INIS-XA--210

INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL. 8, NO. 7 JULY 1999

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

ISSN 1024–5642

THE ITER DIVERTOR CASSETTE PROJECT MEETING

by Drs. M. Merola EFDA-CSU Garching, B. Riccardi ENEA-Frascati and R. Tivey JCT

The Divertor Cassette Project (ITER Large Project L-5) topical meeting was held on May 26 - 28, 1999 at the ENEA Brasimone Research Centre in Camugnano (Bologna), Italy. Specialists from all the four Parties and the JCT participated in the meeting that was aimed at summarising the status of the divertor R&D activities. The meeting was opened by Dr. A. Pizzuto, ENEA Fusion Division Deputy Director for the Experimental Engineering, with an overview of the fusion activities carried out in Brasimone.

The JCT outlined the features expected to be incorporated into the latest divertor design of the Reduced Technical Objective/Reduced Cost ITER (RTO/RC ITER). Although the proportion of the in-vessel space allocated to the divertor is smaller than in the 1998 ITER design, the new design still manages to maintain the predicted peak heat flux onto the targets at similar levels. A reduction of the coolant inlet temperature from 140 to 100° C has been proposed and should allow the use of series flow through the divertor plasma facing components (PFCs), which promises benefits in terms of divertor cost and overall machine safety.

The status of R&D activities related to component design, manufacturing and testing was then presented by the four Parties, in particular the progress made since the last L-5 meeting held in St Petersburg in June 1998. Efforts in the Home Teams have focused on developing Carbon-fibre Composite (CfC) armoured PFCs capable of sustaining the 20 MW/m^2 heat flux anticipated where the separatrix intercepts the divertor targets, and tungsten armoured PFCs capable of handling up to 5 MW/m^2, the peak heat flux expected elsewhere in the divertor Apart from developing the PFCs, the Large Project L-5 aims at demonstrating the integration of PFCs built by all four Home Teams onto a divertor outboard channel cassette mock-up fabricated in the EU and an inboard channel cassette mock-up fabricated in the US.

In the EU, a prototypical target, with both (CfC) monoblock and tungsten brush-like armours, has been manufactured by Plansee (Austria) and Ansaldo (Italy) (Fig.1). The monoblock is a robust design that uses

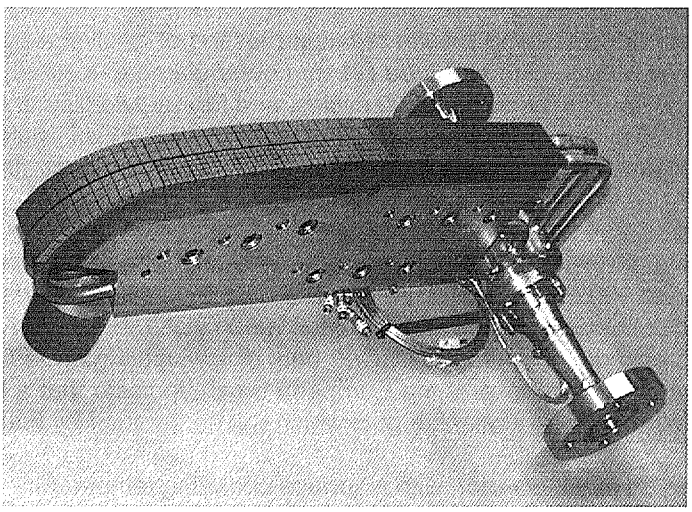

Fig. 1 - CfC monoblock and W brush armoured vertical target mock-up

drilled blocks of CfC into which a copper alloy tube is inserted and joined via a cast pure copper interlayer. The tungsten brush uses rectangular pins of tungsten set in a cast pure copper matrix as a means of accommodating the different thermal expansions of copper and tungsten. This is then electron-beam welded to a copper alloy heat sink. The prototype is presently under test at the Le Creusot facility in France, where it will be cycled up to 20 MW/m2. Note that smaller scale mock-ups built by Plansee have already demonstrated satisfactory performance of the CfC monoblock at 20 MW/m2 for 1000 cycles and the tungsten brush at heat flux in excess of 15 MW/m2. In common with most PFCs, the most critical feature of these components is the armour to copper alloy heat sink joint. Hence a number of European laboratories and industries (Seibersdorf, ENEA, VTT, CEA, Plansee) have contributed to the development of non-destructive examination of this joint using ultrasonic inspection and thermal imaging techniques. These have been demonstrated to be workable methods for reliably detecting 2-3 mm defects in the armour to heat sink joints.

The post-neutron-irradiation high heat flux testing of samples and prototypical components with CfC, Be and W armours, irradiated to conditions expected at the end of divertor life in ITER, is nearing completion in the hot cell facility at FZJ in Jülich, Germany. A highlight of these tests so far is that an irradiated CfC armoured component was successfully tested at 15 MW/m2 for 1000 cycles.

The thermohydraulic database produced by CEA Cadarache, France, on critical heat flux tests of divertor components has been confirmed by the round robin test on mock-ups performed in JA and US.

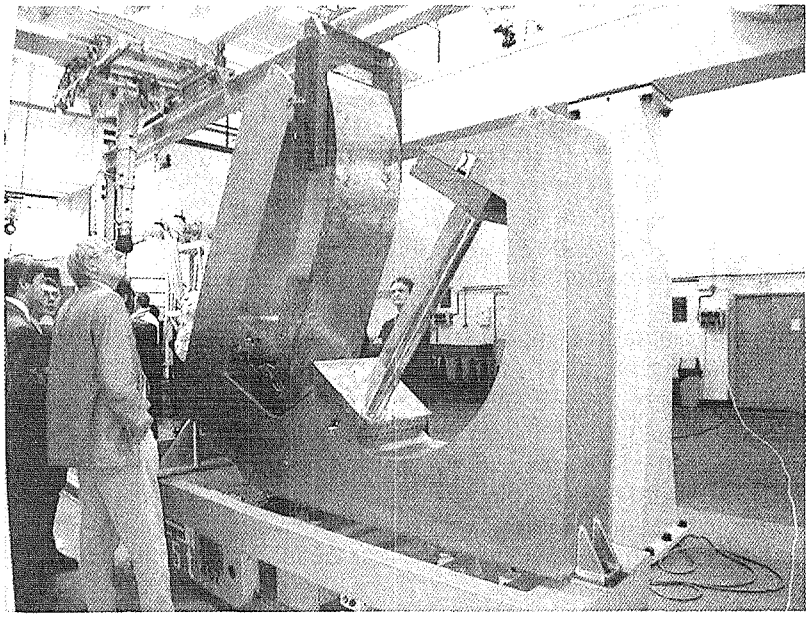

Fig. 2 - Integration prototypes mounted onto the outboard cassette

The JA Home Team reported encouraging results of fatigue testing of a full-scale mock-up using a 2-D CfC monoblock design employing a large diameter tube (21 mm outer diameter instead of 12mm of EU reference design). The mock-up sustained 5 MW/m2 for 3000 cycles, and further two tiles at the center of the mock-up sustained 20 MW/m2 for 1000 cycles. Although during the test at 5 MW/m2 a few tiles exhibited elevated temperatures which would be caused by joint flaws during the manufacturing process; the flaws did not propagate during the fatigue test.

In the RF, a brazed lamellae tungsten mock-up, proposed as a cost effective variant of the tungsten brush, survived up to 18 MW/m2 and 900 cycles at 15 MW/m2. The US Home Team reported that two W brush mock-ups have sustained an incident heat flux of 30 MW/m2 for 1000 cycles. A further two brush mock-ups using tungsten hot isostatically pressed (HIPed) to the CuCrZr heat sink with an intermediate soft Cu layer survived up to 25 MW/m2. These results, and those of the European brush, indicate that a tungsten armoured target capable of sustaining 20 MW/m2 is an attainable goal which will be pursued by future Home team R&D.

A hot liner in the private region of the divertor, with a surface operating temperature of ~800-1200° C, is being investigated by the RF as a potential means of minimising the trapping of tritium. A test programme to investigate its performance is underway.

The EU Home Team (Ansaldo, FN and CSC (Italy)) has built a 3.2 t welded, stainless steel mock-up representing the outboard divertor cassette. Dimensional tests proved that all the required tolerances have been achieved. European built PFCs have already been installed onto the outboard cassette and the Russian built liner PFC is scheduled to be attached in the next two months. In a visit to the ENEA Brasimone laboratories the meeting participants were able to see this assembly (Fig. 2). In the US a 5 t centre segment of the cassette body has been built using stainless steel casting. Tests showed that the material is suitable from both an outgassing and a corrosion point of view. The integration of the JA and RF Home Team components onto the centre segment is planned to be completed by the end of September. The relative merits of producing the divertor cassettes by welding forged material will be compared with fabrication from castings.

There was discussion on the issues that remain to be solved by R&D. In future the EU will continue to focus its efforts on the reference design, on the welded divertor cassette and the development of HIP joining of the armour to the heat sink. The EU, JA and RF will study cost effective alternative designs, such as:

- tungsten monoblocks (EU) as a competitor to the tungsten brush;
- widening the monoblocks to take advantage of the lower coolant temperature (EU);
- flat tiles with hypervapotron cooling (EU);
- monoblock based on large tube diameters and, if feasible, including annular flow (JA);
- hot pressing of tungsten pins into a Cu substrate (JA);
- optimisation of the ohmic fast brazing technique(RF);
- a liner with radiatively cooled tungsten tiles (RF).

In summary, the overall L-5 project has significantly contributed to solving a large part of the critical issues of the ITER divertor design, and impressive achievements have been obtained in the technology of high heat flux components. The divertor design is now based on robust solutions which meet practically all the ITER requirements. Future work will focus on improving the reliability and repeatability of the manufacturing process and on the development of cost effective alternative concepts.

The next L-5 Meeting is provisionally scheduled for April 2000 in Naka.

Fig. 3 - Participants in the Meeting

EU: F. Anselmi (CSC Schio), M. Bet (Ansaldo), F. Bruno (Plansee), P. Chappuis, (CEA Cadarache), G. Dell'Orco (ENEA Brasimone), F. Escourbiac (CEA Cadarache), G. Gandini (FN), M. Grattarola (Ansaldo) M. Merola (EFDA CSU Garching), A. Orsini (ENEA Frascati), A. Peacock (EFDA CSU Garching), A. Pizzuto (ENEA Brasimone), L. Ploechl (Plansee), B. Riccardi (ENEA Frascati), E. Rigal (CEA Grenoble, M. Roedig (FZJ), B. Schedler (Plansee), J. Schlosser (CEA Cadarache), G. Vieider (EFDA CSU Garching), E. Visca (ENEA Frascati)
JA: M. Akiba (JAERI)
RF: I. Mazul, (Efremov Institute)
US: D. E. Driemeyer (Boeing), M. Ulrickson (SNL)
JCT: A. Antipenkov, V. Barabash, S. Chiocchio, V. Chuyanov, G. Janeschitz, R. Tivey

REMEMBERING SAN DIEGO

by Dr. V. Chuyanov, ITER Deputy Director

This is probably inherent to human nature - to appreciate good only when it is gone. We knew that weather in San Diego was good, but how good it was we have understood only after several months of soaking under German rain. When it is sunny every day one starts dreaming about rain and it is difficult to believe that somewhere it is raining all the time.

But this short note is not only about weather. In fact it is not about weather at all. It is about the city and people who hosted ITER for six years and who are fully entitled to share success of this first of a kind and unusual project.

Everyone agrees now that ITER EDA has been a success and not only in the technical sense. Success of ITER as a sociological experiment was determined in very significant part by the people of San Diego- by the City officials and representatives in the State and the Federal Government, by the University of California San Diego, by people who serviced the Project and by people who simply expressed there interest and support.

Excerpt from the Brochure (1991) inviting the ITER EDA to San Diego

"The University of California, in association with General Atomics, Science Applications International, General Dynamics, the City of San Diego and the State of California, is pleased to invite the ITER EDA Joint Central Team to San Diego. San Diego will provide an excellent research environment for ITER EDA, combining exceptional academic and industrial resources with a strong commitment to fusion research. San Diego has been a leading center of magnetic fusion research for over 30 years. The University and General Atomics have long-standing experience in hosting international research teams, and an established infrastructure of support services and programs for international researchers."

"The EDA Joint Work Site will be located near the central campus of the University of California at San Diego (UCSD)., less than a kilometer from the DIII-D fusion research facility. Offices, meeting rooms, library, computer space, and cafeteria will be provided in beautifully landscaped, fully appointed facilities in the Heart of San Diego's science research, and development area. ITER project participants will have convenient access to the University's outstanding facilities, with libraries, cafeterias, restaurants, and recreational facilities."

The City took the hosting of ITER very seriously. A special San Diego Site for ITER Committee was created to facilitate ITER Joint Work siting in San Diego. A lot of thinking was including in preparing and organizing the support. Deep interest to the project has been generated and cultivated for all six years. The San Diego Site for ITER Committee not only won the ITER hosting in a competition with other contenders but continuously supported the Site for all six years.

Wine Tasting in the Temecula Valley

During ITER EDA San Diego became one of the world class Centers of Fusion and was proud of the role. It was a pleasure to answer questions about the Project development asked not only by City officials but by airport shuttle drivers, dentists, bank clerks or simply by our neighbours.

Dr. V. Chuyanov, Head of ITER San Diego Joint Work Site briefing the Members of the Achievement Rewards for College Scientists Foundation Group on 13 October 1994

Problems associated with relocation and accommodation to a new culture have been well understood and softened by friendly every day help. It is difficult now to overestimate the importance of work done by staff of The International Center in the UCSD and personally by Carol Smith who organized support for ITER families and made of the International Center a real ITER club - the center of ITER culture.

A great effort has been performed by Tom Dillon and Maurice Sabado from the Science Applications International Corporation to assemble proper technical support personal and keep the appropriate level of support during all years of project. Their desire to go an extra mile to accommodate project needs, their constant effort to support a feeling of the common goal and the full participation of support personal in technical, political and social life of the project were the most important ingredients of the project success in San Diego.

Santa Claus (Dr. R. Aymar, ITER Director) visits ITER Children at the International Center (December 1997)

The Fusion Office of the DOE paid constant attention to the project. Special meetings with participation of the Head of the Site to consider project support were organized twice each year and were attended by senior representatives of the Fusion Office, UCSD and SAIC. In spite of financial problems of fusion in the US the Joint Work Site always had proper support and equipment. The termination of the project in San Diego by decision of the US Congress created significant difficulties and losses for ITER families. This, certainly, generated distress and some bad feelings. But these feelings will never overshadow our good memories and our friendship with San Diego people who worked with us 6 years, who shared all successes and difficulties of the project, who considered themselves as a part of the project and who were shocked and offended by the termination decision no less than were members of the JCT. These people worked very hard to show that the US is a great country and American people are good dependable friends and they surely succeeded. We all have left San Diego with the best feelings about this City and a part of our soul will stay forever with our friends in San Diego.

ITER Spouses Farewell Lunch at the UCSD Faculty Club. Back row: Valentina Muravieva, Tatyana Balasanova, Nina Sadakova, Larisa Baulo, Amanda Vayakis, Theresa Aitchison (staff), Kathy Dilling; Front row: Midori Fujisawa, Ami Kobayashi, Barbara Ahlfeld (holding Cookbook by ITER Spouses), and Rea Costly

All photos in this article by courtesy of Carol V. Smith

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kuvshinnikov, ITER Office, IAEA, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 2633832, or e-mail: c.basaldella@iaea.org (phone +43 1 260026392).

Printed by the IAEA in Austria
August 1999

99-02377