MEETING REPORT

SUMMARY OF THE 31st NATIONAL VACUUM SYMPOSIUM SESSIONS ON MAGNETIC FUSION AND INERTIAL FUSION TARGET DEVELOPMENT, RENO, NEVADA, DECEMBER 4-6, 1984

HIGHLIGHTS OF THE MAGNETIC FUSION SESSIONS

Special Topical Sessions

On November 5, 1984, two special topical sessions were held in which invited speakers addressed the design of "Advanced Magnetic Fusion Devices" in the morning, and the "Progress of Large Breakeven Devices" in the afternoon session.

John Schmidt [Princeton Plasma Physics Laboratory (PPPL)] presented a comparison of the four designs that were under consideration for the Tokamak Fusion Core Experiment (TFCX) device in 1983-1984, and then discussed the more recent work on compact ignition devices. This latter development was a direct result of budget constraints, forcing a cancellation of the TFCX project and beginning a search for less expensive alternatives to replace the project.

Grant Logan [Lawrence Livermore National Laboratory (LLNL)] described the results of the Mirror Advanced Reactor Study, which was a joint national lab/university/industry collaboration. The resulting design for a 1200-MW(electric) mirror reactor was based on the Tandem Mirror Experiment (TMX) electrostatic configuration with direct energy convertors. The vacuum vessel design called for the use of HT-9 ferritic steel to improve the radiation resistance over 300 series steels, and an LiPb eutectic was specified for combination cooling/blanket modules. Logan made the important observation that the design goal of minimizing size in order to minimize cost can be overemphasized to the point where "afterheat" problems in vessel structures could arise with loss of primary coolant.

William Speers, currently a member of the Next European Torus (NET) design team in Garching, Federal Republic of Germany (FRG), discussed the status of the design of the NET. The scheduling and detailed design of this device are dependent on the results of the Joint European Torus (JET) project over the next few years. The present schedule calls for the introduction of tritium into JET in late 1987 or early 1988. This will be the decision point for the final approval of the NET device. One of the important design points under consideration is the neutron fluence. A high fluence device would possibly allow the extrapolation of radiation damage to the levels expected in a demonstration reactor.

Jim Rome [Oak Ridge National Laboratory (ORNL)] concluded the morning session with a presentation of an advanced device that has passed the design stage and is now under construction—the Advanced Toroidal Facility (ATF). The ATF is a torsatron-type device that has the advantages of being steady state and possessing no predicted beta limits. One of the primary goals of the device is to study beta limitations including the so-called "second stability region." The engineering of the device is impressive because of the need for a highly convoluted vacuum vessel and precise coil placement.

The afternoon session was opened by Don Grove (PPPL) who gave a status report on results of ohmic heating (OH) confinement studies and the initial neutral beam injection (NBI) experiments in the Tokamak Fusion Test Reactor (TFTR) device. The flexibility of the movable limiter and programmable power supplies has allowed a wide range of operating parameters to be investigated in the first two years of TFTR operation. Confinement scaling studies have been performed by varying plasma major and minor radii, plasma current, and toroidal field (TF). Values of energy confinement in excess of 0.3 s have been obtained in OH plasmas at plasma currents and fields that are roughly half of the full performance values. The results of these scaling studies are being used as input for computer models being developed to predict the behavior of TFTR at full power. The TFTR is expected to approach full performance conditions in late 1985 or early 1986 with the operation of four NBI lines.

A status report on the operation of the JET device was given by George Duesing. Impressive energy confinement times have been produced in JET as a result of the large plasma volume and elongation. Duesing quoted values of 0.8 s for OH discharges with 3×10^{13} cm^{-3} plasma densities. Plans are proceeding for the installation of auxiliary heating on JET. Neutral beam sources have been operated at full power (80 keV, 60 A) for 15 s on a test stand. A prototype limiter/radio-frequency (rf) antennae array is planned for installation in January 1985. Auxiliary heating experiments will begin later in 1985.

The remainder of the session dealt with two large fusion devices presently under construction. Lawrence Davis [GA Technologies, Inc. (GA)] described the design changes that are transforming the Doublet III device into the Big Dee project. The basic design goal was to maximize the plasma size in a new vacuum vessel constrained to the existing TF coils. The plasma current will be upgraded to 5 MA. The planned auxiliary heating systems include 10 to 14 MW of neutral injection, 20 MW of ion cyclotron resonance heating at 40 to 60 MHz and 20 MW of electron cyclotron heating (ECH) at 60 GHz. The high-power operation of the device necessitates new design for tile armor protecting the vacuum vessel wall. For particle control a 0.3-m^2 pumped limiter is planned. The schedule for device operation calls for vessel conditioning in late 1985 and plasma operation in early 1986.

Gary Porter (LLNL) presented a brief overview of the status of the large mirror project, the Mirror Fusion Test Facility-B (MFTF-B), which is scheduled for completion in 1987. Porter described the results of the plasma modeling code that was developed for MFTF-B, which included the local vacuum conditions of the MFTF-B vessel. The success of TMX configurations is very dependent on careful control of local vacuum conditions. With a vessel as large and complicated as MFTF-B, vacuum requirements must be accurately specified because of the cost of implementation.

Plasma/Material Interactions

Invited talks were given by G. Staudenmaier (Institute for Plasma Physics, Garching, FRG) on his *in situ* measurements of erosion and deposition in the boundary plasma of the Axially Symmetric Divertor Experiment device, and by R. D. Watson [Sandia National Laboratories (SNL)] reviewing the interlaboratory testing program for high heat flux components and materials. Related papers were given in the session by J. R. Easoz et al. (Westinghouse) on high heat flux testing. Analyses of the performance of actual limiter materials were presented by P. H. Edmonds et al. (ORNL) and H. F. Dylla et al. (PPPL).

Plasma Diagnostics

The state of the art of plasma probe measurements was reviewed in two invited talks in this session given by D. Manos (PPPL) and W. Wampler (SNL). Manos concentrated on recent advances in the application and interpretation of electrostatic probes, and Wampler described the carbon resistance probe, a unique probe of his invention that can be used for *in situ* flux measurements. The remainder of the session was devoted to contributed talks, which involved spectroscopic measurements. J. Goree (PPPL) described far-infrared laser scattering measurements of plasma density fluctuations. T. L. Yu (LLNL) described quantitative measurements of intrinsic impurities in TMX-U plasmas. Three research groups (from GA, ORNL, and LLNL) described various techniques for measuring impurities in high-power neutral beams.

Plasma Fueling and Neutral Transport

Discussions of pellet fueling physics and technology have been a tradition of the past several American Vacuum Society meetings. The 1984 fueling session included an invited talk by M. Greenwald (Massachusetts Institute of Technology) on the Alcator C results of the past year. With pellet fueling of ohmic discharges, line average densities of 1×10^{15} cm^{-3} were obtained and values of $n\tau$ exceeded the Lawson criterion of 6×10^{13} $cm^{-3} \cdot s$. Greenwald discussed recent attempts to understand the reasons for better confinement with pellet-fueled discharges. One possibility is the reduction of edge neutral losses due to the peaked density profiles induced by pellet fueling.

H. Sorensen (Risø National Laboratory, Denmark) described new developments in D_2 pellet injection technology, including a pneumatic system that can generate pellets over an adjustable range of pellet diameters and velocities, and a new electromagnetic pellet accelerator that has been tested to velocities exceeding 1.7 km/s.

Contributed papers in this session included presentations of neutral pressure measurements and their effect on end plugging in the Phaedrus and TMX (J. Conrad et al. and W. Pickels et al.). Probe measurements of boundary plasma properties were presented by W. L. Hsu et al. with a study of TMX, and R. Zuhr with a study in the TEXTOR tokamak. Theoretical papers relating to neutral transport were presented by W. Neuman and D. Heifetz. Neuman discussed a kinetic model of a plasma neutral gas interaction, and Heifetz discussed a new model for low-energy recycling, which is important for tokamak transport simulations.

Plasma Heating

Presentations in the session on plasma heating dealt with recent ion cyclotron resonance frequency (ICRF) heating experiments and the development of high-power ECH and ion sources. P. Colestock (PPPL) reviewed the results of high-power (3-MW) ICRF experiments in the Princeton Large Torus tokamak, concentrating on rf/edge plasma interactions. Improvements in rf antennae design led to the present situation where megawatt levels of rf can be injected and good heating efficiency is observed, without excessive impurity introduction. Further measurements and modeling are required, however, to understand the density behavior and impurity generation mechanisms in these experiments.

A. Karo (LLNL) presented a computer modeling study of the vibrational relaxation of H_2 molecules, a subject important to the development on optimization of negative ion sources. Experimental papers related to negative ion source development using surface conversion were given by groups at LLNL and Lawrence Berkeley Laboratories. The session concluded with a presentation by K. W. Bieg (SNL) on the development of high-power pulsed ion sources for inertial fusion applications.

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HIGHLIGHTS OF THE INERTIAL FUSION TARGET FABRICATION SESSIONS

Sessions concerned with aspects of inertial fusion target fabrication were opened with an invited presentation by R. L. Schriever (U.S. Department of Energy) who reviewed significant advances made in the U.S. inertial fusion program in the last five years. Frequency conversion of neodymium lasers and subsequent improved coupling of laser energy with the target using shorter wavelengths were noted as a major turning point in attaining high-density implosion. Significant reduction of hot electron production in the implosion as a result of the frequency conversion was also cited as a major accomplishment. With completion of driver programs, he stressed, the current emphasis is on target fabrication to achieve high-density and temperature compression. The activities in the United Kingdom and Japan were the topics of the invited talks, which highlighted the novel approach to foam fabrication of the British group, and an automatic levitation device in Japan that transports charged glass microballoons for characterization and deposits them in preselected positions.

Description of the Cornell University submicron structure facility by Wolf, an invited speaker, was very informative and potentially very useful to the target fabrication community. Glass chemistry in the formation of glass microballoons was discussed by Doremus (Rensselaer Polytechnic Institute), another invited speaker, who described various properties of the glass microballoons, including deterioration and weathering.

A number of papers from LLNL; Los Alamos National Laboratory; KMS, Industries, Inc.; and the University of Rochester described various aspects of target fabrication activities and significant progress made at those facilities.

The sessions on inertial fusion target fabrication showed that a great deal of work is continuing in materials, fabrication, and characterization development. From the papers presented, we note that key areas of target fabrication development are cryogenic targets, plastic shell fabrication, and coating of nonsupported targets.

The complete proceedings of this conference will be published in the May/June 1985 issue, Vol. 3A, of the *Journal of Vacuum Science and Technology*.

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