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Hypersonic Air-breathing and Combined Cycle Propulsion, and Hypersonic Vehicle (7)

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EXPERIMENTS WITH HYDROGEN/AMMONIA MIXTURES FOR AIRBREATHING HYPERSONIC PROPULSION

Abstract

Hydrogen (H2) is highly desirable for hypersonic propulsion use as a zero-emission renewable fuel as when burned with oxygen, water is the only product. It is also widely abundant and has the highest energy density of any fuel. Issues with H2 are its storage and transportation, its incompatibility with certain metals, and its small size allows it to leak through small cracks. Alternatively, hydrogen could be stored and transported in liquid form but requires cryogenic conditions. Ammonia (NH3) is a hydrogen-carrier that has thermal properties similar to that of propane and, as such, could utilize the already existing transport and storage facilities. When operating in air-breathing hypersonic engine conditions, both fuels could potentially release large amounts of nitrous oxides (NOx). There are still key questions that need answers from fundamental experimentation and modeling efforts before engines can be designed, such as those regarding the products and pathways of these fuels and their corresponding ignition delay times (IDTs). Fundamental chemical kinetics data at engine-relevant conditions are needed for optimizing existing combustors and designing new ones. Typically, chemical kinetic mechanisms which contain combustion pathways and reaction rates are used by designers and engineers with computational fluid dynamic (CFD) codes. To properly validate these mechanisms and gain confidence in their predictions, experimental measurements (e.g., autoignition delay time and species time history measurements) are taken to provide validation targets. In this context, shock tubes provide an optimal tool for gathering the needed IDT data for model development; they are nearly ideal devices for studying combustion as they provide well-controlled step changes in temperature and pressure and, for sufficiently large diameter tubes, are not significantly affected by surface or transport phenomena. This study reports the autoignition delay times of hydrogen/ammonia mixtures at conditions similar to turbine engine operating conditions (20-30 bar, 1000-1300 K). Varying amounts of H2 (10-90