Paper ID: 27798
oral

66th International Astronautical Congress 2015

SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (9)

Author: Mr. Ryan Clark
United States, ryan.j.clark@wmich.edu

DETONATION COMBUSTION WAVE STABILIZATION IN SCRAMJETS

Abstract

Sub-orbital propulsion is an application motivating research in scramjet propulsion. A possible means to achieve scramjet propulsion is to utilize a detonation wave combustion. This can be accomplished by adding heat to a supersonic premixed combustible mixture in order to increase the temperature and pressure to the point of ignition, such that the combustion process couples with the shock, thereby generating a detonation wave. Heat can be added through a shock wave generated by the geometric configuration of the scramjet. An advantage to utilizing a detonation wave in scramjet propulsion is that it will yield rapid combustion as a result of the compression and high temperatures it induces. Since the detonation wave induces compression the required compression from the forebody and inlet will be smaller, therefore the losses associated with flow deceleration in the inlet will be smaller as well. In addition, the rapid combustion allows for a short combustor length, resulting in less combustor cooling load and a shorter and lighter-weight engine system. One of the technical tasks that must be addressed is the establishment of experimental and theoretical evidence supporting the stabilization of detonation waves in scramjets. Such evidence must also address the conditions (i.e., combustor inlet parameters) for which the stabilization occurs. Results from a numerical study show supporting evidence for the stabilization of detonation waves in a model scramjet configuration. Simulations were conducted using ANSYS Fluent and a chemical reaction mechanism from CHEMKIN. Studies were conducted for combustor inlet flow conditions of 1 MPa, 700 K, and Mach 3. Hydrogen concentrations, for a pre-mixed hydrogen-oxygen mixture, ranging from six percent molar concentration to fourteen percent were tested. The minimum and maximum amount of hydrogen necessary to obtain a stabilized detonation wave were established. Correlations between fuel concentration, inlet speed, and detonation wave velocity were established in order to assess the effect of heat release on the detonation wave velocity. The cases for which a detonation wave was stabilized were compared in order to assess the effect of heat addition, as a result of greater hydrogen concentrations, on properties across the detonation wave and the surrounding flow features. The sensitivity and robustness of the inlet combustor parameters are quantified in order to assess the stability of the combustion as observed in the numerical results.