Abstract

Assuming a fixed thrust, the area and volume of a chamber can be changed by varying the CR. CEA was not at first intended to be a tool for engine design to determine the impact on chamber performance. Both chemistry assumptions were not used. It was learned that CR has essentially no impact when assuming equilibrium chemistry as shown in Figure 1, whereas CEA does adjust the chamber length to hold the total chamber volume and volume constant—almost as the actual area combustion chamber FAC option. CEA does not allow the frozen chemistry assumption when running the FAC option; only for the Ideal area (IAC) option.

Parameters

Using the MHD subsonic injector test data, CEA was run on the test conditions to calculate the jet vacuum loss using a 2D area ratio nozzle. Figure 2 shows the results of the analysis that indicates the test setup is utilized. The CEA prediction for equilibrium chemistry. Figure 3 shows the effect of changing the contraction ratio while changing parameters for the same CR. The effect of performance for the 3% increase in jet velocity—or about 5% for a 1% change. This implies that a subsonic nozzle can achieve a C* efficiency greater than 1.

Conclusion

1) The C* efficiency trend is similar for both cryogenic and hypergolic propellants. As L* increases, the rate of change of C* efficiency decreases. It is impossible to precisely correlate C*, C* eta, or L* to L* or L* alone, since test data clearly shows that Injector Type, Injector Density, Momentum Ratio, Fuel Injection Temperature, Chamber Pressure, and Mixture Ratio also affect these performance values.

2) To properly correlate engine performance to chamber dimensions, one needs to be able to vary the chamber length and volume. Since the CEA model only allows Contraction Ratio variability and the model adjusts the L* to hold L* constant, it was not possible to develop a correlation between L* and frozen or equilibrium chemistry-based Isp.

3) The effect of other chamber and injector parameters on C* and Isp was completed, specifically for NTO/Aerozine-50 and LOX/Hydrogen propellant combinations. These trends can be used qualitatively to size a subsonic injector for Lunar Lander Descent or Ascent Engine applications.