Operation Of A Cryogenic Rocket Engine

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Rocket Propulsion Elements AIAA
This book teaches the reader to build rockets--powered by compressed air, water, and solid propellant--with the maximum possible fun, safety, and educational experience. Make: Rockets is for all the science geeks who look at the moon and try to figure out where Neil Armstrong walked, watch in awe as rockets lift off, and want to fly their own model rockets. Starting with the basics of rocket propulsion, readers will start out making rockets made from stuff lying around the house, and then move on up to air-, water-, and solid propellant-powered rockets. Most of the rockets in the book can be built from parts in the Estes Designer Special kit.

A Physical Hypothesis for the Combustion Instability in Cryogenic Liquid Rocket Engines (Preprint). Springer
The book follows a unified approach to present the basic principles of rocket propulsion in concise and lucid form. This textbook comprises of ten chapters ranging from brief introduction and elements of rocket propulsion, aerothermodynamics to solid, liquid and hybrid propellant rocket engines with chapter on electrical propulsion. Worked out examples are also provided at the end of chapter for understanding uncertainty analysis. This book is designed and developed as an introductory text on the fundamental aspects of rocket propulsion for both undergraduate and graduate students. It is also aimed towards practicing engineers in the field of space engineering. This comprehensive guide also provides adequate problems for audience to understand intricate aspects of rocket propulsion enabling them to design and develop rocket engines for peaceful purposes.

Modern Engineering for Design of Liquid-Propellant Rocket Engines John Wiley & Sons
The key to opening the use of space to private enterprise and to broader public uses lies in reducing the cost of the transportation to space. More routine, affordable access to space will entail aircraft-like quick turnaround and reliable operations. Currently, the space Shuttle is the only reusable launch vehicle, and even parts of it are expendable while other parts require frequent and extensive refurbishment. NASA's highest priority new activity, the Reusable Launch Vehicle program, is directed toward developing technologies to enable a new generation of space launchers, perhaps but not necessarily with single stage to orbit capability. This book assesses whether the technology development, test and analysis programs in propulsion and materials-related technologies are properly constituted to provide the information required to support a December 1996 decision to build the X-33, a technology demonstrator vehicle; and suggest, as appropriate, necessary changes in these programs to ensure that they will support vehicle feasibility goals.

Characterization of Cryogenic Solid Hybrid Rocket Motors **Maker Media, Inc.**
Self-sustaining pressure oscillations in the combustion chamber, or combustion instability, is a commonly encountered and potentially damaging phenomenon in liquid propellant rocket engines (LPREs). In the high-frequency variety of combustion instability, the pressure oscillations in the combustion chamber take on the form and frequency of an acoustic resonance mode of the combustion chamber volume. The most common mode in naturally occurring instability, and also the most destructive, is the first tangential mode, with acoustic gas oscillations oriented transversally to the direction of propellant injection. The instability is driven by the coupling between acoustic oscillations and unsteady energy release from combustion. The mechanisms through which injection and combustion firstly respond to the acoustic field, and secondly feed energy back into the acoustic field have not yet been fully characterised. Shear coaxial-type injectors are common in LPREs. Past experimental and numerical research efforts have investigated the interaction between this type of injector and transverse acoustic fields. Some experimental efforts have successfully forced transverse acoustic modes and studied their influence on shear coaxial injection under LPRE-like conditions. Acoustic forcing of coaxially injected LOx/H2 has previously been conducted only at low pressures and injection performance levels. This work addresses the lack of experimental data available for the interaction of shear coaxial injection of LOx/H2 with acoustics under conditions representative of industrial engines. A new experimental rocket combustor, designated 'BKH', was developed for investigating the response of a reacting spray of coaxially injected LOx/H2 to an acoustic field. For characterising the response, simultaneous high-speed recordings of both backlit shadowgraph and hydroxyl radical (OH*) chemiluminescence imaging have been captured through optical access windows. The operating conditions of BKH extend to conditions more representative of actual LPREs than has previously been achieved with LOx/H2 in studies of flame-acoustic interaction. BKH was run at pressures of 40 or 60 bar, which correspond to subcritical and supercritical thermo-physical regimes for oxygen. Hydrogen injection temperature was ambient, around 290 K, or cryogenic, around 50 K. An array of multiple injectors was used to better represent real engines. A system for modulating the nozzle exhaust flow was used to induce acoustic perturbations inside the combustion chamber. Two types of perturbation were applied to the near-injection region; oscillating acoustic pressure, and oscillating transverse acoustic velocity. BKH was used to investigate how subcritical or supercritical pressure level and ambient or cryogenic hydrogen injection temperature influence the interaction of acoustic pressure or velocity with injection and combustion processes. Shadowgraph imaging reveals up to 70% reduction in the length of the oxygen jet when subjected to acoustic velocity of amplitude approaching that of the hydrogen injection velocity. Furthermore, the mode of jet breakup changes from its natural growth-and-detachment behaviour to a 'transverse stripping' mechanism. OH* imaging reveals a corresponding decrease in the extent of the flame, and increase in emission intensity. When subjected to acoustic pressure, OH* emission from the flame was observed to fluctuate in phase with pressure. Thus, responses to both acoustic pressure and velocity have been observed in BKH, which together may form the basis of a coupling mechanism for driving natural combustion instability in LPREs.

Internal Combustion Processes of Liquid Rocket Engines BoD – Books on Demand
Explores aeronautical and space chemical propulsion. The book provides an understanding of propulsion systems through illustrative description of the systems; analysis of modeled systems; examination of the performance of real systems in this light; and a comparative assessment of aeronautical and space propulsion system elements.

National Academies Press
As the subject of tribology comprises lubrication, friction and wear of contact components highly relevant to practical applications, it challenges scientists from chemistry, physics and materials engineering around the world on todays sophisticated experimental and theoretical foundation to complex interdisciplinary research. Recent results and developments are preferably presented and evaluated in the context of established knowledge. Consisting of eleven chapters divided into the four parts of Lubrication and Properties of Lubricants, Boundary Lubrication Applications, Testing and Modeling, and Sustainability of Tribosystems, this textbook therefore merges basic concepts with new findings and approaches. Tribology Fundamentals and Advancements, supported by competent authors, aims to convey current research trends in the light of the state of the art to students, scientists and practitioners and help them solve their problems.

Make: Rockets John Wiley & Sons
The updated and expanded third edition of this book focuses on the multi-disciplinary coupling between flight-vehicle hardware alternatives and enabling propulsion systems. It discusses how to match near-term and far-term aerospace vehicles to missions and provides a comprehensive overview of the subject, directly contributing to the next-generation space infrastructure, from space tourism to space exploration. This holistic treatment defines a mission portfolio addressing near-term to long-term space transportation needs covering sub-orbital, orbital and escape flight profiles. In this context, a vehicle configuration classification is introduced covering alternatives starting from the dawn of space access. A best-practice parametric sizing approach is introduced to correctly design the flight vehicle for the mission. This technique balances required mission with the available vehicle solution space and is an essential capability sought after by technology forecasters and strategic planners alike.

Fundamental Concepts of Liquid-Propellant Rocket Engines AIAA
A modern pedagogical treatment of the latest industry trends in rocket propulsion, developed from the authors' extensive experience in both industry and academia. Students are guided along a step-by-step journey through modern rocket propulsion, beginning with the historical context and an introduction to top-level performance measures, and progressing on to in-depth discussions of the chemical aspects of fluid flow combustion thermochemistry and chemical equilibrium, solid, liquid, and hybrid rocket propellants, mission requirements, and an overview of electric propulsion. With a wealth of homework problems (and a solutions manual for instructors online), real-life case studies and examples throughout, and an appendix detailing key numerical methods and links to additional online resources, this is a must-have guide for senior and first year graduate students looking to gain a thorough understanding of the topic along with practical tools that can be applied in industry.

Future Spacecraft Propulsion Systems and Integration Springer Science & Business Media
Operation of a Cryogenic Rocket EngineSpringer Science & Business Media

Proceedings of the Twentieth International Cryogenic Engineering Conference (ICEC20) National Academies Press
This book is intended for students and engineers who design and develop liquid-propellant rocket engines, offering them a guide to the theory and practice alike. It first presents the fundamental concepts (the generation of thrust, the gas flow through the combustion chamber and the nozzle, the liquid propellants used, and the combustion process) and then qualitatively and quantitatively describes the principal components involved (the combustion chamber, nozzle, feed systems, control systems, valves, propellant tanks, and interconnecting elements). The book includes extensive data on existing engines, typical values for design parameters, and worked-out examples of how the concepts discussed can be applied, helping readers integrate them in their own work. Detailed bibliographical references (including books, articles, and items from the “ gray literature ”) are provided at the end of each chapter, together with information on valuable resources that can be found online. Given its scope, the book will be of particular interest to undergraduate and graduate students of aerospace engineering.

NASA Authorization for Fiscal Year 1964 Createspace Independent Publishing Platform
This paper describes a space infrastructure concept that exploits lunar water for propellant production and delivers it to users in cis-lunar space. The goal is to provide responsive economical space transportation to destinations beyond low Earth orbit (LEO) and enable in-space commerce. This is a game changing concept that could fundamentally affect future space operations, provide greater access to space beyond LEO, and broaden participation in space exploration. The challenge is to minimize infrastructure development cost while achieving a low operational cost. This study discusses the evolutionary development of the infrastructure from a very modest robotic operation to one that is capable of supporting human operations. The cis-lunar infrastructure involves a mix of technologies including cryogenic propellant production, reusable lunar landers, propellant tankers, orbital transfer vehicles, aerobraking technologies, and electric propulsion. This cislunar propellant infrastructure replaces Earth-launched propellants for missions beyond LEO. It enables users to reach destinations with smaller launchers or effectively multiplies the user s existing payload capacity. Users can exploit the expanded capacity to launch logistics material that can then be traded with the infrastructure for propellants. This mutually beneficial trade between the cis-lunar infrastructure and propellant users forms the basis of in-space commerce. Oeftering, Richard C. Glenn Research Center CISLUNAR SPACE; COMMERCE; PROPELLANTS; EXTRATERRESTRIAL WATER; SPACE TRANSPORTATION; LOW EARTH ORBITS; SPACE EXPLORATION; LUNAR RESOURCES; GEOSYNCHRONOUS ORBITS; LUNAR SURFACE; AEROSHELLS; COSTS; LUNAR LOGISTICS; LUNAR LANDING; ORBIT TRANSFER VEHICLES; CRYOGENIC ROCKET PROPELLANTS; AEROBRAKING; CRYOGENICS

U.S. Government Research & Development Reports Elsevier
"Scientific CMOS image sensors have lower read noise and dark current than charge coupled devices. They are also uniquely qualified for operation at cryogenic temperatures due to their MOSFET pixel architecture. This paper

follows the design of a cryogenic imaging system to be used as a star tracking rocket attitude regulation system. The detector was proven to retain almost all its sensitivity at cryogenic temperatures with acceptably low read noise. Once the star tracker successfully maintains rocket attitude during the flight of the CIBER-2 experiment, the technology readiness level of scientific CMOS detectors will advance enough that they could see potential applications in deep space imaging experiments."--Abstract.

Reusable Launch Vehicle Springer Nature

This newly reissued debut book in the Rutgers University Press Classics Imprint is the story of the search for a rocket propellant which could be trusted to take man into space. This search was a hazardous enterprise carried out by rival labs who worked against the known laws of nature, with no guarantee of success or safety. Acclaimed scientist and sci-fi author John Drury Clark writes with irreverent and eyewitness immediacy about the development of the explosive fuels strong enough to negate the relentless restraints of gravity. The resulting volume is as much a memoir as a work of history, sharing a behind-the-scenes view of an enterprise which eventually took men to the moon, missiles to the planets, and satellites to outer space. A classic work in the history of science, and described as “ a good book on rocket stuff···that ’ s a really fun one ” by SpaceX founder Elon Musk, readers will want to get their hands on this influential classic, available for the first time in decades.

Advanced Cryogenic Solid Hybrid Rocket Engine Developments: Concept and Test Results Springer Science & Business Media

This book concentrates on modeling and numerical simulations of combustion in liquid rocket engines, covering liquid propellant atomization, evaporation of liquid droplets, turbulent flows, turbulent combustion, heat transfer, and combustion instability. It presents some state of the art models and numerical methodologies in this area. The book can be categorized into two parts. Part 1 describes the modeling for each subtopic of the combustion process in the liquid rocket engines. Part 2 presents detailed numerical methodology and several representative applications in simulations of rocket engine combustion.

Experimental Investigation of High Frequency Combustion Instability in Cryogenic Oxygen-hydrogen Rocket Engines CRC Press

The 1961 Cryogenic Engineering Conference Committee is pleased to present the papers of the 1961 Cryogenic Engineering Conference. We are grateful to have had the University of Michigan at Ann Arbor, Michigan as our host for the seventh annual meeting of this group. The Conference Committee in presenting the papers oftbis Conference takes this opportunity to acknowledge the assistance of an Editorial Committee in the selection of papers for the program. Since over one hundred and twenty papers were submitted, their task of screening and evaluating the papers was a dif ficult one. The Committee guided by G. j. V an Wylen, who also served as chair man of the Conference Committee, included R. W. Arnett, B. W. Birmingham, D. B. Chelton, R. j. Corruccini, C. j. Guntner, M. j. Hiza, R. B. jacobs, A. J. Kidnay, R. H. Kropschot, j. Macinko, D. B. Mann, R. P. Mikesell, R. L. Powell, J. R. Purcell, R. P. Reed, R. j. Richards, A. F. Schmidt, R. B. Stewart, and K. A. Warren.

Rocket Propulsion Rutgers University Press

The definitive text on rocket propulsion—now revised to reflect advancements in the field For sixty years, Sutton's Rocket Propulsion Elements has been regarded as the single most authoritative sourcebook on rocket propulsion technology. As with the previous edition, coauthored with Oscar Biblarz, the Eighth Edition of Rocket Propulsion Elements offers a thorough introduction to basic principles of rocket propulsion for guided missiles, space flight, or satellite flight. It describes the physical mechanisms and designs for various types of rockets' and provides an understanding of how rocket propulsion is applied to flying vehicles. Updated and strengthened throughout, the Eighth Edition explores: The fundamentals of rocket propulsion, its essential technologies, and its key design rationale The various types of rocket propulsion systems, physical phenomena, and essential relationships The latest advances in the field such as changes in materials, systems design, propellants, applications, and manufacturing technologies, with a separate new chapter devoted to turbopumps Liquid propellant rocket engines and solid propellant rocket motors, the two most prevalent of the rocket propulsion systems, with in-depth consideration of advances in hybrid rockets and electrical space propulsion Comprehensive and coherently organized, this seminal text guides readers evenhandedly through the complex factors that shape rocket propulsion, with both theory and practical design considerations. Professional engineers in the aerospace and defense industries as well as students in mechanical and aerospace engineering will find this updated classic indispensable for its scope of coverage and utility.

Rocket Propulsion Elements Springer

Equips students with an up-to-date practical knowledge of rocket propulsion, numerous homework problems, and online self-study materials.

Ignition! Operation of a Cryogenic Rocket Engine

ORBITEC has conducted considerable R & D under various USAF and NASA contracts and company sponsored efforts to develop a new class of rocket propulsion devices, cryogenic solid rocket engines The basic concept of these engines is to freeze a propellant which is normally a gas at room temperature into a solid propellant grain. This solid grain is then combusted with a second propellant These rocket engines promise a number of advantages over conventional liquid rocket engines, including increased simplicity, safety, propellant density, and potentially performance with the addition of High-Energy Density Matter (HEDM's). ORBITEC has tested cryogenic solid hybrid rocket engines including the following propellant combinations: (1) solid oxygen/gaseous hydrogen; (2) solid hydrogen/gaseous oxygen; (3) solid methane/gaseous oxygen; and (4) solid methane-aluminum/gaseous oxygen. The primary focus of this paper is on solid oxygen/gaseous hydrogen. Work achieved to date includes: (1) a total of over 50 solid oxygen test firings; (2) establishment of regression rate data for the different propellant combinations, where the rates can be a factor of 20 to 40 times higher than conventional HTPB-based hybrids; (3) achievement of burn durations from 1 to 30 seconds; and (4) engine chamber pressures as high as 250 psi The potential applications include. research devices to test high-energy density matter (HEDM); hybrid rocket launch vehicle upper stages; or orbit transfer vehicles. During a current sponsored USAF Research Laboratory (RL, Edwards Air Force Base, CA) project, ORBITEC is to design, develop and test a larger, SOX/LH2 flight-type engine that will have throttling and O/F ratio control.

Operation of a Cryogenic Rocket Engine Springer Science & Business Media

"CMOS and sCMOS image sensors are a cost-effective alternative to the more common CCD based experimental sensors. While often being less favored than CCDs at room temperature, CMOS image sensors have a better performance at lower temperatures and are the only of the two highly used technologies that is viable at cryogenic temperatures. This paper discusses development iterations of the star tracking rocket attitude regulation system (CSTARS). This includes discussions of the cryogenic operation of CMOS sensors as well as operating in and interfacing with a NASA sounding rocket as a star tracking system. Both iterations of the project have proved effective in operating sCMOS image sensors at cryogenic temperatures with low read noise. Star tracking has also been successful in the second iteration of the system, which is scheduled to fly with the CIBER-2 sounding rocket experiment. A successful flight with CIBER-2 would prove the readiness of sCMOS sensors for cryogenic operation in a real world application."--Abstract.

Tribology Cambridge University Press

This book presents the operational aspects of the rocket engine on a test facility. It will be useful to engineers and scientists who are in touch with the test facility. To aerospace students it shall provide an insight of the job on the test facility. And to interested readers it shall provide an impression of this thrilling area of aerospace.