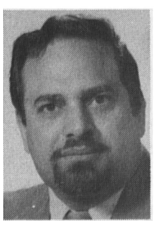
nuclear technology®

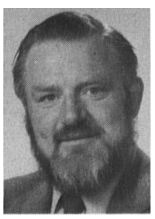
AUTHORS — NOVEMBER 1985

FISSION REACTORS

NUMERICAL SIMULATION OF TWO-PHASE FLOW IN HORIZONTAL INTERCONNECTED SUBCHANNELS

Mamdouh Shoukri
Abd-el-elah Tahir
Michael B. Carver

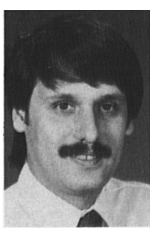


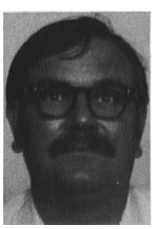


Mamdouh Shoukri (top) (BSc, mechanical engineering, Cairo University, Egypt, 1970; M. Eng. and PhD, mechanical engineering, McMaster University, Hamilton, Ontario, Canada, 1977) is an associate professor in the Department of Mechanical Engineering at McMaster University. His research activities are in nuclear reactor thermal hydraulics, two-phase flow, and boiling and convective heat transfer. Prior to joining the faculty at McMaster, he was with the Ontario Hydro Research Division as the head of the thermofluids unit from 1981 to 1984 and as a research engineer from 1977 to 1981. **Abd-el-elah Tahir** (center) (BSc, mechanical engineering, Ain Shamo University, Cairo, 1965; M. Eng., Carleton University, Ontario, Canada, 1975) is currently working at Chalk River Nuclear Laboratories (CRNL) where he is involved in the development of thermal-hydraulic models and computer codes. **Michael B. Carver** (bottom) (B. Eng., mechanical engineering, McMaster University, Canada, 1963; MSc, thermodynamics, Birmingham University, 1965) is currently head of the applied mathematics branch of CRNL and has specialized in simulation, numerical techniques, and thermal-hydraulic analysis during various tenures in the advanced engineering, mathematics and computation, and engineering research branches at CRNL.

ANALYSIS OF THERMAL REACTOR BENCHMARKS WITH DESIGN CODES BASED ON ENDF/B-V DATA

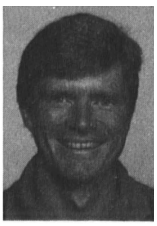
Mark L. Williams
R. Q. Wright
Brian A. Worley
Odelli Ozer
Walter J. Eich

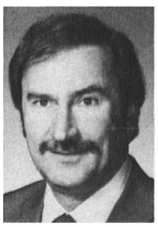




Mark L. Williams (top) (BS, engineering science, Louisiana State University, 1973; MS, nuclear engineering, Georgia Institute of Technology, 1974; PhD, nuclear engineering, University of Tennessee, 1979) is an associate professor of nuclear engineering in the Nuclear Science Center at Louisiana State University (LSU). Prior to joining the faculty of LSU, he was on the research staff of Oak Ridge National Laboratory (ORNL) from 1974 to 1983. His research interests include core neutronics, radiation shielding, and computer code development. **R. Q. Wright** (bottom) (BS, mathematics, Emporia State University, 1960; MS, mathematics,

Emporia State University, 1965) is primarily involved in production, validations, and testing of multigroup cross sections for use in thermal and fast reactor applications in the Computing and Telecommunications Division at ORNL. **Brian A. Worley** (top) (BS, nuclear engineering, University of Tennessee, 1975; MS, 1975, and PhD, 1977, nuclear engineering, Massachusetts Institute of Technology) is currently a member of the Engineering Physics and Mathematics Division at ORNL. His work is primarily in the reactor physics analysis of pebble bed gas-cooled reactors and light water reactors (LWRs). **Odelli Ozer** (center) (DESc, nuclear engineering science, Columbia University, 1968) is manager of the reactor performance subprogram at Electric Power Research Institute (EPRI). His responsibilities include the definition and management of research projects aimed at the development of computer programs and associated data bases for use in the analysis of nuclear reactor core designs and performance characteristics. **Walter J. Eich** (bottom) (BS, physics, Fordham University, 1952; MS, physics, Rutgers University, 1955) is a scientific adviser in the Analytical Methods and Verification Program, Nuclear Power Division, at EPRI. His responsibilities include the development, testing, benchmarking, and automation of LWR core physics codes and associated engineering as embodied principally in the Advanced Recycle Methodology Program (ARMP) codes. He has also been involved in the organization and documentation of the semiannual ARMP user group meetings.



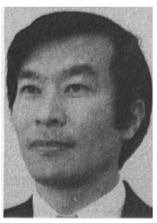


NUCLEAR SAFETY

A REACTOR WATER LEVEL AND PRESSURE PREDICTION METHOD UNDER SMALL LOSS-OF-COOLANT-ACCIDENT CONDITIONS IN BOILING WATER REACTORS

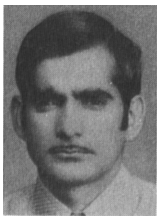
Yukiharu Ohga
Kohyu Fukunishi

Yukiharu Ohga (top) (MS, nuclear engineering, Kyoto University, Japan, 1976) has worked in the area of computerized operation support systems for nuclear power plants at the Energy Research Laboratory (ERL) of Hitachi, Ltd., Japan. His current interests are concerned with the global optimization method for large-scale nonlinear problems in optimal engineering design. **Kohyu Fukunishi** (PhD, control engineering, Osaka University, Japan, 1977) has been in charge of control and instrumentation engineering and data processing of nuclear power plants and also has engaged in the control engineering of the nuclear fusion facility at ERL, Hitachi, Ltd. He was a visiting researcher at U.K. Atomic Energy Authority's Culham Laboratory from 1979 to 1980. He is currently working at the Advanced Research Laboratory, Hitachi, Ltd., and is involved in software research. His interests include artificial intelligence.



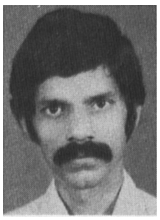
DYNAMICS OF FUEL VAPOR PRESSURE BUILDUP IN VOIDED LMFBR CORES DURING THE TRANSIENT HEATING AND ITS EFFECT ON THE ENERGY RELEASE IN A CORE DISRUPTIVE ACCIDENT

Om Pal Singh
P. Bhaskar Rao



Om Pal Singh (right) (MSc, physics, Allahabad University, India, 1968; PhD, physics, Indian Institute of Technology, Delhi, India, 1971) has worked in the Reactor Physics Section of the Reactor Engineering and Design Group at Reactor Research

Centre, Kalpakkam, India, since 1973. He is responsible for the studies on kinetics, safety, and noise analysis of fast reactors such as the 40-MW(thermal) Fast Breeder Test Reactor that is nearing completion and the 500-MW(electric) Prototype Fast Breeder Reactor that is under design at Kalpakkam. He was an Alexander Humboldt Research Fellow at the Institute for Kerntechnik, Technical University of Hannover, Federal Republic of Germany, for two years, 1976-1977. His areas of research interest include reactor kinetics, neutron transport and diffusion theory, core disruptive accident analysis, molten fuel coolant interaction, equation of state, and power reactor noise analysis. **P. Bhaskar Rao** (right) (MSc, physics, Ranchi University, India, 1972; PhD, physics, Indian Institute of Technology, Madras, India, 1981) has worked in the Reactor Physics Section of the Reactor Engineering and Design Group at Reactor Research Centre, Kalpakkam, India, since 1971. He is also engaged in the safety analysis studies of the fast reactors at the Centre. His research activities and interests include reactor kinetics, thermal-hydraulic safety analysis, core disruptive accidents, fuel coolant (thermal) interaction, equation of state at high temperature, and shock/structure interaction.



CHEMICAL PROCESSING

PUREX DILUENT CHEMICAL DEGRADATION

O. K. Tallent
J. C. Mailen
K. E. Dodson

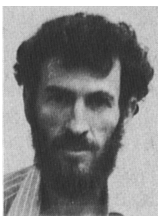
O. K. Tallent (top) (BS, chemistry, University of Tennessee, 1966) is a chemist at Oak Ridge National Laboratory (ORNL). His current interests include actinide separation, high-temperature gas-cooled reactor chemistry, and waste management. **J. C. Mailen** (center) (BS, chemical engineering, Kansas State University; PhD, chemical engineering, University of Florida) is currently interested in separations science and reactor fuel recycle. **K. E. Dodson** (bottom) is a science technologist in the Chemical Technology Division of ORNL and a senior student in chemical engineering at the University of Tennessee. Her research activities have included solvent cleanup and actinide studies related to fuel reprocessing and aqueous chemistry of iodine related to the Three Mile Island accident.

EXPERIMENTAL INVESTIGATION OF THE IODINE PARTITION COEFFICIENT

James L. Kelly
Robert U. Mulder
Chaim J. Babad

James L. Kelly (top) (BS, Tulane, 1950; MS, 1960, and PhD, 1962, chemical engineering, Louisiana State University) is a professor of nuclear engineering at the University of Virginia (UVa), where he has been on the faculty since 1964. His research interests are iodine chemistry, radiation processing, and fission product behavior. **Robert U. Mulder** (bottom) (BS, physics, Universidade de Brasilia, 1973; ME, 1976, and PhD, 1981, nuclear engineering, UVa) is a research assistant professor of nuclear engineering at UVa. Since July 1984 he has also been responsible for directing the UVa Reactor Facility. Recent research interests include radioisotope applications and gravitation

studies. **Chaim J. Babad** (right) (BS, aeronautical engineering, Technion-Israel Institute of Technology; MS, chemical engineering, City University of New York; PhD, nuclear engineering, UVa, 1983) is presently employed in Israel with the Ministry of Defense.



NUCLEAR FUELS

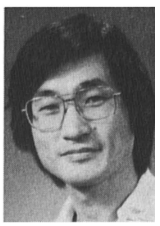
GRAPHITE DISK UO_2 FUEL ELEMENTS DESIGNED FOR EXTENDED BURNUPS AT HIGH POWERS

Roderick D. MacDonald
Ian J. Hastings

Roderick D. MacDonald (top) (M. Eng., metallurgical engineering, Technical University of Nova Scotia, 1960) is currently the scientific administrator for the Applied Research & Development Group at the Chalk River Nuclear Laboratories (CRNL). Since joining Atomic Energy of Canada Limited (AECL), he has worked in the experimental fuel program, specializing in irradiation testing of fuels during both normal operation and loss-of-coolant accidents. **Ian J. Hastings** (PhD, metallurgical science, University of Queensland, 1968) is head of the Fuel Properties and Behaviour Group in the Fuel Materials Branch at CRNL of AECL. His current interests are in oxide fuel behavior under irradiation, particularly release of short-lived fission products under normal and accident conditions, and in fusion ceramics.

STATISTICAL PATTERNS OF FUEL FAILURE IN STAINLESS STEEL CLAD LIGHT WATER REACTOR FUEL RODS

Gary S. Was
Ronald Christensen
Chang Park
Richard W. Smith



Gary S. Was (top right) [BS, nuclear engineering, University of Michigan (UM), 1975; SM, nuclear engineering, Massachusetts Institute of Technology (MIT), 1977; ScD, nuclear materials engineering, MIT, 1980] is an associate professor in the Department of Nuclear Engineering at UM. His current interests include radiation effects on surface and bulk properties of alloys, corrosion, stress corrosion cracking, and hydrogen embrittlement of alloys. **Ronald Christensen** (top left) (BS, electrical engineering, Iowa State University, Ames, 1958; MS, mechanical engineering, gineering, California Institute of Technology, Pasadena, 1959; PhD, physics, University of California, Berkeley, 1969) has taught at Carnegie-Mellon University and is president of Entropy Limited, a firm specializing in mechanistic and statistical modeling of the behavior of complex systems. His interests include probabilistic risk assessment, fuel cycle data base development and analysis, fuel reliability and performance, operations and management cost implications, and efficient inelastic modeling of corrosion, deformation, cracking, and rupture. **Chang Park** (bottom right) (BS, 1974, and MS, 1979, nuclear engineering, Seoul National University, Korea) is a doctoral candidate in the Department of Nuclear Engineering at UM, working in the area of plant reliability and probabilistic risk assessment. **Richard W. Smith** (bottom left) (BS, 1981, and MS, 1985, nuclear engineering, UM) is a doctoral candidate in the Department of Nuclear Engineering at UM. In addition to fuel performance, modeling, his research interests include the mechanisms of irradiation creep and hydrogen embrittlement in metals and alloys.

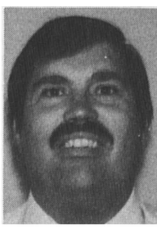
DIFFUSIVITIES OF SOME CONSTITUENTS IN COMPACTED WET BENTONITE CLAY AND THE IMPACT ON RADIONUCLIDE MIGRATION IN THE BUFFER

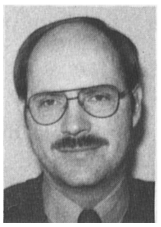
Ivars Neretnieks

Ivars Neretnieks is a professor in chemical engineering at the Royal Institute of Technology in Stockholm, Sweden. He has been doing research in the field of radionuclide migration in geologic media since 1977. He is a consultant to the Swedish Nuclear Fuel Supply Company and the Swiss equivalent, NAGRA, and has participated in the recent safety analyses performed by both organizations. He is principal investigator of two projects in the internationally funded STRIPA project, where he makes *in situ* experiments of tracer migration in crystalline rock at large depths (360 m).

A PILOT-SCALE RADIOACTIVE TEST USING *IN SITU* VITRIFICATION

Craig L. Timmerman
Ken H. Oma

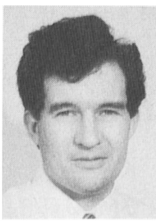




Craig L. Timmerman (top) (BS, chemical engineering, Montana State University, 1974; MS, mechanical engineering, Oregon State University, 1980) is involved in research on waste immobilization process development, specifically on the *in situ* vitrification process. He coordinated the pilot-scale test described in this paper. Currently, he is the task leader for technological support on the *in situ* vitrification program, which assists with the development of large-scale process operations and directs all support activities. **Ken H. Oma** (BS, chemical engineering, Montana State University, 1974; MS, chemical engineering, Rice University, 1976) has been involved in several research projects related to waste immobilization and process development since joining Battelle Pacific Northwest Laboratories in 1979. He has gained particular experience in process off-gas treatment, distributed process control, and computer simulation as applied to the *in situ* vitrification process. He was employed by Rockwell Hanford Operations prior to 1979, where he was involved in prototype equipment development and testing.

DILUTE CHEMICAL DECONTAMINATION PROCESS FOR PRESSURIZED AND BOILING WATER REACTOR APPLICATIONS

Alexander P. Murray
David A. Eckhardt
Sharon L. Weisberg



Alexander P. Murray (top) (BS, 1978, and MS, 1985, chemical engineering, Carnegie-Mellon University) has worked on chemical and electrolytic decontamination developmental projects since 1978. He has also worked in chemistry and engineering analyses related to the nuclear and energy industries. His current activities are decontamination, volume reduction, and radwaste processing. **David A. Eckhardt** (center) (BS, mechanical engineering, University of Pittsburgh, 1975) has 15 years of experience in the design and operation of chemical and nuclear process systems. His prior interests include decontamination, radwaste processing, and steam generator research. He is presently working on Navy-related programs, such as distillation and marine boilers. **Sharon L. Weisberg** (bottom) (BA, chemistry,

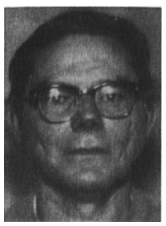
Kenyon College, 1979; MS, chemical engineering, Carnegie-Mellon University, 1981) has worked on ion exchange processes, chromatography, and radioactive waste processing. She is presently enrolled in the MBA program at the University of Pittsburgh.

ANALYSES

A HIGH-PERFORMANCE NEUTRON TIME CORRELATION COUNTER

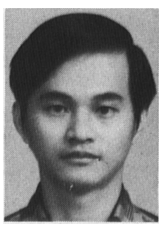
M. O. Menlove
J. E. Swansen

H. O. Menlove (top) (MS, physics, University of Michigan, 1961; PhD, nuclear engineering, Stanford University, 1966) has had considerable experience in the areas of neutron and fission physics as well as gamma-ray spectroscopy prior to joining Los Alamos National Laboratory (LANL). He spent a year at the Kernforschungszentrum Karlsruhe, Federal Republic of Germany, supported by a Fulbright Award. His interests include neutron cross-section measurements, activation analyses techniques, and the application of nuclear methods to the nondestructive assay of fissionable materials. Menlove is currently an LANL fellow, working in nuclear safeguards research and development. **J. E. (Jim) Swansen** joined LANL in 1966 after receiving electronics training at the Oregon Technical Institute and the U.S. Navy. He has design experience with operational amplifiers, digital circuits, random pulser circuitry, microprocessors, and interfaces. His current interests include the optimization of preamp-amplifier-discriminator components to shift register coincidence circuitry to reduce dead-time losses and to obtain stable operation at extremely high counting rates.



AN ITERATIVE CORRECTION METHOD FOR NONDESTRUCTIVE PLUTONIUM WASTE ASSAY

Minsun Ouyang



Minsun Ouyang (BS, 1971, and MS, 1977, nuclear engineering, National Tsing Hua University; PhD, mechanical engineering, University of Wisconsin, 1982) specialized in the development of a radiation monitoring system when he was with the Institute of Nuclear Energy Research, Taiwan (1973-1977). His current interests are in reactor noise analysis and surveillance.

TECHNIQUES

COMPUTER GRAPHICS TO SEPARATE NEUTRON FROM GAMMA-RAY SPECTRA, APPLIED TO THE MEASUREMENT OF NEUTRON ATTENUATION COEFFICIENTS USING AN NE-213 SCINTILLATOR

Martin E. Nelson
Dean A. Miller
Peter F. Wiggins
Gordon Riel
Thomas D. Strickler

Martin E. Nelson (right) (BS, University of Wisconsin, 1966; MS, 1968, and PhD, 1972, nuclear engineering, University of Virginia) has been a faculty member at the U.S. Naval Academy since 1971 and is now a professor in the marine engineering program and director of the nuclear laboratory at the academy. His

research interests are in neutron spectrometers, shielding, and simulation of reactor systems. **Dean A. Miller** (top right) (BS, marine engineering, U.S. Naval Academy, 1984) is working on a master's degree in nuclear engineering at the Massachusetts Institute of Technology. **Peter F. Wiggins** (top left) (BMarE, State University of New York Maritime College, 1958; MME, mechanical engineering, New York University, 1961; PhD, nuclear engineering, University of Maryland, 1970) has been a faculty member at the U.S. Naval Academy since 1962 and is a professor and director of the marine engineering program there. His research interests are in neutron capture gamma rays. **Gordon Riel** (bottom right) (BS, chemical engineering, University of Florida, 1958; MS, 1961, and PhD, 1967, nuclear engineering, University of Maryland) is a research scientist at the Naval Surface Warfare Center. His current research interests include radiation detection with Avalanche diodes, radiation shielding, and shipboard radiation protection. **Thomas D. Strickler** (bottom left) (BA, College of Wooster; MA and PhD, Yale University) is chairman of the Department of Physics at Berea College. He was a research physicist at Oak Ridge National Laboratory and has held that position at the Naval Surface Weapons Center, White Oak, Maryland, from 1979 to the present. His research interests are in neutron shielding measurements and radiation dose measurements.