Operation Of A Cryogenic Rocket Engine

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Technical Abstract Bulletin Springer Science & Business Media
The 1960 Cryogenic Engineering Conference Committee is pleased to present the papers of the 1960 Cryogenic Engineering Conference. Discussion of the papers, wherever available, has also been included to make the papers more valuable and interesting to the reader. This annual meeting once again has been held in Boulder, Colorado. Many delegates will recall that similar meetings were held in Boulder in 1954, 1956 and 1957. However, this year, because of the continued growth of this conference, the National Bureau of Standards Boulder Laboratories was joined by the College of Engineering of the University of Colorado in hosting this sixth national con ference. The Cryogenic Engineering Conference Committee is happy to acknowledge the help of an Editorial Committee which contributed valuable assistance in the difficult and thankless task of screening the preliminary papers and also re viewing the final drafts. This committee headedby R. B. jacobs, who also served as chairman for the Conference Committee, consisted of R. W. Arnett, D. B. Chelton, R. J. Corruccini, T. M. Flynn, R. H. Kropschot, R. M. McClintock, A. F. Schmidt, L. E. Scott and W. A. Wilson.
Liquid Rocket Valve Components AIAA
Development of cryogenic storage systems for manned space flight.
Spacecraft Thermal Control Handbook: Cryogenics Springer Science & Business Media
Introduces advanced mathematical tools for the modeling, simulation, and analysis of chemical non-equilibrium phenomena in combustion and flows, following a detailed explanation of the basics of thermodynamics and chemical kinetics of reactive mixtures. Researchers, practitioners, lecturers, and graduate students will find this work valuable.
Management of Cryogenic Propellants in a Full-scale Orbiting Space Vehicle AIAA
Equips students with an up-to-date practical knowledge of rocket propulsion, numerous homework problems, and online self-study materials.
Advances in Cryogenic Engineering Elsevier
Particularly in the upper stage development of rockets (launchers), gravity dominated fluid motion in upper stage tanks (sloshing) during flight represents an undesired dynamic effect. On the one hand the sloshing forces lead to disturbances, which have to be compensated by the reaction control system. On the other hand, when cryogenic fluids are considered, the fluctuations in tank pressure may be critical under some circumstances compromising the structural stability of the tank. In this field, the utilization of cryogenic propellants represents a high challenge to layout and design of the propulsion components including the propellant tanks. This work deals with two effects that are directly coupled to the sloshing content inside the propellant tank. To investigate these effects a dedicated test setup has been developed. At first, the damping characteristics of sloshing cryogenic nitrogen - which is used as a substitute for the rocket propellants liquid hydrogen and liquid oxygen - are determined. The results are correlated to the theory based on storable propellants. The main part of this work is linked to a characteristic pressure drop inside the propellant tank caused by the sloshing liquid. For the effect to occur, the tank must be pressurized to enable the formation of a thermal stratification below the liquid surface. Sloshing leads to the mixing of liquid in this region with subcooled liquid from the bulk. This affects the decrease of the temperature at the free surface leading to the condensation of superheated vapor. Thus, the pressure in the tank must decreases. Three different pressurization concepts are introduced in this work; self-pressurization where the tank is pressurized by evaporating liquid caused by the heat flowing into the tank. Furthermore, the tank is pressurized with gaseous nitrogen taken from an external gas bottle and at last gaseous helium from an external supply is used for pressurization purpose. By the application of helium as no
Advanced Cryogenic Solid Hybrid Rocket Engine Developments: Concept and Test Results Springer
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.
Applied Cryogenic Engineering BoD – Books on Demand
Metal screens are commonly used as components for fluid handling in spacecraft and rocket tank designs. In most cases, the screens perform a passive separation of the propellant phases. The separation of the liquid from the gaseous propellant phase, is a special challenge. Liquid-gas phase separation means that the gaseous phase is allowed to enter a phase separation device while the liquid phase is blocked. The technical application of this process is the depressurization in a propellant tank. A certain amount of the gaseous propellant phase is vented from the tank through the gas port. The liquid propellant phase remains in the tank in order to be stored for the engine. However, if the tank causes a liquid movement during the depressurization, a part of the liquid can potentially enter the gas port. In order to prevent the unwanted liquid outflow, a separation of the liquid from the gas is necessary. This is possible with the aid of a double screen element and has already been performed for storable liquids in Earth ' s gravity and microgravity as well as for cryogenic liquids in Earth ' s gravity. At the current state of the art, the separation of the liquid from the gaseous phase of the cryogenic propellant hydrogen using a double screen element has not been performed in microgravity. However, with regard to a possible application, it is mandatory to investigate the function of the double screen element for the real propellant under relevant environmental conditions. In this work, a cryogenic test facility has been developed and operated successfully under Earth ' s gravity and microgravity conditions using the drop tower at the University of Bremen. Hereby, the original, cryogenic propellant phases: liquid and gaseous hydrogen, have been used. The experiments show the appearance of the physical processes which are related to the retention capability of a double screen element against liquid hydrogen. Furthermore, these physical processes can obviously be influenced by an unknown boundary condition at the screens: the screen saturation. This unknown boundary condition in turn can obviously be influenced by a certain stimulus which causes a special, fluid mechanical process. A simplified mathematical and two numerical models have been developed which combine the observed, physical processes in the experiments. Two fitting parameters are introduced which influence the flow through screen pressure loss of the liquid and the gaseous hydrogen phase. After the fitting to experimental data, the two fitting parameters have been interpreted with respect to a possible screen saturation. The results lead to a prediction of the unknown boundary condition and indicate that a partial saturation of the screens with liquid could be present in each considered experiment. This can possibly lead to a major influence of the overall resistance of the double screen element against liquid hydrogen.
Rocket and Spacecraft Propulsion Springer
The 1959 Cryogenic Engineering Conference Committee is pleased to pre sent the papers of the 1959 Cryogenic Engineering Conference. We are fortunate to have had the University of California at Berkeley, Ca!., as our host for the fifth national meeting of this kind. The move to the West Coast for this past Cryogenic Engineering Conference was prompted in part by the large concentration of missile activities which are to be found there. Recognition of cryogenic operations and techniques in the mis sile field is given in many of the included papers. The University of California was certainly wen suited for such a meeting as this because it was here that much early work was done in cryogenics. This pioneering in cryogenics is still evident today in the operation of the 72-in. bub ble chamber at the Lawrence Radiation Laboratory. The Cryogenic Engineering Conference salutes the missile industry and the cryogenic pioneers of yesterday and today at the University of California. Special thanks must go to Dr. D. N. Lyon from the Low-Temperature Laboratory of the University of California, who as chairman of the 1959 Cryogenic Engineering Conference Committee has worked tirelessly to increase the stature of this conference. vii ACKNOWLEDGMENT The Cryogenic Engineering Conference Committee is deeply grateful for the continued support and interest of the following organizations who made the 1959 Cryogenic Engineering Conference possible. Aerojet-General Corporation A. D. Little, Inc.
A Review of United States Air Force and Department of Defense Aerospace Propulsion Needs Cuvillier Verlag
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.
Fundamentals of Rocket Propulsion Cambridge University 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.
The Rocket Company CRC Press
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.
Liquid Hydrogen as a Propulsion Fuel, 1945-1959 Springer Science & Business Media
"Drawing on his wide experience of both designing and building hardware and teaching the fundamentals of rocket propulsion to undergraduate students, the author has produced a work that is particularly accessible to those without a formal engineering background who are studying or working in the space industry."--BOOK JACKET.
Fundamental Concepts of Liquid-Propellant Rocket Engines Springer Nature
On June 15, 2011, the Air Force Space Command established a new vision, mission, and set of goals to ensure continued U.S. dominance in space and cyberspace mission areas. Subsequently, and in coordination with the Air Force Research Laboratory, the Space and Missile Systems Center, and the 14th and 24th Air Forces, the Air Force Space Command identified four long-term science and technology (S&T) challenges critical to meeting these goals. One of these challenges is to provide full-spectrum launch capability at dramatically lower cost, and a reusable booster system (RBS) has been proposed as an approach to meet this challenge. The Air Force Space Command asked the Aeronautics and Space Engineering Board of the National Research Council to conduct an independent review and assessment of the RBS concept prior to considering a continuation of RBS-related activities within the Air Force Research Laboratory portfolio and before initiating a more extensive RBS development program. The committee for the Reusable Booster System: Review and Assessment was formed in response to that request and charged with reviewing and assessing the criteria and assumptions used in the current RBS plans, the cost model methodologies used to fame [frame?] the RBS business case, and the technical maturity and development plans of key elements critical to RBS implementation. The committee consisted of experts not connected with current RBS activities who have significant expertise in launch vehicle design and operation, research and technology development and implementation, space system operations, and cost analysis. The committee solicited and received input on the Air Force launch requirements, the baseline RBS concept, cost models and assessment, and technology readiness. The committee also received input from industry associated with RBS concept, industry independent of the RBS concept, and propulsion system providers which is summarized in Reusable Booster System: Review and Assessment.
Advanced Cryogenics AIAA
Cryogenic Technology and Applications describes the need for smaller cryo-coolers as a result of the advances in the miniaturization of electrical and optical devices and the need for cooling and conducting efficiency. Cryogenic technology deals with materials at low temperatures and the physics of their behavior at these temps. The book demonstrates the ongoing new applications being discovered for cryo-cooled electrical and optical sensors and devices, with particular emphasis on high-end commercial applications in medical and scientific fields as well as in the aerospace and military industries. This book summarizes the important aspects of cryogenic technology critical to the design and development of refrigerators, cryo-coolers, and micro-coolers needed by various commercial, industrial, space and military systems. Cryogenic cooling plays an important role in unmanned aerial vehicle systems, infrared search and track sensors, missile warning receivers, satellite tracking systems, and a host of other commercial and military systems. * Provides an overview of the history of the development of cryogenic technology * Includes the latest information on micro-coolers for military and space applications * Offers detailed information on high-capacity cryogenic refrigerator systems used in applications such as food storage, high-power microwave and laser sensors, medical diagnostics, and infrared detectors
Orbital Refueling System (ORS) Cuvillier
Support from the National Science Foundation has made it possible for the tenth annual Cryogenic Engineering Conference, hosted by the University

of Pennsylvania and capably directed by K. R. Atkins and his staff, to emphasize the major international advances in cryogenic engineering. This specific emphasis resulted in a final program of over one hundred papers and has made it necessary to publish the proceedings of the conference in two volumes. The first volume will be similar in nature to previous volumes in this series, while the second volume will feature the international aspect of the conference program. The latter volume, because of this distinction, will be entitled International Advances in Cryogenic Engineering. As in the past, the Cryogenic Engineering Conference Committee gratefully acknow ledges the assistance of all the dedicated workers in the cryogenic field who have contributed their time in reviewing the preliminary papers for the program and the final manuscripts for this volume. Since the list of participants in this thankless task numbers well over one hundred, any attempt to acknowledge their individual contributions in the limited space available would be practically impossible.

Advances in Cryogenic Engineering National Academies Press

The National Bureau of Standards Boulder Laboratories was on September 5-7, 1956 again host to a national conference on cryogenic engineering. Supported financially by many of the leading industrial firms currently active in this rapidly expanding field, the conference, second of its kind, attracted more than 400 scientists and engineers from all parts of the world. This attendance was evidence of the present interest and growth in cryogenic engineering, a field which has as yet not found a satisfactory place within the bounds of existing professional societies. In all but two cases the Proceedings contain the summary or entire text of the paper presented at the confer ence. Forty-nine papers were presented at seven separate sessions. These sessions were divided into the following general topics: Cryogenic Processes Cryogenic Equipment Cryogenic Properties Cryogenic Applications Bubble Chambers The division in some cases had to be somewhat arbitrary since several papers could have been classified under more than one general topic. To make the Proceedings more valuable to the reader, an attempt was made to record the general discussion which followed each paper. Unfortunately, however, the recording devices were not sensitive enough for clear reproduction. The discussions, therefore, have not been included in the Proceed ings.

Reusable Booster System Cambridge University Press

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.

Fabrication of a 65.5-inch-diameter Simulated Rocket Motor Case by Cryogenic Stretch-forming Springer Science & Business Media

"A fictionalized account of the challenges faced by a group of seven investors and their engineering team in developing a low-cost, reusable, Earth-to orbit launch vehicle. The marketing, regulatory, and technical problems are explored ... "cover p. [4].

The Development of Cryogenic Storage Systems for Space Flight Springer Science & Business Media

The program objectives are to demonstrate the applicability of the cryogenic stretch-forming process to the fabrication of large rocket motor cases of heavy wall thickness. Previous work has shown the feasibility of fabricating high strength rocket cases by cryogenic stretch-form ing. Effort under the present contract is directed at 'scaling up' the equipment and tech niques to handle the size and wall thickness of a big-boost motor. (Author).

Rocket Propulsion Springer Science & Business Media

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.