Improved Operational Turndown of an Ultra-Low Emission Gas Turbine Combustor Solar Turbines Incorporated (Solar), under cooperative agreement number DE-FC26-08CH11049, has conducted development activities to improve the durability of the Mercury 50 combustion system to 30,000 hours life and reduced life cycle costs. This project is part of Advanced Materials in the Advanced Industrial Gas Turbines program in DOE's Office of Distributed Energy. The targeted development engine was the Mercury (trademark) 50 gas turbine, which was developed by Solar under the DOE Advanced Turbine Systems program (DOE contract number DE-FC21-95MC31173). As a generator set, the Mercury 50 is used for distributed power and combined heat and power generation and is designed to achieve 38.5% electrical efficiency, reduced cost of electricity, and single digit emissions. The original program goal was 20,000 hours life, however, this goal was increased to be consistent with Solar's standard 30,000 hour time before overhaul for production engines. Through changes to the combustor design to incorporate effusion cooling in the Generation 3 Mercury 50 engine, which resulted in a drop in the combustor wall temperature, the current standard thermal barrier coated liner was predicted to have 18,000 hours life. With the addition of the advanced materials technology being evaluated under this program, the combustor life is predicted to be over 30,000 hours. The ultimate goal of the program was to demonstrate a fully integrated Mercury 50 combustion system, modified with advanced materials technologies, at a host site for a minimum of 4,000 hours. Solar was the Prime Contractor on the program team, which includes participation of other gas turbine manufacturers, various advanced material and coating suppliers, nationally recognized test laboratories, and multiple industrial end-user field demonstration sites. The program focused on a dual path development route to define an optimum mix of technologies for the Mercury 50 and future gas turbine products. For liner and injector development, multiple concepts including high thermal resistance thermal barrier coatings (TBC), oxide dispersion strengthened (ODS) alloys, continuous fiber ceramic composites (CFCC), and monolithic ceramics were evaluated before down-selection to the most promising candidate materials for field evaluation. Preliminary, component and sub-scale testing was conducted to determine material properties and demonstrate proof-of-concept. Full-scale rig and engine testing was used to validated engine performance prior to field evaluation at a Qualcomm Inc. cogeneration site located in San Diego, California. To ensure that the CFCC liners with the EBC proposed under this program would meet the target life, field evaluations of ceramic matrix composite liners in Centaur (reg_sign) 50
gas turbine engines, which had previously been conducted under the DOE sponsored Ceramic Stationary Gas Turbine program (DE-AC02-92CE40960), was continued under this program at commercial end-user sites under Program Subtask 1A - Extended CFCC Materials Durability Testing. The goal of these field demonstrations was to demonstrate significant component life, with milestones of 20,000 and 30,000 hours. Solar personnel monitor the condition of the liners at the field demonstration sites through periodic borescope inspections and emissions measurements. This program was highly successful at evaluating advanced materials and down-selecting promising solutions for use in gas turbine combustions systems. The addition of the advanced materials technology has enabled the predicted life of the Mercury 50 combustion system to reach 30,000 hours, which is Solar's typical time before overhaul for production engines. In particular, a 40 mil thick advanced Thermal Barrier Coating (TBC) system was selected over various other TBC systems, ODS liners and CFCC liners for the 4,000-hour field evaluation under the program. This advanced TBC is now production bill-of-material at various thicknesses up to 40 mils for all of Solar's advanced backside-cooled combustor liners (Centaur 50, Taurus 60, Mars 100, Taurus 70, Taurus 65, Titan 130, Titan 250 and Mercury 50). This TBC coating system significantly outperformed all other TBC systems evaluated under the program. The initial field unit, with the 40 mil advanced TBC developed under this program, has far exceeded the 4,000-hour requirement of the program, accumulating over 20,000 hours of commercial operation at Qualcomm Inc. in San Diego, CA. The 40 mil advanced TBC remains in excellent condition, with no evidence of chipping or spalling. The engine will continue operation until the unit is due for overhaul at approximately 30,000 hours. The Oxide Dispersion Strengthened (ODS) alloy injector tip testing and evaluation was also successful, however, the ODS injector tip development on this program was terminated, primarily due to the fact that the Mercury 50 injector tip was redesigned (Generation 3) by Combustion Engineering.

Draft Environmental Impact Statement/environmental Impact Report, Kern River 2003 Expansion Project Alzeta Corporation has developed surface-stabilized fuel injectors for use with lean premixed combustors which provide extended turndown and ultra-low NOX emission performance. These injectors use a patented technique to form interacting radiant and blue-flame zones immediately above a selectively-perforated porous metal surface. This allows stable operation at low reaction temperatures. This technology is being commercialized under injectors in Solar Turbar. Initial tests demonstrated low NOX emission but, were limited by flashback failure of the injectors. The weld seams required to form cylindrical injectors from flat sheet material were identified as the cause of the failures. The approach for this project was to first develop new fabrication methods to produce injectors without weld seams, verify similar emissions performance to the original flat sheet material and then develop products for microturbines and small gas turbines along parallel development paths. A 37 month project was completed to develop and test a surface stabilized combustion system for gas turbine applications. New fabrication techniques developed removed a technological barrier to the success of the product by elimination of conductive weld seams from the injector surface. The injectors demonstrated ultra low emissions in rig tests conducted under gas turbine operating conditions. The ability for injectors to share a common combustion chamber allowing for deployment in annular combustion liner was also demonstrated. Some further development is required to resolve integration issues related to specific engine constraints, but the nanoSTAR technology has clearly demonstrated its low emissions potential. The overall project conclusions can be summarized: (1) A wet-laid casting method successfully eliminated weld seams from the injector surface without degrading performance. (2) Gas turbine cycle analysis identified several injector designs and control schemes to start and load engines using nanoSTAR technology. A mechanically simple single zone injector can be used in Solar Turbine's Taurus 60 engine. (3) Rig testing of single monolithic injectors demonstrated sub 3 ppmv NOX and sub 10 ppmv CO and UHC emissions (all corrected to 15% O2) at Taurus 60 full-load pressure and combustion air inlet temperature. (4) Testing of two nanoSTAR injectors in Solar Turbine's sector rig demonstrated the ability for injectors to survive when fired in close proximity at Taurus 60 full load pressure and combustion air inlet temperature. (5) Sector rig tests demonstrated emissions performance and range of operability consistent with single injector rig tests. Alzeta has committed to the commercialization of nanoSTAR injectors and has sufficient production capability to conclude development and meet initial demand.

Pounder's Marine Diesel Engines and Gas Turbines

Alternative Energy Systems and Applications The 1st World Conference and Technology Exhibition on Biomass for Energy and Industry, held in
Sevilla in June 2000, brought together for the first time the traditional European Conference on Biomass for Energy and Industry and the Biomass Conference of the Americas, thus creating the largest and most outstanding event in the worldwide biomass sector. The conference elaborated innovative global strategies, projects and efficient practice rules for energy and the environment at a key stage in the industry's development. New concepts and projects were highlighted to increase the social and political awareness for a change in worldwide resource consumption and to promote economically, socially and environmentally sustainable development for the next millennium. In 2 volumes, the Proceedings include some 470 papers essential to an understanding of current thinking, practice, research and global developments in the biomass sector - a vital reference source for researchers, manufacturers, and policy makers involved or interested in the use of biomass for energy and industry.

BMT Abstracts

Introduction to Gas Turbine Theory

Journal of Engineering for Gas Turbines and Power

Synthesis Gas Combustion The ability of thermal energy storage (TES) systems to facilitate energy savings, renewable energy use and reduce environmental impact has led to a recent resurgence in their interest. The second edition of this book offers up-to-date coverage of recent energy efficient and sustainable technological methods and solutions, covering analysis, design and performance improvement as well as life-cycle costing and assessment. As well as having significantly revised the book for use as a graduate text, the authors address real-life technical and operational problems, enabling the reader to gain an understanding of the fundamental principles and practical applications of thermal energy storage technology. Beginning with a general summary of thermodynamics, fluid mechanics and heat transfer, this book goes on to discuss practical applications with chapters that include TES systems, environmental impact, energy savings, energy and exergy analyses, numerical modeling and simulation, case studies and new techniques and performance assessment methods.

Questar, Williams and Kern River Pipelines Project

Turbomachinery International Handbook

Capacity Replacement Project, Northwest Pipeline Corporation

Marine Engineers Review

Thermal Energy Storage

DEVELOPMENT AND DEMONSTRATION OF AN ULTRA LOW NOx COMBUSTOR FOR GAS TURBINES. Everything you wanted to know about industrial gas turbines for electric power generation in one source with hard-to-find, hands-on technical information.

Kern River 2003 Expansion Project This book was developed directly from a series of Solar Turbines Incorporated internal short courses that were presented to an audience with a wide range of technical backgrounds, not necessarily related to turbomachinery. Thus, functional principles and physical understanding are emphasized, rather than the derivation of complicated mathematical equations. While the focus of this book is gas turbine theory, it is not intended to provide an in-depth knowledge of gas turbine aerodynamics or thermodynamics, nor is it intended to make the reader an expert in the field of turbomachinery. Readers will benefit from the many topics and theories that pertain to the subject matter. The text emphasizes simplified explanations of complex physical theories. Hopefully, readers will utilize this book to develop an appreciation of the many engineering disciplines that are involved in the design and analysis of gas turbines.
Readers are also encouraged to further investigate a wide range of topics by studying more specific, subject-matter literature.

Gas Turbines for Electric Power Generation

Gas Turbines This comprehensive, best-selling reference provides the fundamental information you'll need to understand both the operation and proper application of all types of gas turbines. The full spectrum of hardware, as well as typical application scenarios are fully explored, along with operating parameters, controls, inlet and exhaust treatments, inspection, troubleshooting, noise control, inlet cooling for power augmentation and NOx control. This latest edition includes a new chapter on microturbines and additional case studies. The author has provided many helpful tips that will enable diagnosis of problems in their early stages and analysis of failures to prevent their recurrence. Also treated are the effects of the external environment on gas turbines operation and life, as well as the impact of the gas turbine on its surrounding environment.

Challenges and Goals in Industrial and Pipeline Compressors

Thermal Energy Storage

Paper This comprehensive, best-selling reference provides the fundamental information you'll need to understand both the operation and proper application of all types of gas turbines. The full spectrum of hardware, as well as typical application scenarios are fully explored, along with operating parameters, controls, inlet treatments, inspection, troubleshooting, and more. The second edition adds a new chapter on gas turbine noise control, as well as an expanded section on use of inlet cooling for power augmentation and NOx control. The author has provided many helpful tips that will enable diagnosis of problems in their early stages and analysis of failures to prevent their recurrence. Also treated are the effects of the external environment on gas turbine operation and life, as well as the impact of the gas turbine on its surrounding environment.

Asian Oil & Gas The comprehensive guide to engineering alternative and renewable energy systems and applications—updated for the latest trends and technologies This book was designed to help engineers develop new solutions for the current energy economy. To that end it provides technical discussions, along with numerous real-world examples of virtually all existing alternative energy sources, applications, systems and system components. All chapters focus on first-order engineering calculations, and consider alternative uses of existing and renewable energy resources. Just as important, the author describes how to apply these concepts to the development of new energy solutions. Since the publication of the critically acclaimed first edition of this book, the alternative, renewable and sustainable energy industries have witnessed significant evolution and growth. Hydraulic fracturing, fossil fuel reserve increases, the increasing popularity of hybrid and all-electric vehicles, and the decreasing cost of solar power already have had a significant impact on energy usage patterns worldwide. Updated and revised to reflect those and other key developments, this new edition features expanded coverage of topics covered in the first edition, as well as entirely new chapters on hydraulic fracturing and fossil fuels, hybrid and all-electric vehicles, and more. Begins with a fascinating look at the changing face of global energy economy Features chapters devoted to virtually all sources of alternative energy and energy systems Offers technical discussions of hydropower, wind, passive solar and solar-thermal, photovoltaics, fuel cells, CHP systems, geothermal, ocean energy, biomass, and nuclear Contains updated chapter review questions, homework problems, and a thoroughly revised solutions manual, available on the companion website While Alternative Energy Systems and Applications, Second Edition is an ideal textbook/reference for advanced undergraduate and graduate level engineering courses in energy-related subjects, it is also an indispensable professional resource for engineers and technicians working in areas related to the development of alternative/renewable energy systems.

Phase VIII Expansion Project, Florida Gas Transmission Company, LLC
International Directory of Company Histories The book summarizes the history and current status of the development of gas turbine engines and ancillary equipment using ceramic hot section components. Specifically, the book focuses on the evolution of component and engine designs, and the demonstration of design concepts through rig and engine testing of the ceramic gas turbine programs in the United States, Japan, Western Europe, and the countries of the former Soviet Union (primarily Russia). The 33 chapters cover ceramic gas turbine design in small gas turbines for automotive and cogeneration applications, midsize industrial and larger utility gas turbines, and aircraft and aeroderivative applications. Almost all the book chapters have been prepared by technical personnel who are intimately involved in the development and demonstration of the ceramic gas turbine programs in the United States, Japan, and Western Europe. The book will be of interest to engineering and management personnel at turbomachinery equipment manufacturers, development and fabrication personnel at suppliers of ceramic materials and components, researchers in government and private laboratories, teaching staff and students at technical colleges and universities, and personnel involved in planning and monitoring technology development programs. The theme emphasized throughout the book are the ‘lessons learned’ from almost 40 years of ceramic gas turbine design and test experience. Learning directly from the experience of the researchers that took the ceramic gas turbine through the concept, preliminary, and detail design phases, while following the iterative design-test process cycles, is a unique way of becoming quickly familiar with the design challenges and solutions for using ceramics in gas turbine equipment. The book also amply demonstrates the hurdles that had to be overcome to generate functional and durable component design, as well as challenges that remain for the full-scale commercialization of the ceramic gas turbine.

ASME Technical Papers Pounder's Marine Diesel Engines and Gas Turbines, Tenth Edition, gives engineering cadets, marine engineers, ship operators and managers insights into currently available engines and auxiliary equipment and trends for the future. This new edition introduces new engine models that will be most commonly installed in ships over the next decade, as well as the latest legislation and pollutant emissions procedures. Since publication of the last edition in 2009, a number of emission control areas (ECAs) have been established by the International Maritime Organization (IMO) in which exhaust emissions are subject to even more stringent controls. In addition, there are now rules that affect new ships and their emission of CO2 measured as a product of cargo carried. Provides the latest emission control technologies, such as SCR and water scrubbers Contains complete updates of legislation and pollutant emission procedures Includes the latest emission control technologies and expands upon remote monitoring and control of engines

Commerce Business Daily During the last two decades many research and development activities related to energy have concentrated on efficient energy use and energy savings and conservation. In this regard, Thermal Energy Storage (TES) systems can play an important role, as they provide great potential for facilitating energy savings and reducing environmental impact. Thermal storage has received increasing interest in recent years in terms of its applications, and the enormous potential it offers both for more effective use of thermal equipment and for economic, large-scale energy substitutions. Indeed, TES appears to provide one of the most advantageous solutions for correcting the mismatch that often occurs between the supply and demand of energy. Despite this increase in attention, no book is currently available which comprehensively covers TES. Presenting contributions from prominent researchers and scientists, this book is primarily concerned with TES systems and their applications. It begins with a brief summary of general aspects of thermodynamics, fluid mechanics and heat transfer, and then goes on to discuss energy storage technologies, environmental aspects of TES, energy and exergy analyses, and practical applications. Furthermore, this book provides coverage of the theoretical, experimental and numerical techniques employed in the field of thermal storage. Numerous case studies and illustrative examples are included throughout. Some of the unique features of this book include: * State-of-the art descriptions of many facets of TES systems and applications * In-depth coverage of exergy analysis and thermodynamic optimization of TES systems * Extensive new material on TES technologies, including advances due to innovations in sensible- and latent-energy storage * Key chapters on environmental issues, sustainable development and energy savings * Extensive coverage of practical aspects of the design, evaluation, selection and implementation of TES systems * Wide coverage of TES-system modelling, ranging in level from elementary to advanced * Abundant design examples, case studies and references In short, this book forms a valuable reference resource for practicing engineers and researchers, and a research-oriented text book for advanced undergraduate and graduate students of
various engineering disciplines. Instructors will find that its breadth and structure make it an ideal core text for TES and related courses.

Gas World

Turbomachinery International

Shipping World & Shipbuilder

Gas Turbine Handbook, Third Edition Covering basic theory, components, installation, maintenance, manufacturing, regulation and industry developments, Gas Turbines: A Handbook of Air, Sea and Land Applications is a broad-based introductory reference designed to give you the knowledge needed to succeed in the gas turbine industry, land, sea and air applications. Providing the big picture view that other detailed, data-focused resources lack, this book has a strong focus on the information needed to effectively decision-make and plan gas turbine system use for particular applications, taking into consideration not only operational requirements but long-term life-cycle costs in upkeep, repair and future use. With concise, easily digestible overviews of all important theoretical bases and a practical focus throughout, Gas Turbines is an ideal handbook for those new to the field or in the early stages of their career, as well as more experienced engineers looking for a reliable, one-stop reference that covers the breadth of the field. Covers installation, maintenance, manufacturer’s specifications, performance criteria and future trends, offering a rounded view of the area that takes in technical detail as well as industry economics and outlook. Updated with the latest industry developments, including new emission and efficiency regulations and their impact on gas turbine technology. Over 300 pages of new/revised content, including new sections on microturbines, non-conventional fuel sources for microturbines, emissions, major developments in aircraft engines, use of coal gas and superheated steam, and new case histories throughout highlighting component improvements in all systems and sub-systems.

Buccaneer Gas Pipeline Project, Buccaneer Gas Pipeline Company L.L.C., Docket No. CP00-14-000 Vols. for 1977- include a section: Turbomachinery world news, called v. 1-

Technology Report and Product Directory, Land, Sea & Air

Advanced Materials for Mercury 50 Gas Turbine Combustion System Coal, still used to generate more than half of the electric power in the U.S., will likely be part of any future global energy plan. But this finite resource is also responsible for 80 percent of the CO2 emissions from power production, and its continued use will require improved processing techniques that are less damaging to the environment and less costly. One viable option is the use of “clean coal” energy conversion devices that rely on the combustion of gasified coal, referred to as synthesis gas, or syngas. Synthesis Gas Combustion: Fundamentals and Applications presents work from leading combustion authorities who offer their perspectives on various energy and environmental issues linked to the development of syngas and hydrogen combustion. This volume summarizes the current understanding of syngas, focusing first on combustion fundamentals and then on issues specific to application and utilization in fuel cells, internal combustion engines, and steady-flowing combustion devices such as gas turbines or boilers. In discussing syngas production, this book details the technical issues and trade-offs that influence fuel composition. It also explores combustion fundamentals of "clean coal" technologies, including chemical kinetics, flame properties, and emissions. Governments and companies around the world are devoting significant resources to improve understanding of the combustion of coal and bio-derived synthesis gases, to maximize the benefits of gasification technology and limit CO2 emissions. This valuable reference provides state-of-the-art context and technical information needed to develop clean energy systems. These include clean coal technologies, hydrogen and liquid fuel production, use of biomass feedstocks, and usage in fuel cells and other advanced power generation technologies.
1st World Conference on Biomass for Energy and Industry

Ceramic Gas Turbine Design and Test Experience Multi-volume major reference work bringing together histories of companies that are a leading influence in a particular industry or geographic location. For students, job candidates, business executives, historians and investors.

The Gas Turbine Handbook

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