Mechanical and Aerospace Engineering Seminar
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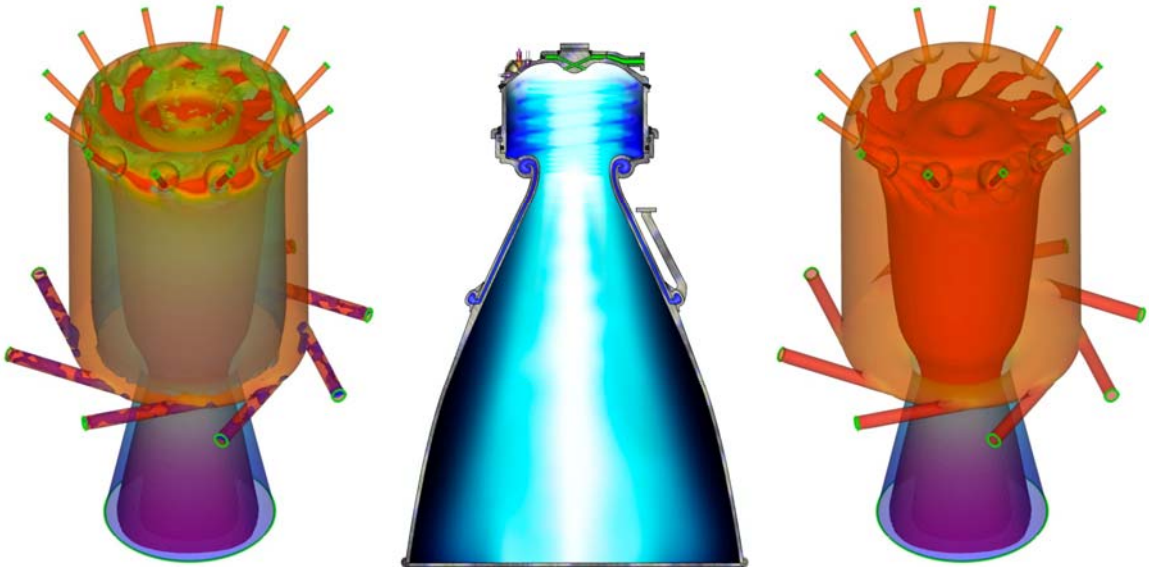
MEC 214

On the Trapped Bidirectional Vortex Engine

Prepared by:
JOE MAJDALANI, PHD, PE
DEPT. OF MECHANICAL, AEROSPACE AND BIOMEDICAL ENGINEERING
THE UNIVERSITY OF TENNESSEE



This talk focuses on the swirl dynamics of the self-cooled Bidirectional Vortex Engine sponsored by AFRL/NASA/ORBITEC; this unconventionally light-weight engine is presently being considered for adoption in next-generation, suborbital space vehicles. The corresponding thrust chamber is a liquid-liquid swirl-driven engine that exploits the motion of a cyclone. The resulting bipolar vortex confines hot combustion products to the inner core region of the engine. The inner vortex is completely surrounded by an outer layer of freshly injected oxidizer. The film-cooling effect derived from the oxidizer stream reduces thermal loading and overall weight. Due to the spiraling path followed by fuel and oxidizer particles, a longer effective chamber length is engendered. The spiraling motion increases both mixing and fuel residence time, thus promoting combustion efficiency. The bidirectional concept was first used in cyclone separators and later applied to hybrid and liquid rocket engines.

BIOGRAPHICAL SKETCH

JOE MAJDALANI, PHD, PE
DEPT. OF MECHANICAL, AEROSPACE AND BIOMEDICAL ENGINEERING
THE UNIVERSITY OF TENNESSEE, SPACE INSTITUTE

Dr. Majdalani received his PhD degree in thermo-fluid science from the University of Utah, Department of Mechanical Engineering, in 1995. Since 1991 he has served as a Teaching Fellow at the University of Utah and as a consultant to several engineering firms. These include Sarcos, the Center for Engineering Design, Halff Associates, Ram Products, Snap-On Tools, S.C. Johnson Wax, S.C. Johnson Professional, Software and Engineering Associates, NASA and Orbital Technologies Corporation (ORBITEC). Between 1997 and 2003 he served as an Assistant and then Associate Professor (with Tenure) in the Department of Mechanical Engineering at Marquette University, Milwaukee. He joined the University of Tennessee in 2003 as the Jack D. Whitfield Professor of High Speed Flows, serving the Department of Mechanical, Aerospace and Biomedical Engineering.

Dr. Majdalani's research devotes itself to the theoretical and numerical modeling of injection and swirl-driven combustion chambers. His interests span thermo-acoustic instabilities, engine internal flowfields, vorticity dynamics, and singular perturbation theory. His research activities since 1997 have materialized in over 130 papers in journal and conference proceedings. His work on core flow modeling of liquid, solid, and hybrid rocket engines has led to the discovery of new solutions to describe cyclonic motions in liquid and hybrid thrust engines, hurricanes, and higher-order injection-driven flowfields. Recently, his work on compressible gas motions has led to the development of a mathematical approach that can be used in lieu of numerical simulations in extracting analytical solutions to high-speed flow problems in multiple dimensions.

Dr. Majdalani received the 1998-1999 College of Engineering Research Award in addition to the 1998-1999 and 1999-2000 Outstanding Teaching Awards from Marquette University. He also received NASA's 2002-2003 and 2003-2004 Faculty Research Infrastructure Awards, the 2002-2003 Higher Education Incentive Award and, from the National Science Foundation, the CAREER Award in 2003 and the International Research and Education in Engineering (IREE) award in 2006. In the Aerospace category, he received the 2007 Ralph R. Teetor Educational Award from SAE International. He is presently a Fellow of ASME, appointed Member of the External Advisory Board, Center for Simulation of Advanced Rockets, University of Illinois, and designated AIAA Technical Expert in Analytic Approaches to Hybrid Rocket Flowfields.