Design of Liquid Propellant Rocket Engines


Modern Engineering for Design of Liquid-Propellant Rocket Engines

Demilitarisation of Munitions

The report presents theory and calculations of mechanics involved in operation of a liquid rocket engine.

Rocket Development


This book intends to build a bridge for the student and the young engineer: to link the rocket propulsion fundamentals and elements (which are well covered in the literature) with the actual rocket engine design and development work as it is carried out in industry (which is very little, if at all covered in literature). The book attempts to further the understanding of the realistic application of liquid rocket propulsion theories, and to help avoid or at least reduce time and money consuming errors and disappointments. In so doing, it also attempts to digest and consolidate numerous closely related subjects, hitherto often treated as separate, bringing them up to date at the same time.

Modern Engineering for Design of Liquid-Propellant Rocket Engines

Under NASA Glenn Research Center sponsorship, MIT has developed the concept of micromachined, bipropellant, liquid rocket engines. This is potentially a breakthrough technology changing the cost-performance tradeoffs for small propulsion systems, enabling new applications, and redefining the meaning of the term low-cost-access-to-space. With this NASA support, a liquid-cooled, gaseous propellant version of the thrust chamber and nozzle was designed, built, and tested as a first step. DARPA is currently funding MIT to demonstrate turbopumps and controls. The work performed herein was the second year of a proposed three-year effort to develop the technology and demonstrate very high power density, regeneratively cooled, liquid bipropellant rocket engine thrust chamber and nozzles. When combined with the DARPA turbopumps and controls, this work would enable the design and demonstration of a complete rocket propulsion system. The original MIT-NASA concept used liquid oxygen-ethanol propellants. The military applications important to DARPA imply that storable liquid propellants are needed. Thus, MIT examined various storable propellant combinations including N2O4 and hydrazine, and H2O2 and various hydrocarbons. The latter are preferred since they do not have the toxicity of N2O4 and hydrazine. In refection of the newfound interest in H2O2, it is once again in production and available commercially. A critical issue for the microrocket engine concept is cooling of the walls in a regenerative design. This is even more important at microscale than for larger engines due to cube-square scaling considerations. Furthermore, the coolant behavior of rocket propellants has not been characterized at microscale. Therefore, MIT designed and constructed an apparatus expressly for this purpose. The report details measurements of two candidate microrocket fuels, JP-7 and JP-10. Epstein, Alan H. and Joppin, C. and Kerrebrock, J. L. and Schneider, Steven J. (Technical Monitor) Glenn Rese

Demilitarisation of Munitions

In recent years, it has been important for scientists and chemical industries to introduce and develop new liquid fuels as jet fuels and propellants for propulsion purposes. Different aspects should be considered for the selection of a good candidate such as combustion performance, desired physical properties, noncarcinogenic and less toxicity. New synthetic hydrocarbon fuels with favorable combustion performance and physical properties have been considered as desirable jet fuels. They can be used in aircrafts such as military jets because of their higher volumetric energy density. A liquid-propellant rocket uses liquid propellants for propulsion. Liquid propellants should have the desirable properties of high energy density per unit mass, high specific impulse, and short ignition delays. Hypergolic propellants as important classes of liquid propellants are characterized by spontaneous reaction upon fuel and oxidizer mixing and high energy yield. Moreover, they should be relatively ignitable and have a small ignition time delay. This book reviews some efforts that have been done to introduce new candidates to replace conventional hydrazine fuels because they are acutely toxic and suspected carcinogens, costly safety precautions and handling procedures are required. This book reviews the latest advances in liquid fuels, which may be used as jet fuels and liquid propellants. Important properties for assessment of a suitable liquid are demonstrated. This book can be used for graduate students in the field of chemistry and chemical engineering. It may also be useful for scientists and researchers who work on the development of new liquid fuels with high performance as well as those that are noncarcinogenic or have less toxicity.

The Science and Design of the Hybrid Rocket Engine

This is a textbook about rocket engineering, concentrating on the nitrous oxide hybrid rocket engine, both small and large. It's also a book about the science of chemical rockets in detail: three of the chapters are full of in-depth rocket science describing how all chemical rockets work. After a first chapter bringing on the science and maths you'll need, the book describes the choice and safe use of hybrid rocket propellants, and how they're handled in practice. Then there are the rocket science chapters. Then you learn how to design, construct, and operate, a large hybrid rocket engine capable of getting you into Space. The book also includes a practical guide to the testing of hybrid rocket engines large and small, and how to fly them safely. Included are full instructions for programming a rocket trajectory simulator in Microsoft Excel, and several appendices containing rocketry information and equations, and instructions on how to design a bell nozzle.

History of Liquid Propellant Rocket Engines
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.

Rocket and Spacecraft Propulsion

Annihilation Since the invention of the V-2 rocket during World War II, combustion instabilities have been recognized as one of the most difficult problems in the development of liquid propellant rocket engines. This book is the first published in the United States on the subject since NASA's Liquid Rocket Combustion Instability (NASA SP-194) in 1972. In this book, experts cover four major subject areas: engine phenomenology and case studies, fundamental mechanisms of combustion instability, combustion instability analysis, and engine and component testing. Especially noteworthy is the inclusion of technical information from Russia and China—a first.

Modern Engineering for Design of Liquid-Propellant Rocket Engines

This is the first book in the literature to cover the development and testing practices for liquid rocket engines in Russia and the former Soviet Union. Combustion instability represents one of the most challenging problems in the development of propulsion engines. A famous example is the F-1 engines for the first stage of the Saturn V launch vehicles in the Apollo project. More than 2000 full engine tests and a vast number of design modifications were conducted to cure the instability problem. This book contains first-hand information about the testing and development practices for treating liquid rocket combustion-instability problems in Russia and the former Soviet Union. It covers more than 50 years of research, with an emphasis placed on the advances made since 1970. The book was prepared by a former R&D director of the Research Institute of Chemical Engineering, NICHIMMASH, the largest liquid rocket testing center in the world, and has been carefully edited by three well-known experts in the field.

Progress In Astronautics and Aeronautics

This is the first major publication on liquid-rocket combustion devices since 1960, and includes 20 chapters prepared by world-renowned experts. Each chapter focuses on a specific aspect of liquid-propellant combustion and thrust chamber dynamics, and is incorporated into the volume in a well-organized, cohesive manner. There are contributions from nine different countries: China, France, Germany, Italy, Japan, the Netherlands, Russia, Sweden, and the United States.

Liquid Rocket Thrust Chambers

Propellant Spray Combustion Processes During Stable and Unstable Liquid Rocket Combustion

The purpose of this program is the acquisition of detailed analytical and experimental information concerning the mechanisms of energy addition from propellant spray combustion to steady flow fields and propagating pressure disturbances. Data are to be obtained and used to evaluate present or formulate new expressions describing the dynamics that contribute to the coupling processes between the spray and gas flow fields. These expressions appear in steady-state and transient propellant combustion models and bear directly on the prediction of performance and onset of high frequency combustion instability in liquid propellant rocket engines. To overcome past difficulties in comparing analytical and experimental results, an experimental apparatus which produces a monodisperse propellant spray uniformly distributed throughout the combustor has been built. The motor, to be operated as a rocket engine combustor under either stable or transient conditions, provides for optical observation and is extensively instrumented to record pressure wave amplification or decay as a function of parameter variation. Test data (drop diameters, velocity and pressure wave growth or decay as functions of chamber length and initial conditions) can be input to the newly-developed combustion models and the validity of the coupling term expressions evaluated by directly comparing the resulting predictions to experimental data. These newly-developed combustion models are described in detail.

A Review of United States Air Force and Department of Defense Aerospace Propulsion Needs

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.

The Conversion of Liquid Rocket Fuels, Risk Assessment, Technology and Treatment Options for the Conversion of Abandoned Liquid Ballistic Missile Propellants (Fuels and Oxidizers) in Azerbaijan

Rocket and air-breathing propulsion systems are the foundation on which planning for future aerospace systems rests. A Review of United States Air Force and Department of Defense Aerospace Propulsion Needs assesses the existing technical base in these areas and examines the future Air Force capabilities the base will be expected to support. This report also defines gaps and recommends where future warfighter capabilities not yet fully defined could be met by current science and technology development plans.

Internal Combustion Processes of Liquid Rocket Engines

Prof. Dr. -Ing. Wolfgang Spyra Brandenburg University of Technology in Cottbus, Germany. The demilitarization and conversion of military properties worldwide has been a topic of growing importance since the end of the Cold War. The slowing of the arms race brought on by weapons treaties and relaxed tensions between NATO and Warsaw Pact nations caused sizable numbers of conventional weapons to become superfluous. The need to process and dispose of such weapons began more quickly in NATO countries. This demilitarization process began shortly after the reunification of Germany and was largely completed by the mid to late 1990's. The remaining process, no small task in itself, of converting lands formerly used by the military into safe and environmentally acceptable landscapes may continue for decades to come. Due to a lack of resources and technology, the process of demilitarization in the former Warsaw Pact countries has launched more slowly. In 2002 both Georgia and Moldova finished projects which destroyed their stocks of liquid ballistic missile components. Both these projects were carried out through the cooperative support of trans-national organizations, private contractors, and research institutions. The Republic of Azerbaijan now finds itself at the beginning of its demilitarization process. Stored at the country's military depots are over 2000 tons of missile fuels, oxidizer, and chemical additives. This hazardous waste is kept in tanks intended only for temporary transport.
and storage.

The Chemistry of Propellants

This is a new release of the original 1960 edition.

Ignition!

Concentrates on the subject of rock propulsion, its basic technology, performance and design rationale. Provides an introduction to the subject, an understanding of basic principles, a description of their physical mechanisms and designs, and an understanding of the application of rocket propulsion to flying vehicles.

Solid Rocket Propulsion Technology

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.

Fundamentals of Theory and Calculation of Liquid-propellant Rocket Engines

Motion, Sound, and Heat.

History of Liquid Propellant Rocket Engines

This book, a translation of the French title Technologie des Propergols Solides, offers otherwise unavailable information on the subject of solid propellants and their use in rocket propulsion. The fundamentals of rocket propulsion are developed in chapter one and detailed descriptions of concepts covered in the following chapters. Specific design methods and the theoretical physics underlying them are presented, and finally the industrial production of the propellant itself is explained. The material used in the book has been collected from different countries, as the development of this field has occurred separately due to the classified nature of the subject. Thus the reader not only has an overall picture of solid rocket propulsion technology but a comprehensive view of its different developmental permutations worldwide.

Liquid Propellant Rockets

Hitherto the disposal of munitions was mostly concerned with obsolete stocks, but the political developments in the states of the former Soviet Union have necessitated the disposal of vast quantities of current and obsolete stocks. Obviously, open burning/open detonation cannot be used on such a large scale, not least for environmental considerations. There are two main technical problems associated with the disposal of munitions on the scale required. First, the materials are not simple wastes or rubbish. Their handling, storage, packaging and transportation are subject to very rigid regulation, and justifiably so, for obvious reasons. Second, they are very valuable goods, for which a high price has been paid by the holding states’ economic systems. Mere destruction would mean the irretrivable loss of the value invested. But therein lies the problem. Goods like steel or brass scrap can easily be reclaimed, but hypergols and other rocket fuels (for instance) represent a true chemical challenge, while, under certain conditions, explosives may be diverted to civilian use. This, in summary, is the problem that the present book deals with: the two-pronged attack involving demilitarization and recycling technologies.

Solid Propellant Rocket Research

Chemical Rocket Propulsion

Liquid Hydrogen as a Propulsion Fuel, 1945-1959

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.

Fundamentals of Astrodynamics

Liquid propellant rocket engines have propelled all the manned space flights, all the space vehicles flying to the planets or deep space, virtually all satellites, and the majority of medium range or intercontinental range ballistic missiles.

LIQUID ROCKET ENGINE

Over the course of the history of today’s rockets, liquid rocket engines have been used as primary propulsion for most space launch vehicles and early ballistic missiles. The basic idea of modern liquid rocket propulsion was first published in 1903. In the early 1900s, various design concepts were
introduced, built and tested to explore the feasibility of liquid propulsion technology. The first successful flight with a liquid-propellant sounding rocket was made in 1926. A large engine development effort started in the 1930s as part of the world's first ballistic missile program with its first deployment in 1944. Subsequently, several major engine efforts were undertaken for longer range ballistic missiles, enabling intercontinental ballistic missile (ICBM) capability in 1957. Space launch vehicles evolved immediately from ICBMs and opened the door to space in 1957 and finally to the moon in 1969. Since then, various classes of operational liquid rocket engines have been designed, developed and flown with a continued increase in confidence. In general, liquid rocket engines enable a wide range of space lift capabilities from small to large payloads. Many satellites, spacecrafts and upper stages also use smaller liquid rocket engines, typically called thrusters, for orbit maneuvering or reaction control. Today, continued improvements in performance, reliability, operability and cost are sought through various research and development efforts.

Liquid Propulsion: Historical Overview, Fundamentals and Classifications of Liquid Rocket Engines

Developed and expanded from the work presented at the New Energetic Materials and Propulsion Techniques for Space Exploration workshop in June 2014, this book contains new scientific results, up-to-date reviews, and inspiring perspectives in a number of areas related to the energetic aspects of chemical rocket propulsion. This collection covers the entire life of energetic materials from their conceptual formulation to practical manufacturing; it includes coverage of theoretical and experimental ballistics, performance properties, as well as laboratory-scale and full system-scale, handling, hazards, environment, ageing, and disposal. Chemical Rocket Propulsion is a unique work, where a selection of accomplished experts from the pioneering era of space propulsion and current technologists from the most advanced international laboratories discuss the future of chemical rocket propulsion for access to, and exploration of, space. It will be of interest to both postgraduate and final-year undergraduate students in aerospace engineering, and practicing aeronautical engineers and designers, especially those with an interest in propulsion, as well as researchers in energetic materials.

Microfabricated Liquid Rocket Motors

Rocket Propulsion Elements

The revised edition of this practical, hands-on book discusses the launch vehicles in use today throughout the world, and includes the latest details on advanced systems being developed, such as electric and nuclear propulsion. The author covers the fundamentals, from the basic principles of rocket propulsion and vehicle dynamics through the theory and practice of liquid and solid propellant motors, to new and future developments. He provides a serious exposition of the principles and practice of rocket propulsion, from the point of view of the user who is not an engineering specialist.

Rocket Engine Combustion Instability

This book intends to build a bridge for the student and the young engineer: to link the rocket propulsion fundamentals and elements with the actual rocket engine design and development work as it is carried out in the industry. The book attempts to further the understanding of the realistic application of liquid rocket propulsion theories, and to help avoid or at least reduce time and money consuming errors and disappointments. This book was written "on the job" for use by those active in all phases of engine systems, design, development, and application, in industry.

Liquid Rocket Valve Components

Combustion Instabilities in Liquid Rocket Engines

The Chemistry of Propellants is a collection of papers and comments presented at the meeting on "The Chemistry of Propellants", held in Paris, France on June 8-12, 1959, organized by the AGARD Combustion and Propulsion Panel. This book is organized into six parts encompassing 25 chapters that serve as an introduction to the broad and important subject of propellant chemistry and propulsion applications. The first part deals with the sources, availability, and comparative costing of propulsion system. The second and third parts discuss the theoretical, thermodynamic, and experimental aspects of liquid and solid propellants. The fourth part examines the main problems concerning preparation, storage, and use of propellants for ramjet, while the fifth part looks into the factors leading to deposits in jet engines and some of the consequences of their existence. The sixth part covers the advantages of the high energy chemical propellants, including fluorine and hydrogen. Combustion and propulsion scientists and researchers will find this book beneficial.

Ignition

Widely known and used throughout the astrodynamics and aerospace engineering communities, this teaching text was developed at the U.S. Air Force Academy. Completely revised and updated 2013 edition.

Understanding Physics

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 restraint 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.

Fundamentals of Rocket Propulsion

If the United States hopes to continue as a leader in space, it must invest now in better earth-to-orbit technology by replacing obsolete launch facilities while also developing a new class of more robust and reliable vehicles. From Earth to Orbit provides strategies to reduce launch costs while increasing the reliability and resiliency of vehicles. It also recommends continued improvements for the Space Shuttle Orbiter and its subsystems and the development of a Space Transportation Main Engine (STME).

Fundamental Concepts of Liquid-Propellant Rocket Engines
David Altman, James M. Carter, S. S. Penner, Martin Summerfield. High Temperature Equilibrium, Expansion Processes, Combustion of Liquid Propellants, The Liquid Propellants Rocket Engine. Originally published in 1960. The Princeton Legacy Library uses the latest print-on-demand technology to again make available previously out-of-print books from the distinguished backlist of Princeton University Press. These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions. The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905.

Rocket Propulsion

Solid Propellant Rocket Research

Liquid Fuels As Jet Fuels and Propellants

From Earth to Orbit

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.

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