Lead Cooled Fast Neutron Reactor Brest Nikiet

This expanded new edition develops the theory of nuclear reactors from the fundamentals of fission to the operating characteristics of modern reactors. The first half of the book emphasizes reactor criticality analysis and all of the fundamentals that go into modern calculations. Simplified one group diffusion theory models are presented and extended into sophisticated multi-group transport theory models. The second half of the book deals with the two main topics of interest related to operating reactors – reactor kinetics/dynamics, and in-core fuel management. Additional chapters have been added to expand and bring the material up-to-date and include the utilization of more computer codes. Code models and detailed data sets are provided along with example problems making this a useful text for students and researchers wishing to develop an understanding of nuclear power and its implementation in today's modern energy spectrum. Covers the fundamentals of neutronic analysis for nuclear reactor systems to help understand nuclear reactor theory; Describes the benefits, uses, safety features, and challenges related to implementation of Small Modular Reactors; Provides examples, data sets, and code to assist the reader in obtaining

mastery over the subjects.
A variety of small (100 MWe) fast reactor core designs are developed, these include compact configurations, long-lived (15-year fuel lifetime) cores, and derated, natural circulation designs. Trade studies are described which identify key core design issues for lead-based coolant systems. Performance parameters and reactivity feedback coefficients are compared for lead-bismuth eutectic (LBE) and sodium-cooled cores of consistent design. The results of these studies indicate that the superior neutron reflection capability of lead alloys reduces the enrichment and burnup swing compared to conventional sodium-cooled systems; however, the discharge fluence is significantly increased. The size requirement for long-lived systems is constrained by reactivity loss considerations, not fuel burnup or fluence limits. The derated lead-alloy cooled natural circulation cores require a core volume roughly eight times greater than conventional compact systems. In general, reactivity coefficients important for passive safety performance are less favorable for the larger, derated configurations.
Handbook of Generation IV Nuclear Reactors presents information on the current fleet of Nuclear Power Plants (NPPs) with water-cooled reactors (Generation III and III+) (96% of 430 power reactors in the world) that have relatively low thermal efficiencies (within the range of 32 36%) compared

to those of modern advanced thermal power plants (combined cycle gas-fired power plants – up to 62% and supercritical pressure coal-fired power plants – up to 55%). Moreover, thermal efficiency of the current fleet of NPPs with water-cooled reactors cannot be increased significantly without completely different innovative designs, which are Generation IV reactors. Nuclear power is vital for generating electrical energy without carbon emissions. Complete with the latest research, development, and design, and written by an international team of experts, this handbook is completely dedicated to Generation IV reactors. Presents the first comprehensive handbook dedicated entirely to generation IV nuclear reactors Reviews the latest trends and developments Complete with the latest research, development, and design information in generation IV nuclear reactors Written by an international team of experts in the field

This book describes the fast reactor (FR), a type of new reactor for nuclear plants, currently under research and development. The book targets young researchers and engineers who will be charged with commercializing this new type of reactor to lead to the development of new components and systems for improved plant reliability and economy. This volume also helps readers to understand the methods of integrating the power plant in its entirety, from the reactor core to all of the various systems

and components, and teaches the way of thinking that forms the background of these methods. This background includes the various organizational and management issues that are encountered as projects move forward and will be explored in great detail based on actual design and construction experience with Japan’s prototype FR, Monju.
New, enriched Reactor. There has never been a Reactor Guide like this. It contains 363 answers, much more than you can imagine; comprehensive answers and extensive details and references, with insights that have never before been offered in print. Get the information you need--fast! This all-embracing guide offers a thorough view of key knowledge and detailed insight. This Guide introduces what you want to know about Reactor. A quick look inside of some of the subjects covered: European Pressurized Reactor - Olkiluoto 3 (Areva's first plant), Molten-Salt Reactor Experiment - Neutronics and thermal-hydraulics, Containment building - Pressurized water reactors, List of nuclear reactors - Belarus, Uranium - Reactors, List of nuclear reactors - Power station reactors, Natural nuclear fission reactor - Mars, Open-pool Australian lightwater reactor - Platypus, Molten-Salt Reactor Experiment - Pump, Gas-cooled reactor - Types, List of nuclear reactors - Research reactors, Aqueous homogeneous reactor - History, Open-pool Australian lightwater reactor - Facility details,

Nuclear reactor - Classification by type of nuclear reaction, Integral fast reactor - Reactor design and construction, Fuji Molten Salt Reactor, Nuclear reactor - Mechanism, Heavy water reactor - Nuclear proliferation, Nuclear reactor - Reactivity control, Gas core reactor rocket - Flow hydrodynamics in open cycle designs, Liquid metal cooled reactor - Lead, Tissue engineering - Bioreactors, Photobioreactor - Tubular photobioreactors, Breeder reactor - USA, Gas-cooled fast reactor - Coolant, Algae fuel - Photobioreactors, List of nuclear reactors - Power stations, Boiling water reactor - Safety systems, List of nuclear reactors - Finland, Light water reactor - Borax Experiments and first Boiling Water Reactor, and much more...

This book presents a new and innovative approach for the use of heat pipes and their application in a number of industrial scenarios, including space and nuclear power plants. The book opens by describing the heat pipe and its concept, including sizing, composition and binding energies. It contains mathematical models of high and low temperature pipes along with extensive design and manufacturing models, characteristics and testing programs. A detailed design and safety analysis concludes the book, emphasizing the importance of heat pipe implementation within the main cooling system and within the core of the reactor, making this book a useful resource for students, engineers, and researchers.

This book provides a comprehensive yet accessible overview of all relevant topics in the field of radiation protection (health physics). The text is organized to introduce the reader to basic principles of radiation emission and propagation, to review current knowledge and historical aspects of the biological effects of radiation, and to cover important operational topics such as radiation shielding and dosimetry. The author’s website contains materials for instructors including PowerPoint slides for lectures and worked-out solutions to end-of-chapter exercises. The book serves as an essential handbook for practicing health physics professionals.

Materials have been presented as to experience in creating and operating Russian and partially foreign research and industrial test benches and reactor plants using heavy liquid-metal coolants (HLMC), i.e. lead-bismuth and lead coolants. Main performance data of reactor circuits, major equipment and their design solutions have been described. There has been provided information on specific features of operating conditions, including operating basis accidents of power circuits cooled with lead and lead-bismuth coolants. This book may be recommended as a teaching aid for students, masters and graduate students learning with specializations related to the nuclear power industry and principally to innovative fast neutron reactors cooled with HLMC. It may be of some interest for researchers, scientific workers and engineers engaged in creating and operating such installations.

For the first time a book has been written on the technological and scientific knowledge, acquired during, buiding , operation and even dismantling of the Superphenix plant. This reactor remains today the most powerful sodium fast breeder reactor operated in the world.(1200 MWe). The last fast breeder reactor operated in the world is BN 800 in Russia that reached his nominal power (800 MWe) in 2016. Joel Guidez began his career in the field of sodium-cooled fast reactors after leaving Ecole Centrale-Paris, in 1973. He has held various positions at Cadarache, Phenix and Superphenix, including as the head of the thermal hydraulic laboratory conducting tests for Phenix, Superphenix and the EFR European Fast Reactor project. He was also head of the OSIRIS research reactor, located at SACLAY, and of the HFR European Commission reactor, located in the Netherlands and spent two years as nuclear attaché at the French embassy in Berlin. His 2012 book “Phenix: the experience feedback” was translated into English and republished in 2013, and this new book on Superphenix is in the same spirit of thematic analysis of a reactor experience feedback. Gérard Prêle graduated from the Ecole Centrale-Lyon and entered EDF and the field of sodium-cooled fast reactors in 1983. In 1985 he joined Superphenix, where he was a duty engineer and was later in charge of safety. He has held various positions at Superphenix and Phenix and was a fast neutron reactor (SFR) engineer at the EDF Centre Lyonnais d’Ingénierie (CLI). He worked as Safety Security Environment and Radiation Protection Mission head in Superphenix at the beginning of dismantling and then in the field of PWR for two years. Since 2006 he has been involved in the Gen IV and the SFR/Astrid projects. Today, as an SFR/system and operations expert, one of his major roles is assisting the CEA in the preliminary design of the ASTRID reactor.

The aim of this book is to disseminate state-of-the-art research and advances in the area of nuclear reactors technology. The book was divided in two parts.Topics discussed in the first part of this compilation include: experimental investigation and computational validation of thermal stratification in PWR reactors piping systems, new methods in doppler broadening function calculation for nuclear reactors fuel temperature, isothermal phase transformation of uranium-zirconium-niobium alloys for advanced nuclear fuel, reactivity Monte Carlo burnup simulations of enriched gadolinium burnable poison for PWR fuel, utilization of thermal analysis technique for study of uranium-molybdenum fuel alloy, probabilistic safety assessment applied to research reactors, and a review on the state-of-the art and current trends of next generation reactors. The second part includes: thermal hydraulics study for a ultra high temperature reactor with packed sphere fuels, benefits in using lead-208 coolant for fast reactors and accelerator driven systems, nuclear power as a basis for future electricity production in the world: Generation III and IV reactors, nanostructural materials and shaped solids for improvement and energetic effectiveness of nuclear reactors safety and radioactive wastes, multilateral nuclear approach to nuclear fuel cycles, and a cold analysis of the Fukushima accident. This report discusses the status of Lead-Cooled Fast Reactor (LFR) research and development carried out during the first half of FY 2008 under the U.S. Department of Energy Generation IV Nuclear Energy Systems Initiative. Lead-Cooled Fast Reactor research and development has recently been transferred from Generation IV to the Reactor Campaign of the Global Nuclear Energy Partnership (GNEP). Another status report shall be issued at the end of FY 2008 covering all of the LFR activities carried out in FY 2008 for both Generation IV and GNEP. The focus of research and development in FY 2008 is an initial investigation of a concept for a LFR Advanced Recycling Reactor (ARR) Technology

Pilot Plant (TPP)/demonstration test reactor (demo) incorporating features and operating conditions of the European Lead-cooled SYstem (ELSY) (almost equal to) 600 MWe lead (Pb)-cooled LFR preconceptual design for the transmutation of waste and central station power generation, and which would enable irradiation testing of advanced fuels and structural materials. Initial scoping core concept development analyses have been carried out for a 100 MWt core composed of sixteen open-lattice 20 by 20 fuel assemblies largely similar to those of the ELSY preconceptual fuel assembly design incorporating fuel pins with mixed oxide (MOX) fuel, central control rods in each fuel assembly, and cooled with Pb coolant. For a cycle length of three years, the core is calculated to have a conversion ratio of 0.79, an average discharge burnup of 108 MWd/kg of heavy metal, and a burnup reactivity swing of about 13 dollars. With a control rod in each fuel assembly, the reactivity worth of an individual rod would need to be significantly greater than one dollar which is undesirable for postulated rod withdrawal reactivity insertion events. A peak neutron fast flux of 2.0 x 1015 (n/cm2-s) is calculated. For comparison, the 400 MWt Fast Flux Test Facility (FFTF) achieved a peak neutron fast flux of 7.2 x 1015 (n/cm2-s) and the initially 563 MWt PHENIX reactor attained 2.0 x 1015 (n/cm2-s) before one of three intermediate cooling loops was shut down due to concerns about potential steam generator tube failures. The calculations do not assume a test assembly location for advanced fuels and materials irradiation in place of a fuel assembly (e.g., at the center of the core); the calculations have not examined whether it would be feasible to replace the central assembly by a test assembly location. However, having only fifteen driver assemblies implies a significant effect due to perturbations introduced by the test assembly. The peak neutron fast flux is low compared with the fast fluxes previously achieved in FFTF and PHENIX. Furthermore, the peak neutron fluence is only about half of the limiting value (4 x 1023 n/cm2) typically used for ferritic steels. The results thus suggest that a larger power level (e.g., 400 MWt) and a larger core would be better for a TPP based upon the ELSY fuel assembly design and which can also perform irradiation testing of advanced fuels and materials. In particular, a core having a higher power level and larger dimensions would achieve a suitable average discharge burnup, peak fast flux, peak fluence, and would support the inclusion of one or more test assembly locations. Participation in the Generation IV International Forum Provisional System Steering Committee for the LFR is being maintained throughout FY 2008. Results from the analysis of samples previously exposed to flowing lead-bismuth eutectic (LBE) in the DELTA loop are summarized and a model for the oxidation/corrosion kinetics of steels in heavy liquid metal coolants was applied to systematically compare the calculated long-term (i.e., following several years of growth) oxide layer thicknesses of several steels.

An history on the development of Nuclear Power, types of reactors, fission theory and a detailed look at how nuclear accidents happened. This book covers; NUCLEAR POWER EARLY DEVELOPMENT details the contributions of noteworthy scientist: THE ATOM details the forces with the Atom: RADIOACTIVITY describes the types of radiation: how it is measured and different sources: NUCLEAR REACTIONS describes Fusion and Fission, how to increase rate of fission by moderation and enrichment. Describes enrichment techniques: HOW RADIATION EFECTS THE HUMAN BODY describes how cancer occurs by effects on chromosomes discuses natural sources of radiation Relative Biological Effectiveness, Radiation Hormesis, Neoplasm: TYPES OF NUCLEAR REACTORS; Describes different types of Thermal

Reactors, and Fast Reactors including Pressure Water Reactors, Gas Cooled Reactors and advance variant, Water Cooled Water Moderated Power Reactor (WWER), Pressurised Heavy Water Reactors, Boiling Water Reactors and advanced variant, Pebble Bed Reactors, Aquesous Homogeneous Reactors, Fast Breeder Reactors, Liquid Metal Fast Breeder Reactors, Sodium Cooled Reactors, Lead Cooled Reactors. Development Stage Reactors these include Integral Fast Reactors (IFR), High Temperature Gas Cooled Reactor, Small Sealed Transportable Autonumous Reactor, Clean and Environmentally Safe Advanced Reactor. Design Stage Reactors, Reduced Moderation Water Reactor, Hydrogen Moderated Self Regulating Nuclear Power Module, Subcritical Reactors, Energy Amplifier, Thorium-based Reactors, Advanced Heavy Water Reactor, Kalpakkarn Mini.DESIGN FACTORS FOR AGR AND PWR discusses fuel, coolant, moderators control rods, chemical compatability, fuel clad.EFFECTS OF REACTIVITY discusses measurement of irradiation, isotopic changes in the fuel, change in Fuel from Uranium to Plutonium and its conversion ratio, refuelling options. Reactor poisons Xenon, Samarium Cadmium, Europium, Gaddolinium, Krypton and Technetium and their significance. TEMPERATURE EFFECTS considers fuel and moderator coefficients. REACTOR CONTROL Describes the various types of control rods i.e grey, coarse, safety and the requirement of superariculated rods in case of distotion. Back up control methods include the use of Nitrogen. Reactivity faults are desribed the protection methods and measurement. GETTING THE RIGHT NEUTRON TO MODERATOR BALANCE including the required level of enrichment. EFFECTS OF REACTOR COMPOSITION ON REACTIVITY : HOMOGENEOUS AND HETEROGENEOUS REACTOR affects of size and shape on neutron leakage, flux distribution in various shaped reactors,

Jo Berssel Envelope: RADIAL FLUX, CHANNEL POWER AND REACTION POWER Channel power variations, alterating reactivity by enrichment, neutron absorbtion, differential irradiation, nuetron reflection. NEUTRON KINETICS Delta K, International reactivity units, Neutron Multiplication, Effective neutron multiplication factor, Delayed neutron lifetime, Codd & Wells Table. OPERATIONAL VALUES OF DELTA K Explin terms defining excess reactivity resulting doubling times then prompt criticality, defines operational limits on Delta K: REACTIVITY BALANCES, Built in reactivity, Reactivity Build Up, Xenon, Control Rods: ALL NUCLEAR SITES WORLD WIDE a list of peacefull nuclear power site that are operational, under construction or shutdown: NUCLEAR FUEL TRANSPORTATION AND DISPOSAL OF WASTE Spent fuel and fission by-products, Diffinition of Low, Intermediate, and High levels of waste, waste storage, Details of storage facilities world wide, nuclear reprocessing plants world wide, vitrification, plutomium oxide, storage flasks A, B and C, transportation of radioactive substances, bespoke sea transportation, transport flask tests, UK NUCLEAR SAFETY RECORD Windscale Fire: NUCLEAR CATASTROPHIES Three mile island meltdown containment, Why chernoble's reactor went prompt critical , Chernobyl Investigatin Conclusions, Fukushima triple meltdown, Acheiving optimum nuclear safety, WANO:
In light of the scientific evidence for changes in the climate caused by greenhouse-gas emissions from human activities, the world is in ever more desperate need of new, inexhaustible, safe and clean primary energy sources. A viable solution to this problem is the widespread adoption of nuclear breeder reactor technology. Innovative breeder reactor concepts using liquid-metal coolants such as sodium or lead will be able to utilize the waste produced by the current light water reactor fuel cycle to power the entire world

for several centuries to come. Breed & burn (B & B) type fast reactor cores can unlock the energy potential of readily available fertile material such as depleted uranium without the need for chemical reprocessing. Using B & B technology, nuclear waste generation, uranium mining needs and proliferation concerns can be greatly reduced, and after a transitional period, enrichment facilities may no longer be needed. In this dissertation, new passively operating safety systems for fast reactors cores are presented. New analysis and optimization methods for B & B core design have been developed, along with a comprehensive computer code that couples neutronics, thermal-hydraulics and structural mechanics and enables a completely automated and optimized fast reactor core design process. In addition, an experiment that expands the knowledge-base of corrosion issues of lead-based coolants in nuclear reactors was designed and built. The motivation behind the work presented in this thesis is to help facilitate the widespread adoption of safe and efficient fast reactor technology.

This book provides a systematic and comprehensive introduction to the neutronics of advanced nuclear systems, covering all key aspects, from the fundamental theories and methodologies to a wide range of advanced nuclear system designs and experiments. It is the first-ever book focusing on the neutronics of advanced nuclear systems in the world. Compared with traditional nuclear systems, advanced nuclear systems are characterized by more complex geometry and nuclear physics, and pose new challenges in terms of neutronics. Based on the achievements and experiences of the author and his team over the past few decades, the book focuses on the neutronics characteristics of advanced nuclear systems and introduces novel neutron transport methodologies for complex systems, high-fidelity calculation software for nuclear design and safety evaluation, and highintensity neutron source and technologies for neutronics experiments. At the same time, it describes the development of various neutronics designs for advanced nuclear systems, including neutronics design for ITER, CLEAR and FDS series reactors. The book not only summarizes the progress and achievements of the author’s research work, but also highlights the latest advances and investigates the forefront of the field and the road ahead.

This publication presents a survey of worldwide experience gained with fast breeder reactor design, development and operation. It is focused on the following subjects: state of the art of liquid metal fast reactor (LMFR) development and relevant IAEA activities; design features and operating experience of demonstration and commercial sized nuclear power plants with sodium cooled fast reactors; lead-bismuth cooled (LBC) ship reactor operation experience and LBC fast power reactor development; activation characteristics of the primary coolant, reactor and components; treatment and disposal of spent sodium; removal of residual sodium deposits and decontamination after shutdown of the typical loop type LMFR; passive principles of fast reactor emergency shutdown and heat removal, demonstration of safety with test fast reactors during the final stages of operation, and an analysis and assessment of advantages and disadvantages of sodium as a coolant, giving due consideration to the advances in the technology and design of sodium components.

Everyday, the world produces carbon dioxide that is released into the Earth's atmosphere. This increase in carbon dioxide content is responsible for a rise in the temperature of our planet and contributes to what is known as "Global Warming". One answer to global warming is to replace and retrofit current technologies with alternative ones, which are of comparable or greater efficiency but do not release carbon dioxide. We call this Alternate energy. Climate change, population growth and fossil fuel depletion imply that renewables will need to play a bigger role in the future than they do today. According to British Petroleum and Royal Dutch Shell, two of the world's largest oil companies, onethird of the world's energy will need to corne from solar, wind, and other renewable resources by 2050. Alternative energy refers to energy sources that have no undesirable consequences such as those caused by fossil fuels or nuclear energy. Alternative energy sources are renewable and are thought to be «free». Compared to conventional energy sources, they all release less carbon. They include solar energy, wind energy, geothermal energy, fuel cell batteries and nuclear energy. This book provides a comprehensive overview of the main types of renewable energy. In addition, the text explains the underlying physical and technological principles of renewable energy and examines the environmental impact and future prospects of different energy sources. It includes over 350 detailed illustrations, more than fifty tables of data, and a wide range of case studies.

The Administration and Congress have not been able to agree on the future role of fast nuclear breeder reactors. They cannot decide whether to rely on nuclear power as a long- or short-term energy supply source. If a long-term future for nuclear power is desired, or even if a nuclear option is to be maintained, construction and operation of a fast breeder demonstration plant is needed. The date for the commercialization of the liquid metal fast breeder reactor (LMFBR) has been postponed from 1986 to about 2020. The reasons given for the delay included concern that plutonium-based nuclear fuels may lead to international nuclear weapons proliferation, projections supporting a diminished need for commercial breeder reactors, projections that LMFBR's would not become economically competitive for several decades, questions about the safety of LMFBR's, and the belief that the Clinch River Breeder Reactor was too small, too costly, and technically obsolete. In fiscal year 1981, the Department of Energy (DOE) is planning to terminate its participation in the gas-cooled fast breeder reactor program while continuing to fund the light water breeder reactor program. But the light water breeder reactor program cannot be viewed as an alternative or backup to LMFBR's because its objective and purpose are different. DOE withdrawal from participation in the technology development program will probably cause the collapse of the industrial infrastructure that has grown in support of the program, and consequently, the only nuclear alternative to the LMFBR program will be lost. GAO believes that the current strategy of postponing the commercialization date of the LMFBR program will not necessarily enable this country to achieve its nonproliferation goals. The projections of the availability of uranium are uncertain. Unanticipated events could increase the future demand for nuclear energy and the need for an early commercialization of breeder reactors. The ultimate economics of the LMFBR program are difficult to accurately project. The LMFBR is no more or less safe than the current generation of light water reactors. The LMFBR program lacks a clear mission. The disagreement between Congress and the Administration has made planning and directing the program difficult for DOE. Recent actions by the Administration underscore its desire to kill the Clinch River project and to defer any commitment for a substitute plant. A strong LMFBR program includes constructing and operating a plant, something which has not been done. A backup technology should be available for development in case the LMFBR program fails to meet its objectives.

The LEADER project goal is to improve and develop a scaled demonstrator of the LFR technology, ALFRED. The work in this thesis is focused in the ALFRED project framework and its mission is to obtain few-group cross section data for LFRs. Cross sections The neutron transport problem is crucial in nuclear engineering and nuclear reactor physics. Neutron transport theory and the diffusion theory applied to neutron reactions are briefly described, including their principles and hypothesis. The two different computational approaches to solve the neutron transport problem are summarized. The software used to obtain the data is based on a modification of the Monte Carlo method. Thus, some basic probability theory concepts are introduced. This section follows with the discussion of the Monte Carlo method and its principles, and how it can be applied to solve the neutron transport problem. Afterwards, the Serpent code is explained, as well as its features and characteristics. The process of creating a 2-dimension model of ALFRED fuel assembly and the elaboration of Serpent input files are detailed. Cross section data for five neutron energy groups and at different material temperatures is obtained by running several simulations using Serpent. The last section includes a brief description of LFR technology and some specific ALFRED features. Some advantages and disadvantages of LFRs are included, along with some proposals to solve the disadvantages. The last part of this section illustrates the proposed ALFRED core scheme, using the data publicly available to date.

The feasibility of constructing a nuclear reactor operating in the fast neutron spectrum for the production of fissionable material and power has been under study at Chicago since 1945. It is hoped that such reactors can eventually be constructed to economically convert fertile material into fissionable material at a rate significantly greater than it will be consumed and simultaneously produce significant amounts of electrical power. The Argonne National Laboratory has built and has been operating since August, 1951, a 1,000 kw fast reactor known as the Experimental Breeder Reactor (EBR). The machine was primarily designed to perform limited experiments using the smallest possible critical mass. Work on various types of fast breeders has been studied at KAPL, and Los Alamos is now operating a mercury cooled Pu fueled fast reactor. Brookhaven has been studying a lead cooled unit. This report will attempt review of the program and progress which has been made to date on the EBR.

An authoritative and unbiased guide to nuclear technology and the controversies that surround it. Are you for nuclear power or against it? What's the basis of your opinion? Did you know a CT scan gives you some 2 millisieverts of radiation? Do you know how much a millisievert is? Does irradiation make foods safer or less safe? What is the point of a bilateral Russia-US nuclear weapons treaty in a multipolar world? These are nuclear questions that call for nuclear choices, and this book equips citizens to make these choices informed ones. It explains, clearly and accessibly, the basics of nuclear technology and describes the controversies surrounding its use.

Sodium Fast Reactors with Closed Fuel Cycle delivers a detailed discussion of an important technology that is being harnessed for commercial energy production in many parts of the world. Presenting the state of the art of sodium-cooled fast reactors with closed fuel cycles, this book:Offers in-depth coverage of reactor physics, materials, design, s

Interest in fast reactor development has increased with the Department of Energy's introduction of the Global Nuclear Energy Partnership (GNEP) [1]. The GNEP program plans development of a sodium cooled Advanced Burner Reactor (ABR) that can be used to reduce the amount spent LWR fuel in storage and the number of high level waste sites needed for expansion of nuclear power throughout the world over the 21st century. In addition, the program proposes to make nuclear power more available while reducing the proliferation concerns by revising policies and technology for control of weapons useable materials. This would be accomplished with establishment of new institutional arrangements based on selective siting of reprocessing, enrichment and waste disposal facilities. The program would also implement development of small reactors suitable for use in developing countries or remote regions with small power grids. Over the past several years, under the Department of Energy (DOE) NERI and GEN IV programs research has been conducted on small lead cooled reactors. The Small Secure Transportable Autonomous Reactor (SSTAR) [2] is the most recent version of this type of reactor and research is continuing on it in the GEN IV program in parallel with GNEP. SSTAR is a small (10MWe-100MWe) reactor that is fueled once for life. It complements the GNEP program very well in that it serves one of the world markets not currently addressed by large reactors and its development requirements are similar to those for the ABRs. In particular, the fuel and structural materials for these fast spectrum reactors share common thermal and neutron environments. The coolants, sodium in ABR and lead or lead-bismuth eutectic (LBE) in SSTAR, are the major developmental difference. This report discusses the status of structural materials for fast reactor core and primary system components and selected aspects of their development.

An invaluable resource for both graduate-level engineering students and practising nuclear engineers who want to expand their knowledge of fast nuclear reactors, the reactors of the future! This book is a concise yet comprehensive introduction to all aspects of fast reactor engineering. It covers topics including neutron physics; neutron flux spectra; flux distribution; Doppler and coolant temperature coefficients; the performance of ceramic and metal fuels under irradiation, structural changes, and fission-product migration; the effects of irradiation and corrosion on structural materials, irradiation swelling; heat transfer in the reactor core and its effect on core design; coolants including sodium and lead-bismuth alloy; coolant circuits; pumps; heat exchangers and steam generators; and plant control. The book includes new discussions on lead-alloy and gas coolants, metal fuel, the use of reactors to consume radioactive waste, and accelerator-driven subcritical systems.

Discussing methods for maximizing available energy, Energy Conversion surveys the latest advances in energy conversion from a wide variety of currently available energy sources. The book describes energy sources such as fossil fuels, biomass including refuse-derived biomass fuels, nuclear, solar radiation, wind, geothermal, and ocean, then provides the terminology and units used for each energy resource and their equivalence. It includes an overview of the steam power cycle, gas turbines, internal combustion engines, hydraulic turbines, Stirling engines, advanced fossil fuel power systems, and combined-cycle power plants. It outlines the development, current use, and future of nuclear fission. The book also gives a comprehensive description of the direct energy conversion methods, including, Photovoltaics, Fuel Cells, Thermoelectric conversion, Thermionics and MHD It briefly reviews the physics of PV electrical generation, discusses the PV system design process, presents several PV system examples, summarizes the latest developments in crystalline silicon PV, and explores some of the present challenges facing the large scale deployment of PV energy sources. The book discusses five energy storage categories: electrical, electromechanical, mechanical, direct thermal, and thermochemical and the storage media that can store and deliver energy. With contributions from researchers at the top of their fields and on the cutting edge of technologies, the book provides comprehensive coverage of end use efficiency of green technology. It includes in-depth discussions not only of better efficient energy management in buildings and

industry, but also of how to plan and design for efficient use and management from the ground up.
This report provides an update on development of a pre-conceptual design for the Small Secure Transportable Autonomous Reactor (SSTAR) Lead-Cooled Fast Reactor (LFR) plant concept and supporting research and development activities. SSTAR is a small, 20 MWe (45 MWt), natural circulation, fast reactor plant for international deployment concept incorporating proliferation resistance for deployment in non-fuel cycle states and developing nations, fissile self-sufficiency for efficient utilization of uranium resources, autonomous load following making it suitable for small or immature grid applications, and a high degree of passive safety further supporting deployment in developing nations. In FY 2006, improvements have been made at ANL to the pre-conceptual design of both the reactor system and the energy converter which incorporates a supercritical carbon dioxide Brayton cycle providing higher plant efficiency (44 %) and improved economic competitiveness. The supercritical CO2 Brayton cycle technology is also applicable to Sodium-Cooled Fast Reactors providing the same benefits. One key accomplishment has been the development of a control strategy for automatic control of the supercritical CO2 Brayton cycle in principle enabling autonomous load following over the full power range between nominal and essentially zero power. Under autonomous load following operation, the reactor core power adjusts itself to equal the heat removal from the reactor system to the power converter through the large reactivity feedback of the fast spectrum core without the need for motion of control rods, while the automatic control of the power converter matches the heat removal from the reactor to the grid load. The report includes early calculations for an international benchmarking problem for a LBE-cooled, nitride-fueled fast reactor core organized by the IAEA as part

of a Coordinated Research Project on Small Reactors without Onsite Refueling; the calculations use the same neutronics computer codes and methodologies applied to SSTAR. Another section of the report details the SSTAR safety design approach which is based upon defense-in-depth providing multiple levels of protection against the release of radioactive materials and how the inherent safety features of the lead coolant, nitride fuel, fast neutron spectrum core, pool vessel configuration, natural circulation, and containment meet or exceed the requirements for each level of protection. The report also includes recent results of a systematic analysis by LANL of data on corrosion of candidate cladding and structural material alloys of interest to SSTAR by LBE and Pb coolants; the data were taken from a new database on corrosion by liquid metal coolants created at LANL. The analysis methodology that considers penetration of an oxidation front into the alloy and dissolution of the trailing edge of the oxide into the coolant enables the long-term corrosion rate to be extracted from shorter-term corrosion data thereby enabling an evaluation of alloy performance over long core lifetimes (e.g., 30 years) that has heretofore not been possible. A number of candidate alloy specimens with special treatments or coatings which might enhance corrosion resistance at the temperatures at which SSTAR would operate were analyzed following testing in the DELTA loop at LANL including steels that were treated by laser peening at LLNL; laser peening is an approach that alters the oxide-metal bonds which could potentially improve corrosion resistance. LLNL is also carrying out Multi-Scale Modeling of the Fe-Cr system with the goal of assisting in the development of cladding and structural materials having greater resistance to irradiation.

This book presents a comprehensive review of studies in nuclear reactors technology from authors across the globe.

Topics discussed in this compilation include: thermal hydraulic investigation of TRIGA type research reactor, materials testing reactor and high temperature gas-cooled reactor; the use of radiogenic lead recovered from ores as a coolant for fast reactors; decay heat in reactors and spent-fuel pools; present status of two-phase flow studies in reactor components; thermal aspects of conventional and alternative fuels in supercritical water?cooled reactor; two-phase flow coolant behavior in boiling water reactors under earthquake condition; simulation of nuclear reactors core; fuel life control in light-water reactors; methods for monitoring and controlling power in nuclear reactors; structural materials modeling for the next generation of nuclear reactors; application of the results of finite group theory in reactor physics; and the usability of vermiculite as a shield for nuclear reactor.
A reusable multiple lead seal assembly provides leak-free passage of stainless-steel-clad instrument leads through the cover on the primary tank of a liquid-metal-cooled fast-breeder nuclear reactor. The seal isolates radioactive argon cover gas and sodium vapor within the primary tank from the exterior atmosphere and permits reuse of the assembly and the stainless-steel-clad instrument leads. Leads are placed in flutes in a seal body, and a seal shell is then placed around the seal body. Circumferential channels in the body and inner surface of the shell are contiguous and together form a conduit which intersects each of the flutes, placing them in communication with a port through the wall of the seal shell. Liquid silicone rubber sealant is injected into the flutes through the port and conduit; the sealant fills the space in the flutes not occupied by the leads themselves and dries to a rubbery hardness. A nut, threaded onto a portion of the seal body not covered by the seal shell, jacks the body out of the shell and shears the sealant without damage to the body, shell, or leads. The leads may then be removed from the

body. The sheared sealant is cleaned from the body, leads, and shell and the assembly may then be reused with the same or different leads.

Overview of how decisions by China on climate, energy, and environmental policy will influence the country's capacity to decarbonize.

Since 2002, the Department of Energy's (DOE's) Generation IV Nuclear Energy Systems (Gen IV) Program has addressed the research and development (R & D) necessary to support next-generation nuclear energy systems. The six most promising systems identified for next-generation nuclear energy are described within this roadmap. Two employ a thermal neutron spectrum with coolants and temperatures that enable hydrogen or electricity production with high efficiency (the Supercritical Water Reactor-SCWR and the Very High Temperature Reactor-VHTR). Three employ a fast neutron spectrum to enable more effective management of actinides through recycling of most components in the discharged fuel (the Gas-cooled Fast Reactor-GFR, the Lead-cooled Fast Reactor-LFR, and the Sodium-cooled Fast Reactor-SFR). The Molten Salt Reactor (MSR) employs a circulating liquid fuel mixture that offers considerable flexibility for recycling actinides and may provide an alternative to accelerator-driven systems. At the inception of DOE's Gen IV program, it was decided to significantly pursue five of the six concepts identified in the Gen IV roadmap to determine which of them was most appropriate to meet the needs of future U.S. nuclear power generation. In particular, evaluation of the highly efficient thermal SCWR and VHTR reactors was initiated primarily for energy production, and evaluation of the three fast reactor concepts, SFR, LFR, and GFR, was begun to assess viability for both energy production and their potential contribution to closing the fuel cycle. Within the Gen IV Program itself, only the VHTR class of reactors was selected for continued development. Hence, this document will address the multiple activities under the Gen IV program that contribute to the development of the VHTR. A few major technologies have been recognized by DOE as necessary to enable the deployment of the next generation of advanced nuclear reactors, including the development and qualification of the structural materials needed to ensure their safe and reliable operation. The focus of this document will be the overall range of DOE's structural materials research activities being conducted to support VHTR development. By far, the largest portion of material's R & D supporting VHTR development is that being performed directly as part of the Next-Generation Nuclear Plant (NGNP) Project. Supplementary VHTR materials R & D being performed in the DOE program, including university and international research programs and that being performed under direct contracts with the American Society for Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, will also be described. Specific areas of high-priority materials research that will be needed to deploy the NGNP and provide a basis for subsequent VHTRs are described, including the following: (1) Graphite: (a) Extensive unirradiated materials characterization and assessment of irradiation effects on properties must be performed to qualify new grades of graphite for nuclear service, including thermo-physical and mechanical properties and their changes, statistical variations from billot-to-billot and lot-to-lot, creep, and especially, irradiation creep. (b) Predictive models, as well as codification of the requirements and design methods for graphite core supports, must be developed to provide a basis for licensing. (2) Ceramics: Both fibrous and load-bearing ceramics must be qualified for environmental and radiation service as insulating materials. (3) Ceramic Composites: Carbon-carbon and SiC-SiC composites must be qualified for specialized usage in selected high-temperature components, such as core stabilizers, control rods, and insulating covers and ducting. This will require development of component-specific designs and fabrication processes, materials characterization, assessment of environmental and irradiation effects, and establishment of codes and standards for materials testing and design requirements. (4) Pressure Vessel Steels: (a) Qualification of short-term, high-temperature properties of light water reactor steels for anticipated VHTR off-normal conditions must be determined, as well as the effects of aging on tensile, creep, and toughness properties, and on thermal emissivity. (b) Large-scale fabrication process for higher temperature alloys, such as 9Cr-1MoV, including ensuring thick-section and weldment integrity must be developed, as well as improved definitions of creep-fatigue and negligible creep behavior. (5) High-Temperature Alloys: (a) Qualification and codification of materials for the intermediate heat exchanger, such as Alloys 617 or 230, for long-term very high-temperature creep, creep-fatigue, and environmental aging degradation must be done, especially in thin sections for compact designs, for both base metal and weldments. (b) Constitutive models and an improved methodology for high-temperature design must be developed.

The objectives of this dissertation were to find a principal domain of promising and technologically feasible reactor physics characteristics for a multi-purpose, modular-sized, lead-cooled, fast neutron spectrum reactor fueled with an advanced uranium-transuranic-nitride fuel and to determine the principal limitations for the design of an autonomous long-term multi-purpose fast reactor (ALM-FR) within the principal reactor physics characteristic domain. The objectives were accomplished by producing a conceptual design for an ALM-FR and by analysis of the potential ALM-FR performance characteristics. The ALM-FR design developed in this dissertation is based on the concept of a secure transportable autonomous reactor for hydrogen production (STAR-H2) and represents further refinement of the STAR-H2 concept towards an economical, proliferation-resistant, sustainable, multi-purpose nuclear energy system. The development of the ALM-FR design has been performed considering this reactor within the frame of the concept of a self-consistent nuclear energy system (SCNES) that satisfies virtually all of the requirements for future nuclear energy systems: efficient energy production, safety, self-feeding, non-proliferation, and radionuclide burning. The analysis takes into consideration a wide range of reactor design aspects including selection of technologically feasible fuels and structural materials, core configuration optimization, dynamics and safety of long-term operation on one fuel loading, and nuclear material non-proliferation. Plutonium and higher actinides are considered as essential components of an advanced fuel that maintains long-term operation. Flexibility of the ALM-FR with respect to fuel compositions is demonstrated acknowledging the principal limitations of the long-term burning of plutonium and higher actinides. To ensure consistency and accuracy, the modeling has been performed using state-of-the-art computer codes developed at Argonne National Laboratory. As a result of the computational analysis performed in this work, the ALM-FR design provides for the possibility of continuous operation during about 40 years on one fuel loading containing mixture of depleted uranium with plutonium and higher actinides. All reactor physics characteristics of the ALM-FR are kept within technological limits ensuring safety of ultra-long autonomous operation. The results obtained provide for identification of physical features of the ALM-FR that significantly influence flexibility of the design and its applications. The special emphasis is given to existing limitations on the utilization of higher actinides as a fuel component.

This book is a complete update of the classic 1981 FAST BREEDER REACTORS textbook authored by Alan E. Waltar and Albert B. Reynolds, which , along with the Russian translation, served as a major reference book for fast reactors systems. Major updates include transmutation physics (a key technology to substantially ameliorate issues associated with the storage of high-level nuclear waste), advances in fuels and materials technology (including metal fuels and cladding materials capable of high-temperature and high burnup), and new approaches to reactor safety (including passive safety technology), New chapters on gas-cooled and lead-cooled fast spectrum reactors are also included. Key international experts contributing to the text include Chaim Braun, (Stanford University) Ronald Omberg, (Pacific Northwest National Laboratory, Massimo Salvatores (CEA, France), Baldev Raj, (Indira Gandhi Center for Atomic Research, India) , John Sackett (Argonne National Laboratory), Kevan Weaver, (TerraPower Corporation) ,James Seinicki(Argonne National Laboratory). Russell Stachowski (General Electric), Toshikazu Takeda (University of Fukui, Japan), and Yoshitaka Chikazawa (Japan Atomic Energy Agency).
The Department of Energy's (DOE's) Generation IV Nuclear Energy Systems Program will address the research and development (R & D) necessary to support next-generation nuclear energy systems. Such R & D will be guided by the technology roadmap developed for the Generation IV International Forum (GIF) over two years with the participation of over 100 experts from the GIF countries. The roadmap evaluated over 100 future systems proposed by researchers around the world. The scope of the R & D described in the roadmap covers the six most promising Generation IV systems. The effort ended in December 2002 with the issue of the final Generation IV Technology Roadmap [1.1]. The six most promising systems identified for

next generation nuclear energy are described within the roadmap. Two employ a thermal neutron spectrum with coolants and temperatures that enable hydrogen or electricity production with high efficiency (the Supercritical Water Reactor - SCWR and the Very High Temperature Reactor - VHTR). Three employ a fast neutron spectrum to enable more effective management of actinides through recycling of most components in the discharged fuel (the Gas-cooled Fast Reactor - GFR, the Lead-cooled Fast Reactor - LFR, and the Sodium-cooled Fast Reactor - SFR). The Molten Salt Reactor (MSR) employs a circulating liquid fuel mixture that offers considerable flexibility for recycling actinides, and may provide an alternative to accelerator-driven systems. A few major technologies have been recognized by DOE as necessary to enable the deployment of the next generation of advanced nuclear reactors, including the development and qualification of the structural materials needed to ensure their safe and reliable operation. Accordingly, DOE has identified materials as one of the focus areas for Gen IV technology development.

This open access book discusses the eroding economics of nuclear power for electricity generation as well as technical, legal, and political acceptance issues. The use of nuclear power for electricity generation is still a heavily disputed issue. Aside from technical risks, safety issues, and the unsolved problem of nuclear waste disposal, the economic performance is currently a major barrier. In recent years, the costs have skyrocketed especially in the European countries and North America. At the same time, the costs of alternatives such as photovoltaics and wind power have significantly decreased. Contents History and Current Status of the World Nuclear Industry The Dramatic Decrease of the Economics of Nuclear Power Nuclear Policy in the EU The Legacy of Csernobyl and Fukushima Nuclear Waste and

Decommissioning of Nuclear Power Plants Alternatives: Heading Towards Sustainable Electricity Systems Target Groups Researchers and students in the fields of political, economic and technical sciences Energy (policy) experts, nuclear energy experts and practitioners, economists, engineers, consultants, civil society organizations The Editors Prof. Dr. Reinhard Haas is University Professor of energy economics at the Institute of Energy Systems and Electric Drives at Technische Universität Wien, Austria. PD Dr. Lutz Mez is Associate Professor at the Department for Political and Social Sciences of Freie Universität Berlin, Germany. PD Dr. Amela Ajanovic is a senior researcher and lecturer at the Institute of Energy Systems and Electrical Drives at Technische Universität Wien, Austria.--