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Author: Mr. Liyin Wu
China Aerodynamics Research and Development Center(CARDC), China

INVESTIGATION ON SUPERSONIC COMBUSTION WITH MACH 10 FREEFLOW IN SHOCK TUNNEL

Abstract

Supersonic combustion of gaseous hydrogen in a two-dimensional tube was studied in a room temperature hydrogen driven shock tunnel which can provide a hypersonic free stream with total pressure of 28 MPa, total enthalpy of 4.7 MJ/kg and nominal Mach number of 10. The simulation of non-equilibrium flow with air dissociation reaction and ground test have been completed. The results revealed that ignition occurred at the beginning of the test time and combustion lasted about 3 ms. The total length of the test model is 2.9 m, the width of the inner wall is kept constant at 250mm. The model consists of three parts: the contraction section, iso-straight section, and expanded section. The contraction section is used for air intake and compressing the air to increase the static temperature and static pressure. The height of the iso-straight section is 60.7mm, where the Mach number is about 5 and the combustion occurs. Gaseous hydrogen fuel was injected into the supersonic gas stream at a pressure of 2-4 MPa through two rows of circular holes in the upper and lower walls at a position of 270 mm from the exit of the contraction section. And it is proved that self-ignition occurred. The mixing and combustion process were reproduced in detail by numerical method. The differences of the combustion phenomena between the fuel injection scheme of detachable physical slope-assisted mixing and injection directly perpendicular to the local wall were compared and analyzed. In the study, High-speed photography technique was used to record the process of the hydrogen injection, the ignition and the combustion. The establishment process and the structures of the flow field were revealed by the high-speed schlieren images. Additionally, the static pressure and heat flux along the inner wall showed that a violent combustion took place in the iso-straight section.