ENS Fusion technology™

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OVERVIEW

A STUDY OF THE ISSUES AND EXPERIMENTS FOR FUSION NUCLEAR TECHNOLOGY

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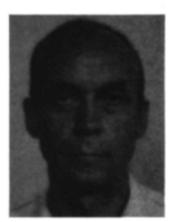


M. A. Abdou (top right) (PhD, nuclear engineering, University of Wisconsin, 1973) is a professor in the Department of Mechanical, Aerospace, and Nuclear Engineering at the University of California, Los Angeles (UCLA). He is the principal investigator of FINESSE. **P. J. Gierszewski** (top left) [ScD, nuclear engineering, Massachusetts Institute of Technology (MIT), 1983] is working with the FINESSE project at UCLA on attachment from the Canadian Fusion Fuels Technology Project. His interests include the solid breeder blanket and plasma interactive component design. **M. S. Tillack** (center right) (SM, 1980, and PhD, 1984, nuclear engineering, MIT) is a senior development engineer at UCLA in the fusion engineering program, working primarily on the FINESSE project to investigate issues of fusion nuclear technology development. His specific research interests also include various aspects of blanket/first-wall engineering, such as liquid-metal magnetohydrodynamics (MHD), corrosion, and electromagnetic effects. **K. Taghavi** (center left) (PhD, mechanical engineering, UCLA, 1982) worked with the fusion program at UCLA from 1982 to 1985 on thermal-fluid aspects of fusion reactors. He is currently an assistant professor of mechanical engineering at the University of Kentucky. His research interests include thermal hydraulics and safety of fusion and nuclear reactors. **K. Kleefeldt** (bottom right) [Ing. grad., mechanical engineering, Polytechnical State College, Wolfenbüttel, Federal Republic of Germany (FRG), 1961; Dipl. Ing., nuclear engineering, University of Karlsruhe, FRG, 1970] joined the Karlsruhe Nuclear Research Center in 1963. His main interest has been in the fuel element and core components of mechanical engineering within the FRG fast breeder reactor program. Since 1982, he has worked in the fusion program in thermomechanical engineering of high-heat flux components for system studies, with a recent focus on the Next European Torus. **G. Bell** (bottom left) (BS, 1981, and MS, 1983, UCLA) is a member of the

technical staff in the Energy Division of TRW, Inc. He is also pursuing his PhD in mechanical engineering at UCLA. His work in fusion is primarily in materials compatibility and transport phenomena. **H. Madarame** (top right) [Dr. Eng., University of Tokyo (UT), Japan, 1976] is an associate professor in the Department of Nuclear Engineering, UT. He was a visiting associate research engineer in the fusion engineering program at UCLA from 1984 to 1985. His current interests include MHD flow in a fusion reactor blanket. **Y. Oyama** (top left) (MS, nuclear physics, Osaka University, 1975) is a research scientist in the Department of Reactor Engineering at the Japan Atomic Energy Research Institute. He is involved in the fusion neutronics experiments, in particular in neutron spectrum measurement. **D. H. Berwald** (second from top right) (PhD, nuclear engineering, University of Michigan, 1977) is manager of the Department of Systems Engineering, Energy Systems Operations at TRW. His research interests include nuclear design and shielding analysis, fusion technology, advanced fission reactor fuel cycles, applications of advanced isotope separation technologies, and high-level waste disposal. **J. K. Garner** (center left) (BS, mechanical engineering, University of California-Santa Barbara, 1980; MS, mechanical engineering, UCLA, 1985) is head of the Design Analysis Section of the Energy Division at TRW in Redondo Beach, California. He has worked primarily in the area of fusion blanket design at TRW since 1980. **R. Whitley** (photo not available) (MS, 1976, and PhD, 1984, nuclear engineering, UCLA) is a member of the Department of Systems Engineering of the Energy Division at TRW. He has worked primarily in the area of fusion systems simulation at TRW since 1980. **J. Straalsund** (photo not available) (BS, physical metallurgy, 1963, and PhD, engineering science, 1967, Washington State University) is currently manager of materials science and technology at Westinghouse Hanford Company/Hanford Engineering Development Laboratory (HEDL). He has 12 years of experience in managing research groups concerned with postirradiation mechanical properties, in-reactor deformation, alloy development for both fission and fusion reactors, microstructure, and physical metallurgy. **R. Burke** (photo not available) (BS, mechanical engineering, Villanova University, 1964; MS, 1966, and PhD, 1972, plasma physics, University of California, Davis) is currently manager of the Fusion Materials Irradiation Test Accelerator at HEDL. His current interests are development of accelerator technology and applications in materials research and strategic defense. He has worked on fusion concepts and system studies for both magnetic and inertial confinement fusion and was formerly group leader of the Heavy Ion Fusion Project at Argonne National Laboratory (ANL). **J. Grover** (third from top right) (BS, mechanical engineering, University of Utah, 1969) is manager of instruments and analysis at Westinghouse Hanford Company. He has responsibility for the design and fabrication of test vehicles for use in various test facilities throughout the country. His current interests include fusion structural materials development and testing of blanket designs. **E. Opperman** (bottom left) (BS, physics and mathematics, University of Wisconsin, Stevens Point, 1973; MS, nuclear engineering, University of Wisconsin, Madison, 1975) is a senior engineer in irradiation technology at HEDL. His current interests include the evaluation of neutron effects on the integrity of coated high-heat flux fusion reactor materials and development of optimized systems for the transportation and disposal of high-level nuclear waste. **R. Puigh** (bottom right) (PhD, experimental nuclear physics, Florida State University, 1976) spent three years at the University of Washington in a postdoctoral position in the same field before coming to Westinghouse Hanford Company in 1979. He has been involved in the field of neutron radiation

effects on structural materials for the past six years, with particular emphasis on in-reactor deformation. During the past year, his interests have expanded to include irradiation effects on solid breeder ceramic materials for the fusion program and refractory alloys for the space reactor program. **J. W. Davis** (top right), a design specialist in materials, is manager of all materials activities in fusion energy at McDonnell Douglas Astronautics Company (MDAC). He has worked on the design of UWMAK-II and has participated in most of the tokamak reactor studies (UWMAK-III, EPR, TNS, STARFIRE, DEMO, and INTOR) in materials and design-related studies. His current activities include coordinating the activities on the *Materials Handbook for Fusion Energy Systems* and participating in various design studies. **G. D. (Dave) Morgan** (top left) (BS, mechanical engineering, 1965, and MS, engineering mechanics, 1968, University of Missouri-Rolla) has been a systems integration analyst on the MDAC fusion energy staff since 1978. His primary interests were first-wall and blanket engineering and design. He was deputy manager of the Blanket Comparison and Selection Study (BCSS), and was also responsible for all solid breeder blanket design group activities. **G. Deis** (center right) (BS, 1976, and MS, 1977, mechanical engineering, Ohio State University) has been involved in various areas of fusion research since 1978, including experimental device engineering and studies of nuclear/nonnuclear testing approaches. He is presently an engineer with the free-electron laser program at Lawrence Livermore National Laboratory (LLNL). **M. C. Billone** (center left) [PhD, mechanical engineering, Northwestern University (NU), 1972] is with the Materials Science and Technology Division at ANL. He has taught mechanical and nuclear engineering at NU for seven years, and he has specialized in the thermochemical performance of nuclear ceramics and metals at ANL. His current activities include modeling of tritium transport in solid breeder blankets of fusion reactors and participation in the DEMO, BCSS, FINESSE, and the Tokamak Power Systems Study programs. **K. I. Thomassen** (bottom right) [PhD, electrical engineering, Stanford University (SU)] has been program leader for the Mirror Fusion Test Facility (MFTF) at LLNL since 1977. He has been on the electrical engineering faculties at SU and MIT. From 1973 until 1977 he was associate division leader for technology of the Controlled Thermonuclear Reactor Division at Los Alamos National Laboratory. His current interests include upgrades of MFTF-B and fusion technology development. **D. L. Jassby** (bottom left) (BS, physics, McGill University; PhD, astrophysical sciences, Princeton University) served as assistant professor in the UCLA electrical sciences department from 1970 to 1973. He is now a principal research physicist at Princeton Plasma Physics Laboratory. His research activities include the heating of toroidal plasmas, the design of magnetic confinement fusion devices, and the production and application of fusion neutrons.

RESEARCH ON MUON CATALYZED FUSION IN THE USSR

Luciano Bracci
Giovanni Fiorentini

Luciano Bracci (photo not available) [University of Pisa (UP), Italy, 1969] is presently associate professor of mathematical methods of physics at UP. Since 1975, he has worked on mesic atoms and mesic molecules. His interests include the physics of magnetic monopoles and the phenomenology of grand unification theories. **Giovanni Fiorentini** (photo not available) (UP, Italy, 1970) is on the staff of the Italian National Institute of Nuclear Physics. He has worked in the area of mesic atoms and mesic molecules, and more recently in physics of magnetic monopoles and the phenomenology of grand unification theories.

BLANKET ENGINEERING

INCREASE OF TRITIUM BREEDING RATIO BY BLANKETS HAVING FRONT BREEDER ZONE IN FUSION REACTORS

Koichi Maki

Koichi Maki (BS, nuclear engineering, Tokyo University, Japan, 1968; MS, nuclear engineering, Kyoto University, Japan, 1971) is a researcher at Energy Research Laboratory, Hitachi, Ltd. He worked in fields of nuclear force and fast breeder reactor physics. His research interests are neutronics and plasma transport simulation in fusion reactors.

A NONLINEAR, MULTIVARIABLE METHOD FOR FUSION REACTOR BLANKET OPTIMIZATION

BLANKET OPTIMIZATION STUDIES FOR THE HYLIFE INERTIAL CONFINEMENT FUSION REACTOR

Wayne R. Meier
Edward C. Morse

Wayne R. Meier (top) (BS, physics, Western Illinois University, 1974; MS, nuclear engineering, University of Illinois, 1976; PhD, University of California, Berkeley, 1984) is a research engineer in the Energy and Military Applications Group of the Laser Fusion Program at Lawrence Livermore National Laboratory. He has been involved in the conceptual design of various reactor concepts for inertial confinement fusion (ICF) for the past six years. His current technical interests include neutronics, fusion-fission hybrids, and the economics of ICF electric power plants. **Edward C. Morse** (BS and PhD, University of Illinois) is presently an associate professor of nuclear engineering at the University of California, Berkeley.

MATERIALS ENGINEERING

MECHANICAL AND ELECTRICAL PROPERTIES OF CANDIDATE ORGANIC INSULATORS AFTER NEUTRON IRRADIATION AT 4 K

Dennis S. Tucker
John D. Fowler, Jr.
Frank W. Clinard, Jr.

Dennis S. Tucker (top) (BA, mathematics, Laverne College; MS, ceramic engineering, Georgia Institute of Technology; PhD, materials science, University of Florida) has been with Los Alamos National Laboratory (LANL) for one year. He is involved with radiation effects in materials for fusion reactors and in the environmental effects of low earth orbit on space structures. **John D. Fowler, Jr.** (center) (MS, nuclear engineering, North Carolina State University, 1976; PhD, physics, University of North Carolina, 1970) has worked on measurement of electrical conductivity, loss tangent, and dielectric breakdown strength of ceramic and organic insulators. He also has done computer simulations of thermal stresses in radio-frequency windows for fusion applications. His present interests are in computer graphics. **Frank W. Clinard, Jr.** (bottom) (BS, mechanical engineering, and MS, metallurgical engineering, North Carolina State University; PhD, materials science, Stanford University, 1965) has been with LANL since 1964. Since 1972, he has been involved in studies of materials for fusion reactor applications, and is presently leader of the Radiation Effects Section at LANL.

FIRST-WALL TECHNOLOGY

SPECTRAL DEPENDENCE OF ACTIVATION AT FUSION REACTOR FIRST WALLS

Howard L. Heinisch
Frederick M. Mann
Donald G. Doran

Howard L. Heinisch (top) (BA, physics, Ripon College, 1966; MS, 1968, and PhD, 1972, physics, University of Nebraska) is a senior scientist at Hanford Engineering Development Laboratory (HEDL). His research centers on the fundamental aspects of irradiation effects, and includes damage analysis and atomistic computer modeling as well as mechanical properties experiments. **Frederick M. Mann** (center) (BS, physics, Stanford University, 1970; PhD, physics, California Institute of Technology, 1975) is a senior scientist at HEDL. He is currently working on nuclear data evaluation and processing and computer code development for the fusion, liquid-metal, and thermal reactor programs. **Donald G. Doran** (bottom) (PhD, physics, Washington State University, 1960) has performed or managed radiation effects studies at HEDL since 1970. He serves as chairman of the Office of Fusion Energy's Damage Analysis and Fundamental Studies Task Group.

ICF DRIVER TECHNOLOGY

PELLET DELIVERY FOR THE CONCEPTUAL INERTIAL CONFINEMENT FUSION REACTOR HIBALL

Ronald Kreutz

Ronald Kreutz (PhD, physics, University of Cologne, Federal Republic of Germany, 1977) worked at the I. Physical Institute of the University of Cologne from 1974 to 1978. He has been employed at Interatom GmbH since 1978 as a member of the Fusion Technology Group. He is currently involved in the design and manufacturing of calorimeter panels for neutral beam injectors and in blanket design studies for the Next European Torus.

BLANKET ENGINEERING

APPLICATION OF MULTILAYERED BLANKET CONCEPT TO THE TOKAMAK CONFIGURATION FOR TRITIUM BREEDING CALCULATIONS

Om Prakash Joneja
Vijay R. Nargundkar

Om Prakash Joneja (top) [MSc, Punjabi University, India, 1966; Graduate, Bhabha Atomic Research Centre (BARC) Training School, 1967; PhD, physics, University of Bombay, 1976] has actively worked on fast neutron spectrometry and development of Monte Carlo codes. His present interest includes development of new experimental techniques for on-line measurement of tritium breeding in fusion blankets. He has worked at the Institute of Reactor Development, Jülich, Federal Republic of Germany (FRG), from 1972 to 1974 in the field of fast neutron spectrometry and recently, from 1979 to 1980 in the same institute on $LiAlO_2$ blanket assembly for measuring tritium production. **Vijay R. Nargundkar** (MSc, physics, Karnataka University, India,

1956; PhD, pulsed neutron studies, University of Bombay, India, 1966) has worked at BARC since 1957. He has worked in the field of fission physics at Atomic Energy of Canada, Limited, Chalk River, Canada (1961 and 1962), pulsed fast reactors at the Joint Institute for Nuclear Research, Dubna, Soviet Union (1972), and fusion blanket neutronics at the Institute of Reactor Development, Jülich, FRG (1977 and 1978). He has been the facility supervisor of the Purnima Critical Facility. His current interest is theoretical and experimental studies of fusion blanket neutronics.

FUSION FUEL CYCLES

APPARENT MUON LOSS IN MUON CATALYZED FUSION

Johann Rafelski

Johann Rafelski (PhD, University of Frankfurt, Federal Republic of Germany, 1973) is a physics professor and has been director of the Institute of Theoretical Physics and Astrophysics at the University of Cape Town since 1983. He has served in various positions at the University of Pennsylvania, Argonne National Laboratory, and the University of Frankfurt. His main areas of interest include heavy ion collisions, vacuum structure, neural nets, and muon catalyzed fusion.