were found for main fuel injection with a sufficient distance upstream of the wall cavity. At lower stagnation temperature, the combustion was anchored at the leading edge of the wall cavity by heat release in the cavity shear layer. At high stagnation temperature, combustion was stabilized in the fuel jet wake with a short downstream distance. For an intermediate range of stagnation temperature, the reaction zone oscillated between jet-wake and cavity stabilized position with intermediate locations being unstable. While fuel injection close to the wall cavity, the reaction zone locations for the two stabilization modes overlapped, wall pressure measurements showed that cavity stabilized combustion is the steadiest, followed by jet-wake stabilized, and the oscillatory case. Therefore, high-enthalpy rocket chamber plume exhausted after the thermally choked point, it has a wake effect on fuel-air mixing and flame-holding within a limited combustor length.