AEROSPACE & MECHANICAL ENGINEERING

2010 COLLOQUIUM 2011

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INFORMAL COFFEE PERIOD BEFORE THE SEMINAR IN ROOM 365 FITZPATRICK HALL

UNIVERSITY OF NOTRE DAME, NOTRE DAME, INDIANA 46556

SPEAKER: **Dr. Hyungrok Do**
Mechanical Engineering
Stanford University
Stanford, California

TOPIC: **ADVANCED METHODS OF ENHANCING OR CONTROLLING SUPERSONIC COMBUSTION AND SCRAMJET INLET UNSTART**

DATE: Thursday, February 24, 2011

TIME: 3:30 p.m.

PLACE: 138 DeBartolo Hall

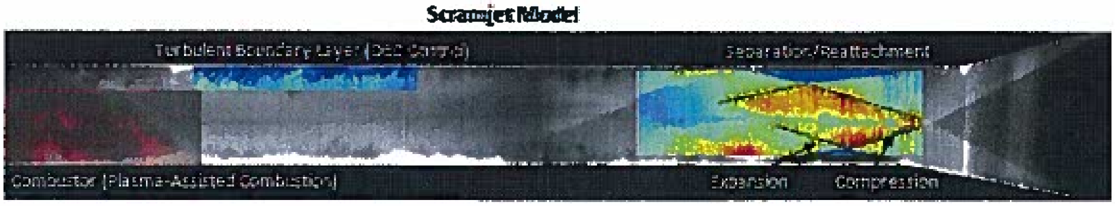
ABSTRACT

Scramjet (Supersonic Combustion Ramjet) engines have been under development over the last several decades as next generation aircraft propulsion technologies. The scramjet engine, like the turbojet or ramjet engine, is an air-breathing engine, drawing in external air for combustion, and is capable of accelerating aircraft to levels far beyond Mach 5. To maximize its net thrust during hypersonic flight, the engine requires supersonic combustion. This seminar discusses a few critical issues and recent research activities related to supersonic combustion enhancement using nonequilibrium plasma discharges and also the problem of aircraft inlet unstart causing in-flight engine malfunctioning, and possible ways to delay it.

Stable combustion is the source of reliable engine thrust. However, flame stabilization in supersonic environments is difficult because of the limited flow residence time in the combustor. Inherent limitations of conventional flame holders, mostly passive devices such as wall cavities, prompted the use of plasma discharges for accelerating combustion reactions and minimizing stagnation pressure loss; flow disturbances inducing shockwaves are the sources of stagnation pressure loss. Plasma discharges, produced by collisions between high energy electrons and neutral gas molecules, can enhance the reactivity of fuel/oxidizer mixtures by exciting internal molecular energy states. Our research focuses on the use of novel plasma concepts for enhancing combustion, with the plasma consuming electrical energy that is several orders of magnitude less than the energy released by combustion. This challenge resulted in the development of a two-stage energy channeling concept, by which nanosecond discharge plasma is used to partially ignite the boundary layer, piloting downstream combustion of an injected fuel stream. The scheme is relatively simple, and requires minor modifications to typical scramjet engine configurations, and can serve as a means of sustaining combustion in adverse flow conditions.

Successful flame holding guarantees reliable thrust, however, its heat release can possibly trigger abrupt loss of thrust (unstart) under certain flight conditions. Excessive heat release from the combustor induces thermal choking that limits incoming air flow resulting in a sudden reduction in thrust. Most of the strategies for avoiding this unstart utilize boundary layer modification techniques although the influence of boundary layers on the unstart process is not well understood. We have carried out unstart studies using various model inlets, distinguished by different wall boundary and incident shock conditions. In this seminar, I will present our findings, including the use of planar laser Rayleigh scattering for flow characterization, and the use of dielectric barrier discharge plasmas for controlling the boundary layers that affect the unstart process.

Scramjet Model



NOTE: ***If you are interested in meeting individually with Dr. Do, please contact Evelyn at 631-5431***