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Structural Alloys For Power Plants

The high temperature capability of nickel alloys makes them critical for power plant applications. Microstructural evolution in such alloys determines the long-term performance such as creep life. This chapter concentrates on modelling creep in solid solution-strengthened and precipitation-strengthened nickel alloys.

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Knott, The University of Birmingham, UK Part 2 Structural alloys and their development 5 Austenitic steels and alloys for power plants Y. Yin and R. Faulkner, Loughborough University, UK, and F.

Starr, Consultant, UK 6
Bainitic steels and alloys for power plants

Structural Alloys for Power Plants : A. Shirzadi ...
Contents ix 11.10 Fatigue

induced by thermal strain 343 11.11 Fatigue crack growth and interactions 345 11.12 Conclusion 350 11.13 References 353 12 Radiation damage to structural alloys in nuclear power plants: mechanismsand remediation

355 G. S. Was, University ofMichigan,USAandP.L. Andresen, General Electric Global Research,USA 12.1 Introduction 355 12.2 Overview: the radiation damageevent 356

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7 Ferritic and martensitic steels for power plants P.J. Ennis, University of Leicester, UK Abstract: The metallurgical background and

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Current fleets of conventional and nuclear power plants face increasing hostile environmental conditions due to increasingly high temperature operation for improved capacity and efficiency, and the need for long term service.

Additional challenges are presented by the requirement to cycle plants to meet peak-load operation. This book presents a comprehensive review of structural materials in conventional and nuclear energy applications. Opening chapters address operational challenges and structural alloy requirements in different types of power plants. The following sections review power plant structural alloys and methods to mitigate critical materials degradation in power plants.

Due to their continuing role in electricity generation, it is important that coal power plants operate as efficiently and cleanly as possible. Coal Power Plant Materials and Life Assessment reviews the materials used in coal plants, and how they can be assessed and managed to optimize plant operation.

Part I considers the structural alloys used in coal plants. Part II then reviews performance modelling and life assessment techniques, explains the inspection and life-management approaches that can be adopted to optimize long term plant operation, and considers the technical and economic issues involved in meeting variable energy demands. Summarizes key research on coal-fired power plant materials, their behavior under operational loads, and approaches to life assessment and defect management Details the range of structural alloys used in coal power plants, and the life assessment techniques applicable to defect-free components under operational loads Reviews the life assessment techniques applicable to components containing defects and the approaches that can be adopted to optimize plant operation and new plant and component design

High-performance alloys that can withstand operation in hazardous nuclear environments are critical to presentday in-service reactor support and maintenance and are foundational for reactor concepts of the future. With commercial nuclear energy vendors and operators facing the retirement of staff during the coming decades, much of the scholarly knowledge of nuclear materials pursuant to appropriate, impactful, and safe usage is at risk. Led by the multi-award winning editorial team of G. Robert Odette (UCSB) and Steven J.

Zinkle (UTK/ORNL) and with contributions from leaders of each alloy discipline, Structural Alloys for Nuclear Energy Applications aids the next generation of researchers and industry staff developing and maintaining steels, nickel-base alloys, zirconium alloys, and other structural alloys in nuclear energy applications. This authoritative reference is a critical acquisition for institutions and individuals seeking state-of-the-art knowledge aided by the editors’ unique personal insight from decades of frontline research, engineering and management. Focuses on in-service irradiation, thermal, mechanical, and chemical performance capabilities. Covers the use of steels and other structural alloys in current fission technology, leading edge Generation-IV fission reactors, and future fusion power reactors.

Provides a critical and comprehensive review of the state-of-the-art experimental knowledge base of reactor materials, for applications ranging from engineering safety and lifetime assessments to supporting the development of advanced computational models.

A program on fireside corrosion is being conducted at Argonne National Laboratory to evaluate the performance of several structural alloys in the presence of mixtures of synthetic coal ash, alkali sulfates, and alkali chlorides. Candidate alloys are also exposed in a small-scale coal-fired combustor at the National Energy Technology Laboratory in Pittsburgh. Experiments in the present program, which addresses the effects of deposit chemistry, temperature, and alloy chemistry on the corrosion response of alloys, were conducted at temperatures in the range of 575-800 C for time periods up to (almost equal to)1850 h. Alloys selected for the study included HR3C, 310TaN, HR120, SAVE 25, NF709, modified 800, 347HFG, and HCM12A. In addition, 800H clad with Alloy 671 was included in several of the exposures. Data were obtained on weight change, scale thickness, internal penetration, microstructural characteristics of corrosion products, mechanical integrity, and cracking of scales. Results showed that relationship of corrosion rates to temperature followed a bell-shaped curve, with peak rates at (almost equal to)725 C, but the rate itself was dependent on the alloy chemistry. Several alloys showed acceptable rates in the sulfate-containing coal-ash environment; but NaCl in the deposit led to catastrophic corrosion at 650 and 800 C.

Operating at a high level of fuel efficiency, safety, proliferation-resistance, sustainability and cost, generation IV nuclear reactors promise enhanced features to an energy resource which is already seen as an outstanding source of reliable base load power. The performance and reliability of materials when subjected to the higher neutron doses and extremely corrosive higher temperature environments that will be found in generation IV nuclear reactors are essential areas of study, as key considerations for the successful development of generation IV reactors are suitable structural materials for both in-core and out-of-core applications. Structural Materials for Generation IV Nuclear Reactors explores the current state-of-the art in these areas. Part One reviews the materials, requirements and challenges in generation IV systems. Part Two presents the core materials with chapters on irradiation resistant austenitic steels, ODS/FM steels and refractory metals amongst others. Part Three looks at out-of-core materials. Structural Materials for Generation IV Nuclear Reactors is an essential reference text for professional scientists, engineers and postgraduate researchers involved in the development of generation IV nuclear reactors. Introduces the higher neutron doses and extremely corrosive higher temperature environments that will be found in generation IV nuclear reactors and implications for structural materials Contains chapters on the key core and out-of-core materials, from steels to advanced micro-laminates Written by an expert in that particular area

This book addresses structural material corrosion in coolant circuits, simulation of erosion corrosion of carbon and low-alloy steels, and simulation of stress corrosion. It also discusses corrosion of copper alloys, zirconium corrosion, optimization of water chemistry at operating nuclear power plants, coolant tendency to deposit hardness salts on heat-transfer surfaces, and inspection of metallic components. In addition, there are two appendixes, the first showing the chemical composition of steels, the second discussing solubility of iron, cobalt, zinc and copper corrosion products under conditions simulating power unit water chemistry.

A program on coal-ash corrosion is being conducted at Argonne National Laboratory to evaluate the performance of several structural alloys in the presence of mixtures of synthetic coal ash, alkali sulfates, and alkali chlorides. Candidate alloys are also exposed in a small-scale coal-fired combustor at the National Energy Technology Laboratory in Pittsburgh. Experiments in the present program, which addresses the effects of deposit chemistry,

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study included HR3C, 310TaN, HR120, SAVE 25, NF709, modified 800, 347HFG, and HCM12A. In addition, 800H clad with Alloy 671 was included in several of the exposures. Ni-base alloys selected for the study included 600, 601, 617, 690, 625, 602CA, 214, 230, 45TM, HR 160, and 693. Data were obtained on weight change, scale thickness, internal penetration, microstructural characteristics of corrosion products, mechanical integrity of the scales, and cracking of scales. Results showed that the relationship of corrosion rates to temperature followed a bell-shaped curve for Fe-base alloys, with peak rates at {approx}725 C, but the rate itself was dependent on the alloy chemistry. Several Fe-base alloys showed acceptable rates in the sulfate-containing coal-ash environment; but NaCl in the deposit led to catastrophic corrosion at 650 and 800 C.

Ni-base alloys generally exhibited less corrosion than the Fe-base alloys under similar exposure conditions; however, they were susceptible to localized corrosion in the form of pits.

Failures or forced shutdowns in power plants are often due to boilers, and particularly failure of boiler tubes. This comprehensive resource deals with the subject of failure investigation of boiler tubes from basic fundamentals to practical applications. Coverage includes properties and selection of materials for boiler tubes from a metallurgical view point, damage mechanisms responsible for failure of boiler tubes, and characterization techniques employed for investigating failures of boiler tubes in thermal power plants and utility boilers of industrial/commercial/institutional (ICI) boilers. A large number of case studies based on the actual failures from the field are described, along with photographs and microstructures to allow for easy comprehension of the theory behind the failures. This book is geared to practicing engineers and for studies in the major area of power plant engineering. For non-metallurgists, a chapter has been devoted to the basics of material science, metallurgy of steels, heat treatment, and structure-property correlation. A chapter on materials for boiler tubes covers composition and application of different grades of steels and high temperature alloys currently in use as boiler tubes and future materials to be used in supercritical, ultra-supercritical and advanced ultra-supercritical thermal power plants. A comprehensive discussion on different mechanisms of boiler tube failure is the heart of the book. Additional chapters detailing the role of advanced material characterization techniques in failure investigation and the role of water chemistry in tube failures are key contributions to the book. The authors have long-standing experience in the field of metallurgy and materials technology, failure investigation, remaining life assessment (RLA) and fitness for service (FFS) for industrial plant and equipment, including power plants. They have conducted a large number of failure investigations of boiler tubes and have recommended effective remedial measures in problem solving for power and utility boilers.

Calcium and Chemical Looping

Technology for Power Generation and Carbon Dioxide (CO_2) Capture reviews the fundamental principles, systems, oxygen carriers, and carbon dioxide carriers relevant to chemical looping and combustion. Chapters review the market development, economics, and deployment of these systems, also providing detailed information on the variety of materials and processes that will help to shape the future of CO2 capture ready power plants. Reviews the fundamental principles, systems, oxygen carriers, and carbon dioxide carriers relevant to calcium and chemical looping Provides a lucid explanation of advanced concepts and developments in calcium and chemical looping, high pressure systems, and alternative CO2 carriers Presents information on the market development, economics, and deployment of these systems