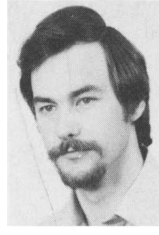
nuclear technology®

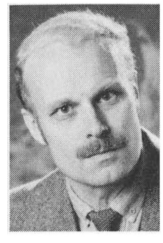
AUTHORS — AUGUST 1984

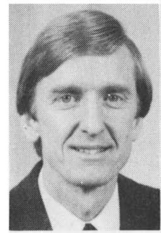
STATUS OF METALLIC MATERIALS DEVELOPMENT FOR APPLICATION IN ADVANCED HIGH-TEMPERATURE GAS-COOLED REACTORS

CREEP RUPTURE BEHAVIOR OF CANDIDATE MATERIALS FOR NUCLEAR PROCESS HEAT APPLICATIONS

F. Schubert
Udo Bruch
R. Cook
H. Diehl
Philip J. Ennis
W. Jakobeit
H. J. Penkalla
Eberhard te Heesen
G. Ullrich

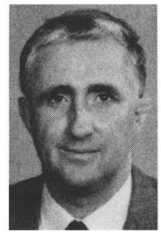


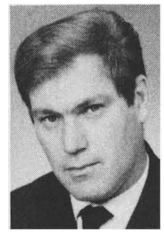




F. Schubert (top right) [Dipl.-Physicist, University of Saarland, Federal Republic of Germany (FRG), 1968; Dr. rer. nat., Technical University of Aachen, FRG, 1974] is head of the materials evaluation office of the Institute for Reactor Materials (IRM), Kernforschungsanlage (KFA)-Jülich. He is chairman of the working group on materials at the German Research and Development Company of HTR, Entwicklungsgemeinschaft HTR. Before joining KFA he was involved in the R&D of high-temperature superalloys at Thyssen Special Steel Work and Thyssen Investment Casting Work, both in the fields of metallurgy and processing. His current work of developing a design code for high temperatures in multiaxial creep, creep ratchetting, creep buckling, and lifetime prediction. **Udo Bruch** (top left) (Dr.-Ing., mechanical engineering, University of Bochum, 1977) has been employed in R&D at Rheinische Braunkohlenwerke AG (RB), Cologne, since 1977. He has been appointed to the Department for Reactor Materials at the Nuclear Research Center (KFA), Jülich, and works in the field of corrosion and creep of high-temperature alloys in steam reformer and coal gasification atmospheres. **R. Cook** (center right) (PhD, metallurgy, University of Sheffield, 1964) joined the Central Electricity Research Laboratories to work on high-temperature mechanical properties of steels, including materials for gas-cooled reactors, following a two-year postdoctoral fellowship at the University of Pennsylvania. He worked on the Dragon Project from 1974 to 1976, and his work since then has been primarily concerned with creep of materials for high-temperature gas-cooled reactors (HTGRs). **H. Diehl** (bottom left) (Dr.-Ing., mechanical engineering, Technische Hochschule Darmstadt, 1977) was an instructor for materials technology and testing after graduation in 1966 and worked on several research programs for creep-resistant steels and on failure analysis for service-loaded components at the Institute for Materials Technology of the Technische Hochschule Darmstadt. In 1977 he moved to KFA-Jülich, where he spent nearly two years at IRM organizing the HTGR material programs and in the evaluation of materials data for design. Since 1979 he has worked at Hochtemperatur Reaktorbau GmbH, Mannheim, on materials problems for HTGR projects as well as for the commercial thorium high-temperature reactor in construction. He is the leader of the subgroup for materials under irradiation of the PNP materials program. **Philip J. Ennis** (bottom right) (BSc, physical metallurgy, University of Birmingham,

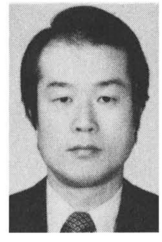
United Kingdom, 1965) is a research metallurgist at IRM, KFA-Jülich. Prior to joining KFA in 1976, he was with INCO Europe Ltd. for 11 years and worked on the development of nonferrous nickel-containing alloys. His current interests are the mechanical properties of high-temperature alloys in HTGR environments and the influence of corrosion on mechanical behavior. **W. Jakobeit** (top right) (Dipl.-Ing., mechanics, Technical University of Braunschweig, 1960) has been employed in the Central Material Laboratory of Brown Boveri & Company Ltd., Mannheim, since 1961, where he is involved with the high-temperature properties of steels and superalloys (tensile, creep, low-cycle fatigue). Besides those investigations, he is also working on the development of a turbine blade made of Mo-TZM. He is the group leader of the Creep Testing Laboratory. **H. J. Penkalla** (top left) (Dipl.-Physicist, Dr. rer. nat., Technical University of Aachen, FRG, 1976) is working on the development of a design code for high-temperature reactor components. Prior to joining KFA in 1979, he was with the Joint Research Centre of the European Communities in Petten, The Netherlands, for one year, where he studied the interaction of creep and carburization in process gases. **Eberhard te Heesen** (bottom right) (Dipl.-Ing., metallurgy, Technical University of Aachen, FRG, 1966) has worked in structural materials at Interatom GmbH, Bergisch Gladbach, since 1968. His areas of interest are testing and qualification of structural materials for permanent components of sodium-cooled fast breeder reactors and high-temperature nuclear power plants. **G. Ullrich** (bottom left) (Dipl.-Ing., metallurgist, University of Clausthal and Saarbruecken, 1961) was a junior scientist in industry from 1961 to 1962. Since 1963 he has worked at the Swiss Federal Institute for Reactor Research. He has been head of the metallurgical department at the institute since 1979.





CREEP RUPTURE PROPERTIES OF HASTELLOY-X AND INCOLOY-800H IN A SIMULATED HTGR HELIUM ENVIRONMENT CONTAINING HIGH LEVELS OF MOISTURE

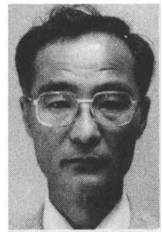
Kyung Sub Lee



Kyung Sub Lee (PhD, materials engineering, Rensselaer Polytechnic Institute, 1976) has studied high-temperature gaseous corrosion of high-temperature gas-cooled reactors at Brookhaven National Laboratory (BNL). He has also worked in the areas of low-temperature mechanical properties of cast stainless steel and hydrogen embrittlement of metals during his six-year tenure at BNL. Currently, he teaches at Hanyang University in Seoul, Korea.

CREEP AND RUPTURE BEHAVIOR OF A SPECIAL GRADE HASTELLOY-X IN SIMULATED HTGR HELIUM

Yuji Kurata
Yutaka Ogawa
Tatsuo Kondo



Yuji Kurata (top) [BS, metallurgical engineering, Tohoku University (TU), 1975] is a research scientist at the Materials Engineering Laboratory of the Japan Atomic Energy Research Institute (JAERI). He has worked in high-temperature gas-cooled reactor (HTGR) fuel development. He is presently involved in studies on creep behavior of heat-resistant alloys for HTGRs in simulated reactor environments. **Yutaka Ogawa** (bottom) (Dr. Eng., TU, 1977) has worked in creep testing of heat-resistant alloys in

simulated HTGR helium environments at JAERI. He is interested in precise measurement of long-term creep strains. **Tatsuo Kondo** (right) (BS, metallurgical engineering, TU; MS, 1963, and PhD, 1965, The Ohio State University) has been employed at JAERI since 1958 and is deputy director of the fuels and materials department. He has worked in the areas of corrosion-assisted fracture of metals in reactor environments and alloy development. He presently supervises the material research programs for HTGRs, light water reactors, and nuclear fusion.

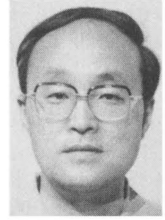
CREEP RUPTURE PROPERTIES OF SUPERALLOYS DEVELOPED FOR NUCLEAR STEELMAKING

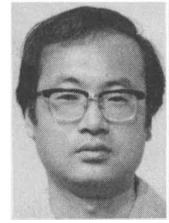
Tatsuhiko Tanabe
Yoshikazu Sakai
Tatsuo Shikama
Masakazu Fujitsuka
Heitaro Yoshida
Ryoji Watanabe

Tatsuhiko Tanabe (top right) (Dr. eng., metallurgy, University of Tokyo, 1963) is a senior researcher at the National Research Institute for Metals (NRIM). He has been involved in the high-temperature gas-cooled reactor (HTGR) program as a chief researcher since 1975. His interests include studies on mechanical properties and development of structural materials in reactor environments. **Yoshikazu Sakai** (top left) (mechanical engineering, Haneda Technical High School, 1969) has worked at NRIM since 1969. He has been involved in the HTGR program as a researcher. He is currently interested in corrosion behavior of heat-resistant alloys in helium environments. **Tatsuo Shikama** (center right) (Dr. eng., nuclear engineering, University of Tokyo, 1977) has worked at NRIM as a member of the HTGR program since 1977. His main interests include low-Z coating to first-wall materials in fusion reactors and their mechanical properties. **Masakazu Fujitsuka** (center left) (BE, chemical engineering, Nihon University, 1976) has been with NRIM since 1967. He has been involved in the HTGR program since 1975. He is currently working on low-Z coating to first-wall materials in fusion reactors. **Heitaro Yoshida** (bottom right) (Dr. eng., metallurgy, Kyoto University, 1952) has been in charge of the HTGR program at NRIM. He is currently director of the Materials Strength Division at NRIM. His main interests are mechanical properties of heat-resistant alloys for reactor environments. **Ryoji Watanabe** (bottom left) (Dr. eng., metallurgy, Hokkaido University, 1945) has been director of the Nuclear Materials Division and is responsible for the HTGR program. He is currently with the Special Purpose Materials Division. He has been active in studying refractory metals and phase stability of nuclear materials.

CREEP PROPERTIES OF HASTELLOY-X IN IMPURE HELIUM ENVIRONMENTS

Tsuneo Nakanishi
Haruo Kawakami

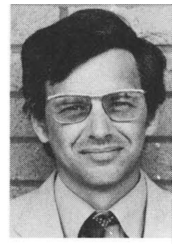




Tsuneo Nakanishi (top) (PhD, metallurgy, Osaka University, 1962) is a group manager of the Metals and Ceramic Group of Fuji Electric Corporate Research and Development, Ltd. (FECRD). He has worked in the area of welding and brazing for electric equipment and machinery, and also oxidation and high-temperature strength of heat-resistant alloys for the high-temperature gas-cooled reactor (HTGR) for about 16 years. **Haruo Kawakami** (BS, Tokyo University, 1971) is group submanager of the Metals and Ceramic Group of FECRD. He has been engaged in R&D of materials for HTGRs for ten years. His previous work experience includes compatibility of metals with graphite, corrosion of heat-resistant alloys in impure helium, and thermal stability of carbon and ceramics.

CREEP PROPERTIES OF INCONEL-617 IN AIR AND HELIUM AT 800 to 1000°C

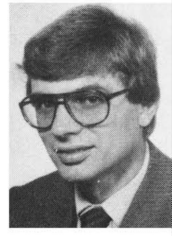
Roger H. Cook

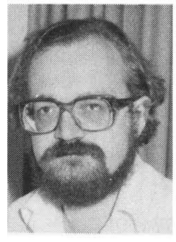


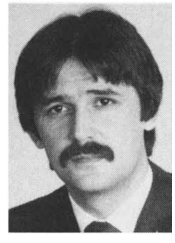
Roger H. Cook (PhD, metallurgy, University of Sheffield, 1964) joined the Central Electricity Research Laboratories to work on high-temperature mechanical properties of steels, including materials for gas-cooled reactors, following a two-year postdoctoral fellowship at the University of Pennsylvania. He worked on the Dragon Project from 1974 to 1976, and his work since then has been primarily concerned with creep of materials for high-temperature gas-cooled reactors.

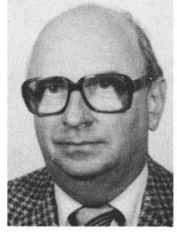
CREEP BEHAVIOR OF MATERIALS FOR HIGH-TEMPERATURE REACTOR APPLICATION

Klaus Schneider
Walter Hartnagel
Peter Schepp
Bernhard Ilschner





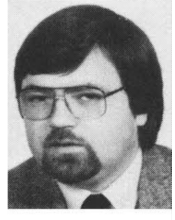


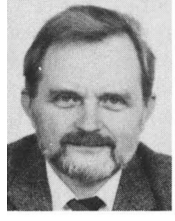


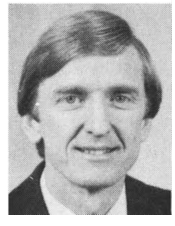
Klaus Schneider (top right) (PhD, material science) wrote his thesis on transmission electron microscopy (TEM) investigation of an aluminum alloy. During a postdoctoral fellowship at the University of California, Berkeley, extensive TEM work was performed to evaluate lattice imaging. Since 1974 he has been at Brown, Boveri & Cie (BBC), Mannheim, Federal Republic of Germany (FRG), and is now head of the physical metallurgy department in the central materials laboratory. **Walter Hartnagel** (top left) [Dipl.-Ing., material science, University of Erlangen-Nürnberg, FRG, 1976] has been employed in the Central Materials Laboratory of BBC, Mannheim. In the department of physical metallurgy he works on problems of high-temperature corrosion and materials behavior for inelastic design analysis. **Peter Schepp** (bottom right) (Dipl.-Ing., University of Erlangen, 1977) first studied hardening mechanisms in nickel-base superalloys, in particular the interaction between dislocations and γ' particles. From 1978 to 1982 he performed research on the creep behavior of Inconel-617, including the effects due to interaction with gas atmospheres containing carbon compounds. **Bernhard Ilschner** (bottom left) (Dr. rer. nat., University of Bonn, 1953) was a professor of materials science from 1965 to 1982 with the engineering faculty, Erlangen University; his main fields of interest are the mechanical properties of metals and ceramics at high temperatures and the thermodynamics and kinetics of solid state reactions.

CREEP AND RELAXATION BEHAVIOR OF INCONEL-617

Walter Osthoff
Hans Schuster
Philip J. Ennis
Hubertus Nickel





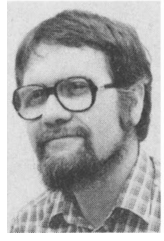


Walter Osthoff (top) [Dipl.-Ing., physical metallurgy, Technical University of Aachen (TUA), Federal Republic of Germany, 1979] joined Kernforschungsanlage (KFA)-Jülich, Institute for Reactor Materials (IRM) and has been working on his doctoral thesis, "Creep in Nickel-Base Alloys." **Hans Schuster** (center) (Dr.-Ing., TUA, 1968) is the section head of IRM at KFA-Jülich. After working in the field of irradiation effects on graphitic core materials for the high-temperature gas-cooled reactor (HTGR), his interest has been in mechanical properties and corrosion effects on high-temperature alloys. Prior to his assignment at IRM, he performed basic studies of irradiation effects in high-purity metals at Rheinisch-Westfälische Technische Hochschule. **Philip J. Ennis** (bottom) (BSc, physical metallurgy, University of Birmingham, United Kingdom, 1965) is a research metallurgist at IRM, KFA-Jülich. Prior to joining KFA in 1976, he was with INCO Europe Ltd. for 11 years and worked on the development

of nonferrous nickel-containing alloys. His current interests are the mechanical properties of high-temperature alloys in HTGR environments and the influence of corrosion on mechanical behavior. **Hubertus Nickel** (right) (Dr. rer. nat., physical chemistry, TUA, 1959) is head of IRM at KFA-Jülich. He is also a full professor of reactor materials and nuclear fuel elements at the TUA and is a member of the German Reactor Safety Commission.

TIME-TO-FAILURE ESTIMATION FOR HIGH-TEMPERATURE MATERIALS UNDER CREEP LOAD BY REPLICAS

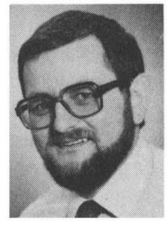
Burkhard Neubauer

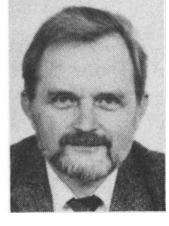


Burkhard Neubauer (Dr. Ing., materials science, Technical University of Hanover, 1973) has been involved at Max-Planck Institute for Iron Research at Düsseldorf with the thermomechanical treatment and the transformation behavior of alloyed steels. Since 1973 he has been with Rheinisch-Westfälischer TUV e.V. at Essen, where he is presently chief engineer in the staff department for the behavior of materials and components. He is responsible for materials science and creep, and since 1975 has worked intensively on life extension of power plants.

INVESTIGATIONS ON THE FATIGUE BEHAVIOR OF HIGH-TEMPERATURE ALLOYS FOR HIGH-TEMPERATURE GAS-COOLED REACTOR COMPONENTS

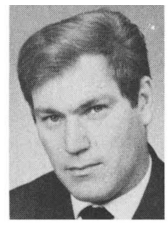
Hans-Peter Meurer
Günter K. H. Gnirss
Wolfgang Mergler
Gerhard Raule
Hans Schuster
Georg Ullrich





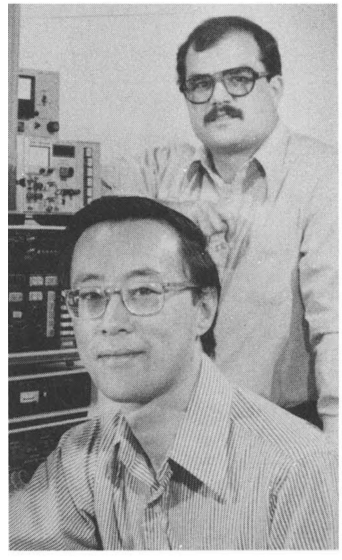
Hans-Peter Meurer (top right) [Dr. rer. nat., physics, Technical University of Aachen, Federal Republic of Germany (FRG), 1979] has been with the structural materials department of Interatom since 1978, where he has been involved with the fatigue testing of high-temperature alloys and austenitic stainless steels. **Günter K. H. Gnirss** (top left) (Dipl.-Ing., Technical High School, Darmstadt, FRG, 1968) has been a member of the Central Materials Laboratory since 1972, working on experimental stress and vibration analysis of components. In recent years his main concern has been the evaluation of high-cycle fatigue and fracture mechanic properties and the application toward lifetime and the integrity determination of power plant components. **Wolfgang Mergler** (center right) (Ing. grad., chemistry, FHS-Aachen, FRG, 1972) has been with Hochtemperatur-Reaktorbau GmbH in Jülich since 1973. Since 1974 he has been a group leader in materials testing. His main areas of interest are LCF measurements and experiments for the prediction of life expectancy. **Gerhard Raule** (bottom left) (Dipl.-phys., University of Heidelberg, FRG), after studying nuclear and solid-state physics, has been investigating the annealing behavior of neutron-induced voids in austenitic reactor materials by electron microscopy at the Nuclear Research Centre of Karlsruhe. Since 1978 he has been employed at Brown, Boveri and Company, Mannheim, and works on the mechanical behavior of high-temperature reactor materials. His interests lie in fatigue processes at high temperatures. **Hans Schuster** (bottom right) (Dr.-Ing., Technical University of Aachen, FRG, 1968) is the section head of the Institute for Reactor Materials (IRM) at Kernforschungsanlage-Jülich. Prior to assignment at IRM, he performed basic studies of irradiation effects in high-purity metals at Rheinisch-Westfälische Technische Hochschule. At IRM, after working in

the field of irradiation effects on graphitic core materials for high-temperature gas-cooled reactors, his interest has been in mechanical properties and corrosion effects on high-temperature alloys. **Georg Ullrich** (right) (Dipl.-Ing., metallurgist, University of Clausthal and Saarbruecken, 1961) was a junior scientist in industry from 1961 to 1962. Since 1963 he has worked at the Swiss Federal Institute for Reactor Research. He has been head of the metallurgical department at the institute since 1979.



HIGH-CYCLE FATIGUE BEHAVIOR OF INCOLOY ALLOY 800H IN A SIMULATED HTGR HELIUM ENVIRONMENT CONTAINING HIGH MOISTURE LEVELS

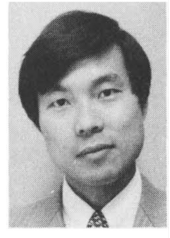
Peter Soo
Robert L. Sabatini



Peter Soo (bottom) (BSc, 1963, and PhD, 1966, physical metallurgy, University of Liverpool) has been employed in the mechanical properties program in the High-Temperature Gas-Cooled Reactor (HTGR) Safety Division at Brookhaven National Laboratory (BNL). Currently, he is an associate head in the Nuclear Waste Management Division at BNL and is involved in the evaluation of waste package performance. **Robert L. Sabatini** (top) (BS, geology, State University of New York at Stony Brook, 1972) is a member of the Metallurgy and Materials Science Division at BNL. He is presently involved in the use of scanning electron microscopy and transmission electron microscopy/shielded transmission electron microscopy to characterize and determine the mechanisms of creep and fatigue failure of HTGR materials, examination of failed light water reactor piping and bolts due to stress corrosion cracking, and microprobe analysis of experimental alloys and compounds.

LOW-CYCLE FATIGUE OF HEAT-RESISTANT ALLOYS IN HIGH-TEMPERATURE GAS-COOLED REACTOR HELIUM

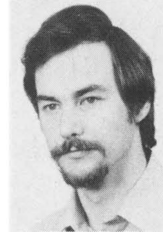
Hirokazu Tsuji
Tatsuo Kondo



Hirokazu Tsuji (top) (MS, mechanical engineering, Kyoto University, 1976) is a research scientist at the Materials Engineering Laboratory in the Japan Atomic Energy Research Institute (JAERI). He is presently involved in the studies on fatigue behavior of metals in simulated high-temperature gas-cooled reactor (HTGR) and light water reactor (LWR) environments. **Tatsuo Kondo** (BS, metallurgical engineering, Tohoku University; MS, 1963, and PhD, 1965, The Ohio State University) has been employed at JAERI since 1958 and is deputy director of the fuels and materials department. He has worked in the areas of corrosion-assisted fracture of metals in reactor environments and alloy development. He presently supervises the material research programs for HTGR, LWR, and nuclear fusion.

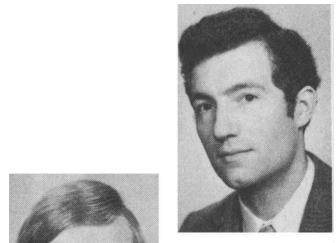
TENSILE AND IMPACT PROPERTIES OF CANDIDATE ALLOYS FOR HIGH-TEMPERATURE GAS-COOLED REACTOR APPLICATIONS

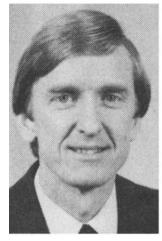
Udo Bruch
Dieter Schuhmacher
Philip J. Ennis
Eberhard te Heesen

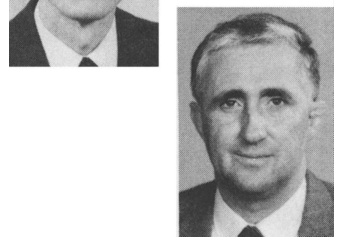


Udo Bruch (right) [Dr.-Ing., mechanical engineering, University of Bochum, Federal Republic of Germany (FRG), 1977] has been employed in R&D at Rheinische Braunkohlenwerke AG (RB), Cologne, since 1977. He has been appointed to the Department for Reactor Materials at the Nuclear Research Center (KFA), Jülich, and works in the field of corrosion and creep of high-temperature alloys in steam reformer and coal gasification

atmospheres. **Dieter Schuhmacher** (top) (Dr.-Ing., welding technology, Technical University of Aachen, FRG, 1975) is manager of materials and quality assurance in the Research and Development Division of RB. Since 1975 he has been involved with materials evaluation and manufacturing problems for coal gasification components and for nuclear process heat. **Phililp J. Ennis** (center) (BSc, physical metallurgy, University of Birmingham, United Kingdom, 1965) is a research metallurgist at the Institute for Reactor Materials, Kernforschungsanlage (KFA)-Jülich. Prior to joining KFA in 1976, he was with INCO Europe Limited for 11 years and worked on the development of nonferrous nickel-containing alloys. His current interests are the mechanical properties of high-temperature alloys in high-temperature gas-cooled reactor environments and the influence of corrosion on mechanical behavior. **Eberhard te Heesen** (bottom) (Dipl.-Ing., metallurgy, Technical University of Aachen, FRG, 1966) has worked in structural materials at Interatom GmbH, Bergisch Gladbach, since 1968. His areas of interest are testing and qualification of structural materials for permanent components of sodium-cooled fast breeder reactors and high-temperature nuclear power plants.

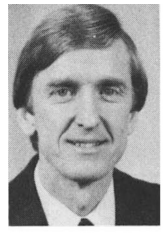


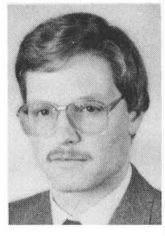


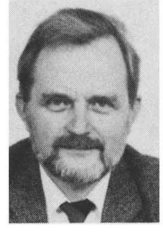


EFFECT OF CARBURIZING SERVICE ENVIRONMENTS ON THE MECHANICAL PROPERTIES OF HIGH-TEMPERATURE ALLOYS

Philip J. Ennis
Klaus P. Mohr
Hans Schuster



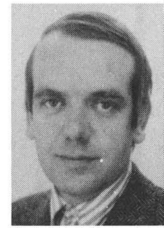




Philip J. Ennis (top) (BSc, physical metallurgy, University of Birmingham, United Kingdom, 1965) is a research metallurgist at the Institute for Reactor Materials (IRM), Kernforschungsanlage (KFA)-Jülich. Prior to joining KFA in 1976, he was with INCO Europe Limited for 11 years and worked on the development of nonferrous nickel-containing alloys. His current interests are the mechanical properties of high-temperature alloys in high-temperature gas-cooled reactor (HTGR) environments and the influence of corrosion on mechanical behavior. **Klaus P. Mohr** (center) [Dipl. Eng., Technical University of Aachen, Federal Republic of Germany (FRG), 1978] has been involved in the metallurgical research program during the past five years at IRM, KFA-Jülich. In 1982 he finished his thesis for a doctoral degree on mechanical properties influenced by carbide precipitation in high-temperature alloys. He now works at Salzgitter AG. **Hans Schuster** (bottom) (Dr.-Ing., Technical University of Aachen, FRG, 1968) is the section head of IRM at KFA-Jülich. Prior to this assignment at IRM, he performed basic studies on irradiation effects in high purity metals at Rheinisch-Westfälische Technische Hochschule. At IRM, after working in the field of irradiation effects on graphitic core materials for the HTGR, his interest has been in mechanical properties and corrosion effects on high-temperature alloys.

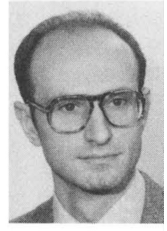
FRACTURE MECHANICS INVESTIGATIONS ON HIGH-TEMPERATURE GAS-COOLED REACTOR MATERIALS

Klaus Krompholz
Erik Bodmann
Günter K. H. Gnirss
Horst Huthmann



Klaus Krompholz (right) [Dr. rer. nat., physics, University of Muenster and Technical University of Darmstadt, Federal Republic of Germany (FRG), 1975] has been a junior scientist with Interatom, Bensberg, from 1976 to 1981. There he worked with high-temperature fracture mechanics. Since January 1982,

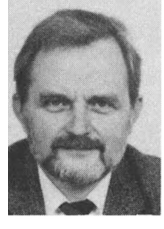
he has worked in the same field at the Swiss Federal Institute for Reactor Research in Wuerenlingen in the Department of Metallurgy. **Erik Bodmann** (top) (Dipl.-Ing., Technical University of Hannover, FRG, 1966) was involved in the development of flight gas turbines at Klöckner-Humboldt-Deutz AG until 1974, responsible for the stress calculations; thereafter he was responsible for the structural mechanics of high-temperature gas-cooled reactors at Hocktemperatur-Reaktorbau GmbH and, since 1980, also for the field of materials. **Günter K. H. Gnirss** (center) (Dipl.-Ing., Technical High School, Darmstadt, FRG, 1968) has been a member of the Central Materials Laboratory since 1972 and worked with experimental stress and vibration analysis of components. In recent years, his main concern has been the evaluation of high-cycle fatigue and fracture mechanic properties and the application to lifetime and integrity determination of power plant components. **Horst Huthmann** (bottom) (Dr. rer. nat., Technical University of Aachen, FRG, 1977; Dipl.-Physicist, University of Münster, FRG, 1971) is an assistant in the Department of Structural Materials of Interatom, Bergisch Gladbach, FRG, working on the influence of a flowing sodium environment on mechanical properties and on experimental fracture mechanics in the high-temperature region. Prior to joining Interatom in 1976 he was with Max-Planck Institute for Iron Research, Düsseldorf, FRG, and worked on ordering reactions in the Fe-Ni system.



THERMODYNAMIC AND KINETIC ASPECTS OF THE CORROSION OF HIGH-TEMPERATURE ALLOYS IN HIGH-TEMPERATURE GAS-COOLED REACTOR HELIUM

Willem J. Quadakkers
Hans Schuster

Willem J. Quadakkers (top) [Dr.-Ing., physics, Technical University of Aachen, Federal Republic of Germany (FRG), 1977] obtained a doctorate degree for a thesis on the development of alloys for vacuum brazing of aluminum in 1981. Since then he has been working on the corrosion behavior of high-temperature alloys in high-temperature gas-cooled reactor (HTGR) helium at the Institute for Reactor Materials (IRM) at Kernforschungsanlage (KFA)-Jülich. **Hans Schuster** (Dr.-Ing., Technical University of Aachen, FRG, 1968) is a section head at IRM at KFA-Jülich. Prior to this assignment at IRM, he performed basic studies of irradiation effects in high purity metals at Rheinisch-Westfälische Technische Hochschule. At IRM, after working in the field of irradiation effects on graphite core materials for the HTGR, his interest has been in mechanical properties and corrosion effects on high-temperature alloys.



RELATIONSHIP OF H_2O AND CH_4 SUPPLY RATES IN HTGR HELIUM TO THE CARBURIZATION OF HASTELLOY-X AND ALLOY 800H

H. Inouye

H. Inouye (BS, metallurgical engineering, Colorado School of Mines, 1943; MS, metallurgy, Massachusetts Institute of Technology, 1952) is a senior staff member of the Metals and Ceramics Division, Oak Ridge National Laboratory, where he has worked since 1952. His work experience includes gas/metal corrosion and alloy development.

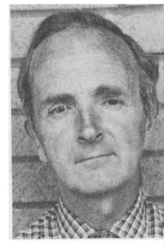
THE DEVELOPMENT AND APPLICATION OF A UNIFIED CORROSION MODEL FOR HIGH-TEMPERATURE GAS-COOLED REACTOR SYSTEMS

Karl G. E. Brenner
Leslie W. Graham

Karl G. E. Brenner (top) (PhD, physics, University of Vienna, 1974) has been employed by the Forschungszentrum Seibersdorf, Vienna, since 1975. He worked in the Organization for Economic Cooperation and Development (OECD) Dragon Project Material's Division until the demise of the project in March 1976. Since then he has been a member of the High Temperature Materials Programme (HTMP) in Poole, Dorset, United Kingdom, working mainly on the experimental and theoretical aspects of high-temperature corrosion in high-temperature gas-cooled reactor environments. **Leslie W. Graham** (BSc and PhD, University of Manchester, 1956) began work on high-temperature reactors in 1958 and joined the OECD Dragon Project in 1961, being responsible in turn for graphite technology, coated particle fuel development, and primary circuit materials. On the termination of this project, he kept the metals team together with the internationally sponsored HTMP based in England.

THE CORROSION BEHAVIOR OF HIGH-TEMPERATURE ALLOYS DURING EXPOSURE FOR TIMES UP TO 10 000 h IN PROTOTYPE NUCLEAR PROCESS HELIUM AT 700 to 900°C

H. G. A. Bates



H. G. A. Bates (BSc, M.I.M., graduate, University of Wales, 1954) formerly specialized in the development of improved materials and welding procedures for use in turbo machinery. He worked on the Dragon Project (1971-1976) when he joined the High Temperature Materials Programme. His current interests are principally concerned with corrosion behavior in low oxidation potential environments.

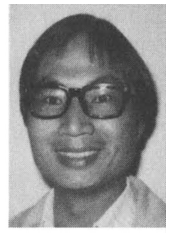
EVAPORATION BEHAVIOR OF HASTELLOY-X ALLOYS IN SIMULATED VERY HIGH TEMPERATURE REACTOR ENVIRONMENTS

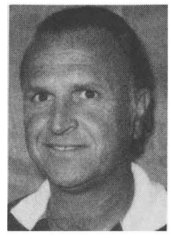
Masami Shindo
Tatsuo Kondo

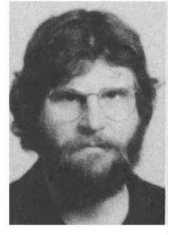
Masami Shindo (top) (BS, metallurgical engineering, Hokkaido University, 1968) is a senior research scientist at the Materials Engineering Laboratory in the Japan Atomic Energy Research Institute (JAERI). He is presently involved in studies on corrosion behavior of heat-resistant alloys in high-temperature gas-cooled reactor (HTGR) environments and alloy development for HTGR application. **Tatsuo Kondo** (BS, metallurgical engineering, Tohoku University; MS, 1963, and PhD, 1965, The Ohio State University) has been employed at JAERI since 1958 and is deputy director of the fuels and materials department. He has worked in the areas of corrosion-assisted fracture of metals in reactor environments and alloy development. He presently supervises the material research programs for HTGRs, light water reactors, and nuclear fusion.

THE EFFECTS OF CONTROLLED IMPURITY HELIUM ON THE MECHANICAL BEHAVIOR OF HASTELLOY ALLOY X

C. C. Li
W. R. Johnson
L. D. Thompson



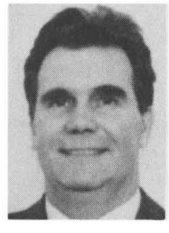


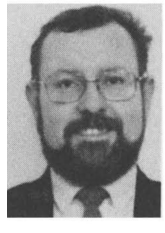


C. C. Li (top) (PhD, metallurgical engineering, The University of Michigan) is a staff engineer at GA Technologies, Inc. (GA). He specializes in high-temperature mechanical properties of ferritic steels and heat-resistant alloys. He is also working in the areas of welding, friction and wear, and coatings of those materials. **W. R. Johnson** (center) (PhD, materials science, Stanford University, 1969) is manager of the Materials Evaluation Branch, Materials and Chemistry Division, at GA. His primary interests during the past approximately 12 years have been in the areas of the evaluation of the effects of corrosion on the mechanical behavior of structural materials in high-temperature gas-cooled reactor (HTGR) environments with emphasis on mechanisms, thermodynamics, and kinetics of corrosion phenomena such as carburization, oxidation, and sulfidation. **L. D. Thompson** (bottom) (BE, metallurgical engineering, Youngstown State University; MS and PhD, materials science and engineering, University of California-Berkeley) is an assistant professor in the mechanical engineering department at San Diego State University. He has worked in the areas of HTGR corrosion, alloy design for HTGR structural components, and fusion reactor first-wall/blanket structural materials problems. His current interests are in the areas of alloy design for advanced turbine applications, solid-state strain-induced phase transformations, and the design and development of fail-safe emergency switches to enhance the safety of advanced energy systems.

BEHAVIOR OF METALLIC MATERIALS BETWEEN 550 AND 870°C IN HIGH-TEMPERATURE GAS-COOLED REACTOR HELIUM UNDER PRESSURES OF 2 AND 50 BAR

M. Cappelaere
M. Perrot
J. Sannier





M. Cappelaere (top) (chemical engineer, Faculté des Sciences, Paris) has been with the corrosion and fluid chemistry department of the Fontenay-aux-Roses Nuclear Research Center since 1960. He is currently in charge of corrosion tests with gas and liquid metals. **M. Perrot** (center) (senior technician) has been assigned to the corrosion and fluid chemistry department of the Fontenay-aux-Roses Nuclear Research Center since 1961. He contributed greatly to the preparation and to the success of the specimen corrosion tests in high-temperature helium loops. **J. Sannier** (bottom) (chemical engineer, Ecole Nationale Supérieure de Chimie, Paris), a senior engineer, joined Commissariat à l'Energie Atomique in 1956 and works in the corrosion and the fluid chemistry department at the Fontenay-aux-Roses Nuclear Research Center where he is in charge of problems of corrosion by gas and liquid metals.