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Mixing and flameholding in supersonic combustor by electrical discharge

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ABSTRACT

Compared to a basic scramjet design, operation of scramjet combustors using plasma assisted ignition and flameholding offers considerably more flexibility over the choice of its geometry, due to replacing mechanical flameholders with a highly effective electrically driven apparatus. The articlce presents the results of an experimental study of supersonic combustor operation enhanced by an electrical discharge. A novel scheme of plasma assisted mixing, ignition, and flameholding is demonstrated, which combines a wall fuel injector and a high-voltage electric discharge into a single module. The experimental combustor with the cross-section of 72 mm (width) ´ 60 mm (height) and length of 600 mm operates at a Mach number of M = 2, initial stagnation temperature of airflow of T_0 = 290–300 K, and stagnation pressure of P_0 = 1.3–2.0 Bar. The combustor is equipped with four plasma ignition modules, flush-mounted side-by-side on the plane wall of the combustion chamber. The combustion tests were performed using ethylene injection with a total mass flow rate of G_{C2H4} < 10 g/s and discharge power in the range of W_{pl} = 3 – 24 kW. The scope of the experiments includes characterization of the discharge interacting with the main flow and fuel injection jet, parametric study of ignition and flame front dynamics, and comparison of this scheme to earlier tested configuration. This approach demonstrates a significant advantage in terms of flameholding limits. An operation mode with strong combustion oscillations was observed at high fuel injection flow rates. Methods of flame front stabilization based on plasma application are discussed. The technique studied in this study may have significant potential for high-speed combustion applications, including cold start/restart of scramjet engines and support of transition regime in dual-mode and off-design operation.