INIS-CA—0042

FusionCanada

Bulletin of the National Fusion Program

Issue 14, May 1991

In this Issue

ISSN 0835-488X

CANADA-JAPAN

Canada-Japan Fusion Agreement

A five-year bilateral fusion cooperation agreement was signed in April between the fusion programs of Canada and Japan. The agreement is embodied in a Memorandum of Understanding (MoU) which will remain in effect until end of March 1996. Under the new MoU, the fusion programs of Canada and Japan can now engage in more extensive collaboration in fusion than was possible under the previous arrangements. The new MoU enables close cooperation in a wide variety of fusion-related subjects.

Japan was the first country with whom Canada established formal arrangements to cooperate in fusion development. The first fusion collaboration agreement between the two countries was signed in 1984, and extended at two year intervals until it expired in March 1991.

Activities

Collaborative activities possible under the new MoU include:

- execution of joint studies, experiments or projects.
- participation in each other's activities such as studies, experiments or projects.
- exchange or provision of equipment and materials.
- exchange or provision of information or data.

Subject Areas

Some of the science and technology areas of mutual interest, already jointly identified by Canada and Japan include:

- fusion technology
- fusion fuels
- breeder blanket technology
- tokamak experiments
- plasma physics
- health and environmental aspects of fusion

Collaborations in these and other topics may be undertaken as projects of mutual interest are identified.

The new MoU was signed by David Jackson, Director-National Fusion Program, on behalf of Atomic Energy of Canada Limited, and by Yoshinori Ihara, President of the Japan Atomic Energy Research Institute (JAERI).

Soon after the new Canada-Japan collaboration agreement was signed, a Japanese delegation visited CFFTP and AECL Research Chalk River Laboratories. This photograph was taken during their April [illegible] visit to Chalk River, where they discussed breeder blanket work including in-reactor breeder materials irradiation and fabrication of solid breeder materials. From right to left: [illegible] (Mitsubishi Heavy Industries), H. Yoshida (JAERI), D. Jackson (National Fusion Program), [illegible] Ono (Toshiba Corporation), S. Hirata (Kawasaki Heavy Industries), M. Nagakura ([illegible] Atomic Power Industries).

We regret that some of the pages in this report may not be up to the proper legibility standards, even though the best possible copy was used for scanning

CCFM/Tokamak de Varennes:

Boronization tests
Plasma biasing continues

On Tokamak de Varennes (TdeV), plasma exposure of a new, highly boronized carbon-composite material has given surprisingly good results during in-plasma boronization tests. Deep plasma exposure of a test limiter head made of the new boronized material resulted in significant improvements in plasma behaviour. The plasma improvements were a result of boron sputtered from the boronized carbon being deposited over the inside surface of the TdeV plasma chamber. The tests were done in collaboration with Yoshi Hirooka of UCLA, who leads the US PISCES program of fusion materials development.

In the tests, a hemispherical carbon-composite test limiter head from UCLA, containing 30% boron (bulk average), was eposed during the week of May 6-10 to about 200 plasma shots. Boron sputtered from the plasma contact surface on the head was distributed around the tokamak vessel, and this boronization appears to have had dramatic effects on plasma purity and behaviour. During the tests, deposited power density on parts of the test head approached 100 kW/cm^2, without noticeable mechanical damage to the carbon-composite material.

The TdeV team were surprised to observe that over the first 10 tokamak plasma shots with the boronized limiter inserted in the TdeV plasma, dramatic improvements in plasma conditions became apparent. In limiter mode operation, oxygen levels in the plasma were halved, global plasma bulk resistivity was halved, and the tokamak pulses could be lengthened from about 800 milliseconds to about 1.3 seconds for the same 2.5 Volt-seconds capacity of the ohmic transformer. The improvements were maintained over the remaining 190 tokamak shots of the test series, as additional boron was sputtered from the test limiter head during subsequent pulses, replenishing the boron coating established throughout the plasma chamber. It is suspected that the deposited surface coating of boron absorbed oxygen impurities from the plasma. In effect, plasma impurities were reduced, resulting in decreased loop voltage and Z_{eff}. This effect is independent of impurity reductions caused by plasma biasing.

The boronized carbon-composite test limiter head was manufactured by Toyo Tanso (Japan). The composite material consists of amorphous graphite, containing boron carbide (B_4C) powder, supported in a woven graphite fibre material. Yoshi Hirooka (UCLA) visited CCFM/TdeV to participate in the experiments. It was shown by surface analyses that boron, sputtered from the new test limiter head by plasma impact, was distributed throughout the TdeV plasma chamber; coating thickness was up to 400 nanometres in places. The coating was thickest on surfaces facing the direction of ion transport around the torus. Boron appears to be transported as ionized boron following the magnetic field lines. Overall, deposited boron thicknesses were found to be similar to those expected from coating by gaseous discharges in diborane or boron trimethyl gases.

The test results suggest the intriguing possibility of designing a retractable probe, tipped with suitable boronized material, with the aim of controlled, continual deposition of boron in tokamaks (or other plasma devices) by sputtering boron from the probe. It is conceivable that such controlled deposition may be helpful in long-term control of tokamak plasma impurity levels.

More information from Barry Stansfield CCFM (514) 652-8735, INRS-Énergie (514) 468-7735, or Brian Gregory or Réal Décoste at CCFM.

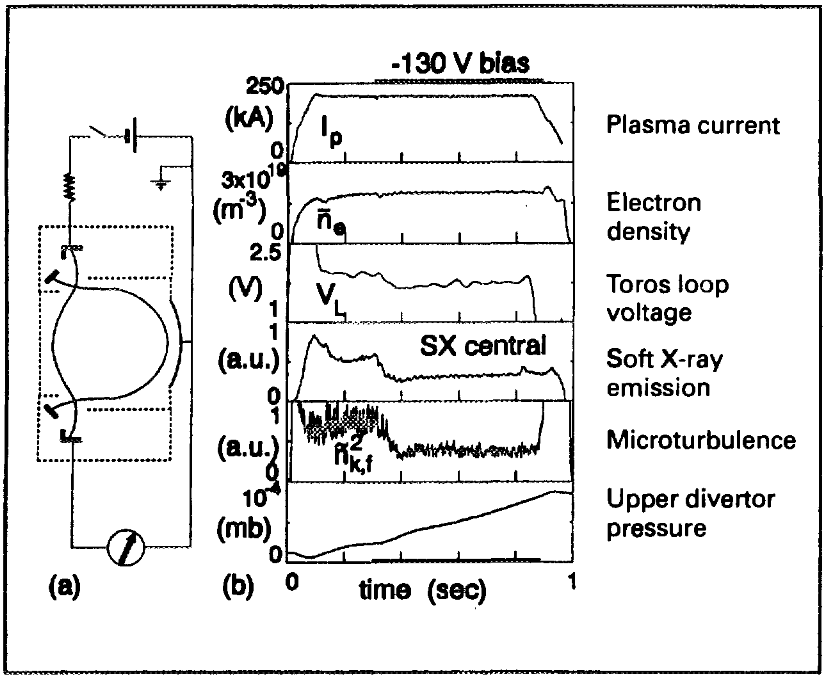
Fast Pump Down.

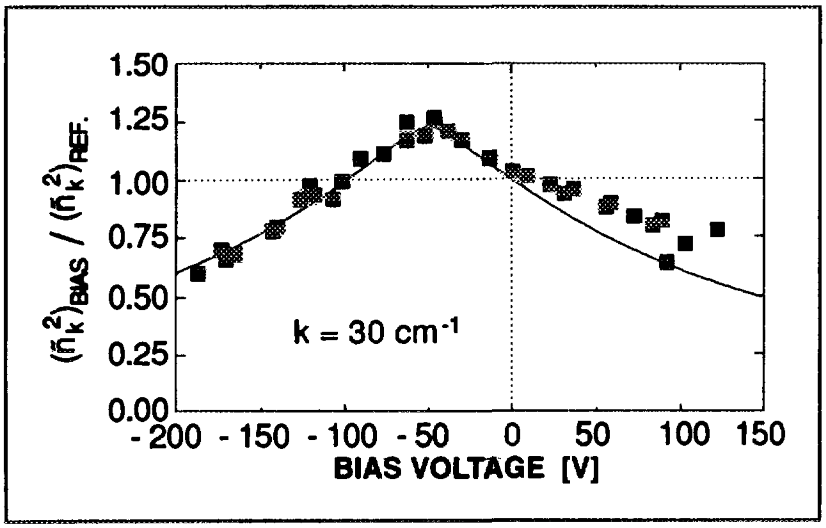
At one point in the series of boronized limiter tests, the TdeV plasma chamber had to be opened to atmospheric pressure to retrieve an internal component, for operational reasons not related to the tests. Normally, return to operational vacuum in the low 10^{-7} torr takes two days or more to accomplish. On this occasion, however (May 9), operational vacuum was restored and good tokamak pulses achieved in less than five hours after closing up the vacuum vessel. This short pump-down time was a considerable surprise. It is tentatively speculated that the boronization inside TdeV helped absorb the traces of water vapour and oxygen which inevitably enter an opened vacuum vessel.

Plasma Biasing

Plasma biasing experiments resumed on April 11 when Tokamak de Varennes (TdeV) started up again after a 12-week maintenance outage. TdeV is now equipped with cryogenic vacuum pumping panels and titanium getter pumps in the main vacuum pumping duct; it can fire about 20 tokamak pulses per hour in divertor or limiter mode.

New plasma biasing experiments since April 11 have confirmed the early results obtained in December and January before the TdeV maintenance shutdown. The accompanying curves show some of the effects on plasma parameters of a negative biasing pulse during a typical divertor-mode shot. In this shot, the plasma is biased for 600 milliseconds at –130 volts (through the one divertor plate) relative to the plasma chamber walls. Biasing starts 300 milliseconds after pulse initiation. Electron density and plasma current (ohmic) are not affected by biasing. Soft X-ray emission drops significantly during negative biasing, as does the absolute level of microturbulence compared with a non-biased divertor plasma. Negative biasing is expected to suppress sputtering from the plasma chamber walls and so reduce the flux of impurities into the plasma. Plasma loop voltage drops 15–20% because of lower impurity content of the plasma. Pressure in the upper divertor chamber was seen to increase by a factor of about three during biasing, compared with normal divertor-mode operation without biasing.





Control of microturbulence level by biasing. Experiments with different biasing levels on TdeV have shown that the microturbulence level in the outer regions of the plasma varies in a repeatable fashion with biasing voltage. The curve illustrates the type of variation observed. Typically, with increasingly negative plasma biasing potential, microturbulence increases, peaking at about –50 volts for TdeV, and then diminishes. Pierre Couture, leader of the Machine Operations group at CCFM has remarked, "It gives us an extra control for repeatably altering plasma conditions. We suspect that biasing tests on other machines would show similar phenomena of microturbulence level alteration with biasing, possibly with a maximum in microturbulence level at some non-zero negative biasing voltage." The curve of relative effect of biasing on microturbulence is not the same at all microturbulence frequencies.

Plasma biasing may offer a promising approach for controlling impurity influx to the plasma and affecting the electric field inside the plasma, the latter being possibly related to H-mode physics. Poloidal velocity is greatly affected by biasing, as measured by Doppler shift of the infrared carbon III line. Calculations indicate that plasma microturbulence is possibly affected by velocity shear stabilization, indicating that the biasing potential affects the electric field inside the separatrix.

More information on Plasma Biasing: Pierre Couture (514) 652-[illegible]16, or Real Décoste or Brian Gregory at CCFM.

Canada-US Collaboration

Compact Toroid Fuelling Gun

Four-site joint venture

A compact toroid (CT) fuelling gun is to be built and operated on Canadian tokamaks, in a joint venture involving three Canadian fusion centres and UC Davis at Livermore (part of University of California). The Canadian Fusion Fuels Technology Project (CFFTP) is the lead agency for this project.

CT fuelling guns may offer a practical way of fuelling tokamak fusion reactors, by injecting fuel as a toroidal mass of plasma into the centre of the tokamak plasma. Such guns may be able to inject fuel masses into tokamaks at rates suitable for supplying the complete fuelling requirement. As yet, CT guns are largely untried for tokamak fuelling, but tests to date and known theory give good indications that the technique may be useful.

A CT toroid is a dense toroid of plasma (shaped somewhat like a smoke ring) in which poloidal and toroidal currents flow, so that a CT has its own toroidal and poloidal magnetic fields. CTs can exist in isolation, and have been accelerated to velocities over 2,000 km/s.

The three Canadian centres in involved in the Canada/UC Davis CT gun project are:

- University of Saskatchewan
- CFFTP
- CCFM

The compact toroid gun is being designed during 1991 in California, in a joint effort by the team of Prof. Dave Hwang (UC Davis at Livermore) and Roger Raman of CFFTP.

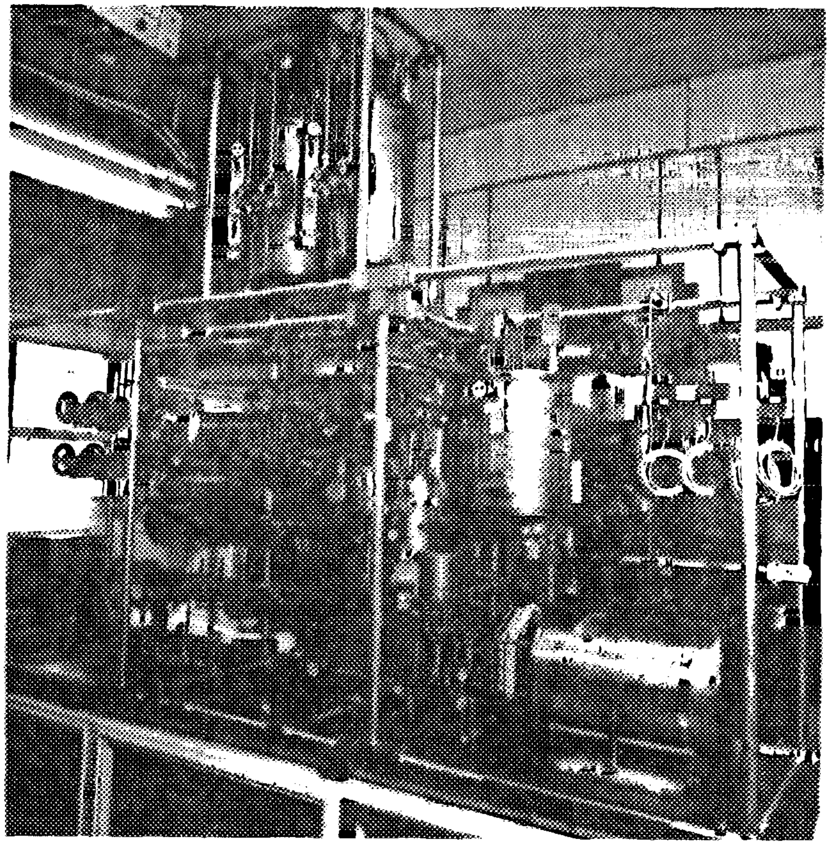
In 1992 the CT fuelling gun will be built at University of Saskatchewan by the Plasma Physics Group, led by Prof. Akira Hirose. The Group will commission the gun on their STOR-M tokamak.

In 1993, it is expected that the CT gun will be mounted on Tokamak de Varennes (TdeV) at CCFM, and compact toroids of hydrogen or deuterium plasma will be injected into the TdeV plasma to explore the physics of CT fuelling of tokamaks. Maximum CT mass to be injected is about one third of the maximum fuel mass of a TdeV discharge.

CFFTP is coordinating the four-site project, and providing most of the funding. Some preliminary design parameters for CTs produced by the CFFTP CT fuelling gun include:

CT volume of about 3 litres (length = 20 cm, diameter = 15 cm)
CT mass = 47 micrograms max. (28×10^{18} particles).
CT velocity (max.) = 1,000 km/s.

Further information: Paul Gierszewski, CFFTP (416) 855-4717 or Prof. Dave Hwang, UC Davis (415) 423-3726.



Highly tritiated water will be electrolyzed at AECL Chalk River in tests of an electrolytic cell built by Belgium's SCK/CEN nuclear research centre at Mol. Water containing tritium up to one million curies per litre will be electrolyzed to produce tritium and oxygen. This photograph shows the closed loop test rig incorporating the cell, prepared for enclosure in a glovebox. The horizontal cylinder at lower right is the containment vessel for the cell and its associated feed tanks for [illegible] water. Stability of electrolysis dynamics and possible corrosion effects will be [illegible]. Maximum tritium inventory is 80,000 curies. The Mol cell is a prototype for [illegible] for fuel processing loops on the Next European Torus (NET). AECL Chalk River is testing the cell for Mol under a CFFTP contract. System commissioning is now in [illegible] tritiated D_2O in the cell. More information: Joan Miller, AECL Chalk River (613) [illegible] ext. 3277, Fax (613) 584-4445

Attachments

Prof. C. S. MacLatchy (Physics Dept., Acadia University, Nova Scotia) arrived at CCFM in May for a one year stay, to collaborate with Claude Boucher of INRS-Énergie on plasma edge flow measurements with Langmuir probes, and on exploitation of the GUNDESTRUP probe concept (q.v.).

Paul Gierszewski of CFFTP goes on attachment to the Japan Atomic Energy Research Institute near Tokyo from September 1–November 30, 1991. He will work on breeder blanket engineering with Dr. H. Yoshida and his group.

Peter Ladd (CFFTP consultant) has left CFFTP to join the TFTR team at Princeton Plasma Physics Laboratory (USA) as the TFTR Vacuum Engineer. He joined PPPL in early June to work under Paul La Marche, Head of Vacuum Systems.

Amanda Hubbard of CCFM returned in April from a three-month working visit at the Tore Supra superconducting tokamak in Cadarache, France, where she assisted in RF current drive experiments. Dr. Hubbard is a plasma physicist specializing in lower hybrid radiofrequency current drive and millimetre wave diagnostics.

Roland Magne of Centre Études Nucleaires (CEN) Cadarache joins CCFM for one year to assist in the completion and installation of the TdeV lower hybrid current drive system. M. Magne is a specialist in high power microwave sources.

Printed in Canada on recycled paper

CFFTP Activities

These are a few of the recent activities of the Canadian Fusion Fuels Technology Project (CFFTP).

Uranium Beds for Westinghouse (Hanford).

CFFTP is supplying 12 uranium getter beds to Westinghouse (Hanford, Washington) for the BEATRIX II breeder irradiation experiments on the FFTF fast reactor. AECL Chalk River is designer and manufacturer of the U beds. They will be used in the tritium recovery systems which capture, for analysis, the tritium produced by samples of breeder material irradiated in FFTF.

CFFTP-NET

CFFTP continues its involvement with the Next European Torus (NET) project, located in Garching, Germany. Recently, CFFTP was awarded a NET contract for a design review and cost estimate for NET's Heating, Ventilating and Air Conditioning systems. Spectrum Engineering is doing the work as a CFFTP subcontractor. A similar contract, for a design review and cost estimate for the NET Reactor Water Cooling System, was also awarded to CFFTP. The work was subcontracted to AECL Research, Qualprotech Inc. and Spectrum Engineering.

Tritium Cleanup System for Glovebox Atmospheres

SAES Getters/USA Inc. and CFFTP have entered into a collaborative agreement to jointly develop and market packaged tritium cleanup systems for glovebox atmospheres. The SAES/ CFFTP Glovebox Cleanup System uses getter bed technology to remove tritium from the inert gases – usually argon or nitrogen – used as gas atmospheres in gloveboxes which house tritium systems.

Five engineering prototypes of the SAES/CFFTP Glovebox Cleanup System are being built at Ontario Hydro's Research Division (OHRD).

The SAES/CFFTP Cleanup System is built as a skid-mounted module designed to stand next to a glovebox, and couple into its inert gas atmosphere circuit. Its main functions are:

- Tritium control.
- Pressure control.
- Cooling of recirculated inert gas.
- Monitoring of inert gas for tritium and oxygen.

SAES Getters/USA Inc. will manufacture and distribute the Cleanup Systems. The design was a collaborative effort between CFFTP, OHRD and SAES.

Further information from Allan Meikle at CFFTP (416) 855-4724

CFFTP Video

CFFTP has made a 20-minute videotape about its R&D programs, its activities, its industry and university affiliations, and its role in Canada's National Fusion Program. The video may be of interest to organizations interested in participating in future CFFTP activities, and to students considering post-graduate studies in science or engineering.

For information on the videotape contact the Information Coordinator, CFFTP, Tel: (416) 855-4711, FAX: (416) 823-8020.

INRS-Énergie/TdeV

Direct Flow Vector Measurements in Plasma Edge.

A novel technique for directly measuring plasma edge flow direction and magnitude is being explored by INRS-Énergie researchers on TdeV. A 13-pin probe array called GUNDESTRUP is inserted into the plasma edge. The probe uses a ring of 12 current collector probes to construct polar plots of ion collection currents around a central post, at the end of which is mounted a pin which acts as a standard Langmuir probe. The researchers hope that a fully developed GUNDESTRUP probe might give direct, rapid measurement of flow direction and magnitude in tokamak plasma edges. Work is concentrating on correlating known plasma flow directions and magnitudes with the asymmetries in the constructed polar plots. The spatial resolution in the radial direction would be about 3 mm. The work is directed Claude Boucher of INRS-Énergie in collaboration with C.S. McLatchy (Acadia University).

More information: Prof. Claude Boucher, INRS-Énergie (514) 468-7753 or CCFM (514) 652 8710.

"Fusion: Energy for the Future"

Educational fusion brochure available.

The National Fusion Program has produced a revised and updated edition of its educational fusion booklet Fusion: Energy for the Future. Copies can be obtained free of charge by writing to the National Fusion Program office at AECL Research in Chalk River Ontario (see Contact Data).

The 32-page illustrated booklet is available in English and French. Thirty-five photographs and diagrams accompany the text. The first half of the booklet explains fusion at a level suitable for high schools and the lay public. The second half of the booklet discusses international fusion projects and ITER, and describes Canada's fusion programs and project centres.

National Fusion Program

Director, *Dr. David P. Jackson*

The National Fusion Program (NFP) coodinates and supports fusion development in Canada. NFP was established to develop Canadian fusion capability, in industry and in research and development centres. NFP develops international collaboration agreements, and assists Canadian fusion centres to participate in foreign and international projects.

NFP is managed for Canada by Atomic Energy of Canada Limited. Federal funding is provided by the Department of Energy, Mines and Resources through the Panel on Energy Research and Development.

'FusionCanada' Bulletin

'FusionCanada' is available free to interested persons. It is published four times each year, in French and English edtions. Write to NFP Office, 'Bulletin Subscriptions' (see Contact Data). Please specify French or English edition, (or both if dsired), and number of copies if several are required.

Contact Data

National Fusion Program

National Fusion Program
ALCL Research
Chalk River Laboratories
Chalk River, Ontario
Canada K0J 1J0

Telephone (613) 584-3311
Program Office: ext. 3174

Dr. David Jackson
Director – National Fusion Program
ext. 3175

Dr. Charles Daughney
Manager – Magnetic Confinement
ext. 3247

Dr. William Holtslander
Manager – International Program
ext. 3241

Dr. Gilbert Philips
Manager – Fusion Fuels
ext. 4321

Program Office
ext. 3174

Fax: (613) 584-4243
Telex : 053-34555

Ce Bulletin est aussi disponible en français

CCFM
Centre canadien de fusion magnetique

CCFM
1804, montée Ste-Julie
Varennes, Québec
Canada J3X 1S1

Dr. Richard Bolton
CCFM Director-General
(514) 652-8701

Dr. Réal Décoste
CCFM Director-Operations
(614) 652-8715

Dr. Brian Gregory
CCFM Director-Research
(514) 652-8729

Secretariet: (614) 652-8702
Fax: (614) 652-8626

CFFTP
Canadian Fusion Fuels Technology Project

CFFTP
2700 Lakeshore Road West
Mississauga, Ontario
Canada L6J 1K3

CFFTP Program Manager
Dr. Donald Dovinvich
(416) 855-4700

Reception: (416) 855-4700
Fax: (416) 823-8020

FusionCanada Office

Macphee Technical Corp.
Suite 300
980 Yonge Street
Toronto, Ontario
Canada M4W 2J5

Telephone: (416) 925-3117
Fax: (416) 925-2809

INRS-Énergie

INRS-Énergie
1650 montée Ste-Julie
Varennes, Québec
Canada J3X 1S2

Dr. Fernand Rheault
Director, INRS-Énergie
(514) 468-7706

Dr. Barry Stansfield
Coordinator, Magnetic Confinement Studies at
INRS-Énergie: (416) 468-7735
at CCFM: (416) 652-8735

Dr. Bernard Terreault
Coordinator, Plasma Wall Interactions
at INRS-Énergie: (416) 468-7711
at CCFM: (416) 652-8726

Secretariat: (514) 468-7700
Fax: (514) 468-7702