MASTER OF SCIENCE
IN
ASTRONAUTICAL ENGINEERING

EVALUATION OF A LIQUID-FUELED PULSE DETONATION ENGINE COMBUSTOR

David L. Forster-Lieutenant, United States Navy
B.S., Memphis State University, 1989
Master of Science in Astronautical Engineering-December 1998
Advisors: David W. Netzer, Department of Aeronautics and Astronautics
Christopher M. Brophy, Department of Aeronautics and Astronautics

An evaluation of five liquid-fueled pulse detonation engine combustor geometries and flow field conditions was performed over a wide range of equivalence ratios. Particle sizing and spray characterization of commercially available atomizers was conducted to determine the optimum conditions that produced acceptable mass flow and particle size distribution for use in the combustor.

The chosen atomizer was installed to the combustor geometries and then analyzed over a range of combustor conditions to measure deflagration to detonation transition (DDT) distances and detonation ave velocities for each condition. Testing was conducted for ambient (100-110°F) and higher wall temperatures (>300°F) at and operating frequency of 5Hz.

It was found that the shortest DDT for JP10 and O_2 was achieved using a stepped front-end insert under hot conditions and with a loaded equivalence ratio greater than .75, but less than 1.15.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Conventional Weapons

KEYWORDS: Pulse Detonation Engine, JP10, Liquid Fuels

BEAM SHAPE CONTROL USING SHAPE MEMORY ALLOYS

Brian L. Kelly-Lieutenant, United States Navy
B.S.E.E., University of South Carolina, 1993
Master of Science in Astronautical Engineering-December 1998
Advisors: Brij N. Agrawal, Department of Aeronautics and Astronautics
Gangbing Song, Department of Aeronautics and Astronautics, University of Ohio

This thesis presents the design and experimental results of active position control of a shape memory alloy (SMA) wire and a SMA wire actuated composite beam. The wire is a single SMA Nickel Titanium wire mounted on a single wire test stand. The composite beam is Aluminum honeycomb with SMA wires embedded in one of its face sheets for active shape control. The potential applications of this experiment include thermo-distortion compensation for precision space structures, stern shape control for submarines, and flap shape control for aeronautical applications. SMA wires are chosen as actuating elements due to their high recovery stress (> 700 MPa) and its tolerance to high strain (up to 8 %). SMA wires are inherently nonlinear, which poses a challenge for control design. The experimental setup consists of the single wire test stand and the composite beam with embedded SMA wires, a HP programmable power supply, a Linear Variable Differential Transformer (LVDT), an infrared laser range sensor, and a dSpace system with a Texas Instrument C-30 DSP for data acquisition and real-time control. A Position and Derivative (PD) control with feed forward action was designed and implemented, and a control accuracy of 0.1 mm was achieved. A non-linear control was added which gives a control accuracy of 0.05 mm with a much faster response.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Controls, Active Damping, Shape Memory Alloys, Vibration Control, Shape Control, Nitinol

MODELING, SIMULATION, AND VISUALIZATION OF AEROCAPTURE

Zigmond V. Leszczynski-Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1989
Master of Science in Astronautical Engineering-December 1998
Advisor: I. Michael Ross, Department of Aeronautics and Astronautics
Second Reader: Steven E. Matousek, NASA Jet Propulsion Laboratory

A vehicle traveling from Earth to another planet on a ballistic trajectory approaches that planet at hyperbolic velocity. Upon arrival, the vehicle must significantly reduce its speed for orbit insertion. Traditionally, this deceleration has been achieved by propulsive capture, which consumes a large amount of propellant. Aerocapture offers a more fuel-efficient alternative by exploiting vehicular drag in the planet's atmosphere. However, this technique generates extreme heat, necessitating a special thermal protection shield (TPS). Performing a trade study between the propellant mass required for propulsive capture and the TPS mass required for aerocapture can help determine which method is more desirable for a particular mission. The research objective of this thesis was to analyze aerocapture dynamics for the advancement of this trade study process. The result was an aerocapture simulation tool (ACAPS) developed in MATLAB with SIMULINK, emphasizing code validation, upgradeability, user-friendliness and trajectory visualization. The current version, ACAPS 1.1, is a three-degrees-of-freedom point mass simulation model that incorporates a look-up table for the Mars atmosphere. ACAPS is expected to supplement the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) Project Design Center (PDC) toolkit as preliminary design software for the Mars 2005 Sample Return (MSR) Mission, Mars 2007 Mission, Mars Micromissions, Neptune/Triton Mission, and Human Mars Mission.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Modeling and Simulation

KEYWORDS: Aerocapture Simulation (ACAPS), Aeroassist, National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL), Human Mars Mission, Mars 2001 Mission, Mars 2005 Sample Return (MSR) Mission, Mars 2007 Mission, Mars Micromissions, Neptune/Triton Mission, MATLAB, SIMULINK

MISSION ANALYSIS FOR THE MARS 2007 OPPORTUNITY

Stephen B. Zike-Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1986
Master of Science in Astronautical Engineering–December 1998
Advisors: I. Michael Ross, Department of Aeronautics and Astronautics
Steven E. Matousek, NASA Jet Propulsion Laboratory

In 2007, NASA will launch an orbiter and a lander to Mars in support of science and exploration goals. The NASA's Jet Propulsion Laboratory is responsible for the mission design. A trajectory analysis is necessary to ensure that the most cost-effective interplanetary transfer is implemented. This thesis presents a comprehensive analysis of all possible type 1, 2, 3, and 4 Earth-Mars trajectories with reasonable launch energy requirements as well as possible return trajectories to Earth for the case of a sample return. Launch periods were determined using the JPL programs MIDAS and CATO. The corresponding C3 requirements for each trajectory were then utilized to obtain the performance capabilities for the Delta II series, Atlas II series, and Ariane 4/5 launch vehicles. The injected mass derived from the performance data was subsequently used as the spacecraft design point. The goal of this analysis was to identify the trajectory type and orbiter capture scheme that produced the maximum post-capture orbiter mass. The advantages and disadvantages of propulsive capture, aerocapture, and aerobraking were addressed for numerous launch scenarios in which the orbiter and lander are either launched on separate launch vehicles or on a single launch vehicle. This comparison was successful in demonstrating the impact of the orbiter capture scheme on the selection of the optimal trajectories.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Mars, National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory, Surveyor, Aerobraking, Aerocapture, Trajectory, Interplanetary