IGC newsletter

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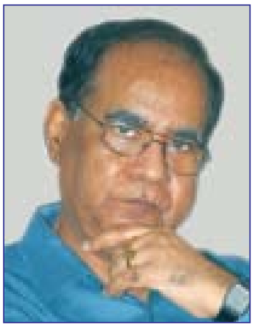
INSIDE

From the Director's Desk



NEW YEAR MESSAGE

Dear Colleague,

It gives me a great pleasure in wishing you and your family a very happy, healthy and prosperous New Year 2008. A new year always ushers in a sense of hope and expectation for fulfilling our dreams, which depend upon the foundations of our experiences, capabilities and past successes.

We have made rapid strides in various areas of fast reactor science, engineering and technology development over the last one year. FBTR has been successfully operated, thus, realizing its objectives and in the process establishing new benchmarks. Challenging campaigns have been planned in the areas of testing and evaluation of fuels, materials and components, achieving higher operating temperatures and safety performance. The current major mission of FBTR is to irradiate the fuel simulating PFBR fuel composition and towards this, the core has been expanded by adding two fresh Mark-I and eight fresh MOX subassemblies, after discharging one high burn-up (155 GWd/t) Mark-I subassembly for Post Irradiation Examination (PIE). From the safety point of view, the seismic re-evaluation of the plant is in progress. The neutron detectors developed for PFBR have been tested in FBTR and the response is found to be acceptable.

With regard to our committed mission of contributions to the design and construction of 500 MWe PFBR, we have been on the right path. The PFBR design review has continued, focusing on the issue of regulatory consent for *"Erection of major equipment"*. Detailed analysis of thermal hydraulics and structural mechanics has been carried out for resolving the issues raised by Project Design Safety Committee, Civil Engineering Safety Committee and various specialist groups, constituted by Atomic Energy Regulatory Board. With respect to manufacturing technology, the hard facing of grid plate on two annular tracks has been successfully achieved - a crucial milestone, paving the way for smooth progress of activities related to final manufacturing stage of grid plate for PFBR. The completion of the manufacture of safety vessel, one of the large diameter thin shell components of reactor assembly, conforming to the tolerances higher than international nuclear standards is another significant milestone in our FBR programme. This has demonstrated indigenous manufacture capability and has given confidence towards successful completion of other important large sized vessels of PFBR Reactor Assembly. A real time Decision Support System (DSS) comprising the most advanced meteorological forecasting module and a dispersion and dose prediction module along with real time meteorological data acquisition and archival system was developed and demonstrated for radiological emergency. We are committed to robust synergy with BHAVINI as well as industries to realize the PFBR with the design specifications on time, with a firm commitment to safety and economy.

On materials front, we are working on modified D9I steels with active support from M/S MIDHANI. The base composition is similar to that of D9 SS with respect to all elements, except that titanium, silicon and phosphorous compositions have been optimized. Based on the synergy across various laboratories of our Centre, we are investigating various modified D9I heats with regard to mechanical properties and void-swelling behavior. We are utilizing atomistic experimental techniques to explain the observed trends. A new methodology based on ultrasonic C-scan presentation was identified to image the microstructure evolution during dynamic recrystallization of alloy D9. Our Centre has also embarked on fabrication of metallic alloy fuel pins for test irradiations. The facility would be commissioned before the end of the year 2008. This achievement will mark the beginning of an important programme of introduction of metallic fuel in FBTR ultimately and paving way for the design and construction of FBRs with metallic fuels.

Reprocessing is a central and important issue in closing the fuel cycle. The success of fast breeder reactors depends on successful, cost-effective and robust closure of the fuel cycle. Enhanced research and development with large manpower for reprocessing activity is a priority for next few years. We have made significant progress by demonstrating reprocessing the high burn-up carbide fuel and necessary steps are being taken to improve the facilities to take on the reprocessing of the oxide fuels for PFBR. Polyvinyl pyridine (PVP) resins for plutonium processing and precious metal recovery are being developed. Innovative separation techniques such as recovery of Pu and Am by supercritical fluid extraction have also been demonstrated, on a laboratory scale. The plant layout for the Fast Reactor Fuel Cycle Facility (FRFCF) is taking good shape.

Indigenous development of compact and reliable sensors has been an important programme of our Centre. It is a matter of pride that the electrochemical hydrogen meter developed in our Centre has been installed in the Phenix reactor in France for detection of steam leak into sodium. These tests will provide us valuable inputs regarding the performance of the meter and this indigenous sensor development. Further, the entire instrumentation package for oil level sensing, including the actual sensors for deployment in PFBR, were made in-house with remarkable performance. The operator information system for Boron Enrichment Plant was installed and commissioned. Innovations in electronics & instrumentation and sensor development have been the hallmark of our Centre, widely acclaimed nationally and internationally.

We have been believing and practicing the *mantra* of synergistic collaborations within the DAE as well as other academic institutes for innovative contributions in fast reactor science & technology. For example, the Kalman filter technique, developed in collaboration with BARC to confirm the dropping of the Diverse Safety Rods into the core of PFBR during a scram, has been tested and results indicate that the technique is suitable for practical implementation. Also, a laser triangulation system, capable of generating profile images of corrosion wall loss and chemical/ scale build-up in vessels with an accuracy of ±0.1 mm has been developed jointly by IGCAR and RRCAT, for planar surface profiling of Titanium dissolver vessel of reprocessing plants of fast reactors.

The successes achieved by our Department is largely due to the development and management of quality manpower. On human resources development front, it is matter of great pride that we have made commendable progress. The Training School of Bhabha Atomic Research Centre (BARC) at IGCAR campus has turned out its first batch officers in September 2007, which is a momentous occasion for the Centre. Further, we have added two new disciplines for post-graduates in Physics and Chemistry viz., Nuclear Reactor Physics with emphasis on Reactor Physics & Safety, as well as Nuclear Fuel cycle chemistry with emphasis on nuclear fuels, chemical separations and associated fuel cycle technologies. It is also heartening to realize the academic programmes of Homi Bhabha National Institute (HBNI), thus imparting multidisciplinary training courses both for employees and students. We have started University Grants Commission (UGC)-Department of Atomic Energy (DAE) Consortium for Scientific Research (CSR) Node, which will help to strengthen the quality and quantity of research in various Indian Universities in the areas of Physical, Chemical and Engineering Sciences. This would facilitate high quality research with universities and in turn, provide vital inputs to our mission programmes. This will fulfill the cherished commitment of the DAE to enhance the research at various universities across the country and in particular, for South India. In its commitment to harness quality manpower for science and technology, the DAE continues to be imaginative and innovative.

The service groups are doing commendable job in developing valuable infrastructure for the Centre. Our civil, electrical and air-conditioning requirements for XI plan are quite large and the groups are committed to muster all its resources to meet the envisaged targets.

The General Services Organization (GSO) is doing its best to improve the housing situation at the townships. In view of envisaged housing demands in XI plan, we are committed to provide good quality of housing to our employees. The hospital has enhanced its services with better amenities. The Schools are making significant contributions by providing quality of education to the students, with due emphasis on molding their character and personality in a holistic manner.

Over the last one year, we have shown high commitment to realize goals, strategic sectors, collaboration with academia and research institutes and industries. It has been a 360° progress experience for the Centre. The year 2008 would see milestone achievements in basic science, FBTR campaigns towards valuable contributions to realize PFBR and future FBRs, robust reprocessing of oxide and metallic fuels. I am looking for more passion, higher quality, enhanced commitment to science, technology and mission-mode programmes, innovation and imagination, increased productivity and above all more happiness and fulfillments for you and your families in the year 2008. I would like to quote George Bernard Shaw – "*Imagination is the beginning of creation. You imagine what you desire, you will what you imagine, and at last you create what you will...*".

Successful realization of the mission of the Centre, namely robust Sodium Cooled Fast Breeder Rector Science & Technology with Closed Fuel Cycle and the vision of the world leadership in this technology needs a good connecting bridge between the mission and the vision. Moreover, connecting bridge between the mission and the vision has to be short in span of time to reap the benefits. I am inspired by Albert Einstein's quotation - "*I never think of the future. It comes soon enough*". We would realize the mission and the vision of the Centre soon enough.

May you fulfill all your dreams and facilitate the country to realize its dreams with your valuable contributions in the year 2008.

Baldev Raj
Director,
IGCAR & GSO

Towards developing an improved alloy D9 SS for clad and wrapper tubes of PFBR

Economic operation of fast breeder reactors (FBRs) is largely dependent on the performance of core structural materials, i.e., clad and wrapper materials of the fuel subassembly, which are subjected to intense neutron irradiation. This leads to unique materials problems like void swelling, irradiation creep and helium embrittlement. The operating temperatures are high and stresses of sufficient magnitude are present so that creep strength, tensile strength and tensile ductility are also important requirements for the core structural materials. In order to increase the burn-up of the fuel and thereby reduce the fuel cycle cost, it is necessary to employ materials which are more resistant to void swelling and have better high temperature mechanical properties. The core structural material chosen for fuel clad and wrapper tubes of PFBR is 20% cold-worked alloy D9 stainless steel (SS) for the initial core. This material has been chosen in view of its better swelling resistance as compared to 316 SS, which is the core structural material for FBTR. The target burn-up is 100,000 MWd/t and the dose is 85 dpa.

For future cores of PFBR, there is a need to use a different composition of alloy D9 SS which swells less and has better creep resistance so that burn-up levels upto 150,000 MWd/t can be realized. A task force was constituted to develop a modified composition of D9 SS which is superior to D9 SS, after carrying out detailed studies on void swelling, thermal creep properties, tensile properties, microstructural stability and weldability. As part of this mandate, the influence of minor elements, namely, titanium in the range of 0.16 to 0.30 wt%, silicon in the range 0.75 to 0.95 wt % and phosphorous in the range of 0.025 to 0.04 wt%, on these properties are being studied to optimise the composition. Fifteen laboratory heats of modified D9 SS were prepared using double vacuum melting process consisting of vacuum induction melting followed by vacuum arc remelting. The base composition was similar to that of D9 SS with respect to all elements other than titanium, silicon and phosphorous.

CREEP PROPERTIES

The influence of titanium content on creep properties of modified D9 SS has been studied at 973 K at different stress levels in the range of 150 to 250 MPa. All the heats contained about 0.75 wt% silicon and 0.025 wt% phosphorous. Figure 1 shows the influence of titanium on the creep curves at 973 K. Maximum rupture life was obtained when the titanium content was about 0.22 to 0.24 wt%; rupture life decreased by increasing/ decreasing the amount of titanium from 0.23 wt%. The peak in rupture life was more pronounced at lower creep stresses as shown in Fig.2. Since titanium is a strong carbide former and the carbide precipitates have a strong influence on creep properties, Ti/C ratio is considered as important parameter to assess the influence of titanium. From Fig. 2, it is seen that Ti/C ratio of about 5.5 to 6 provides maximum creep strength to modified D9 SS containing 0.025 wt% phosphorous and 0.75 wt% silicon. The variation of minimum creep rate with titanium content exhibited the lowest rate corresponding to 0.22 to 0.24 wt% titanium (Fig. 3). Creep rupture ductility generally decreased with increase in titanium content.

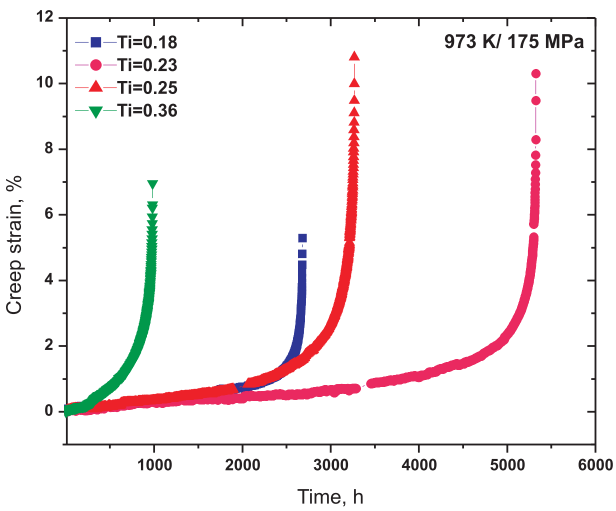


Fig.1 : Influence of titanium on Creep curves of D9 I SS (phosphorous = 0.025 wt%, silicon = 0.75 wt% and carbon = 0.04 wt%).

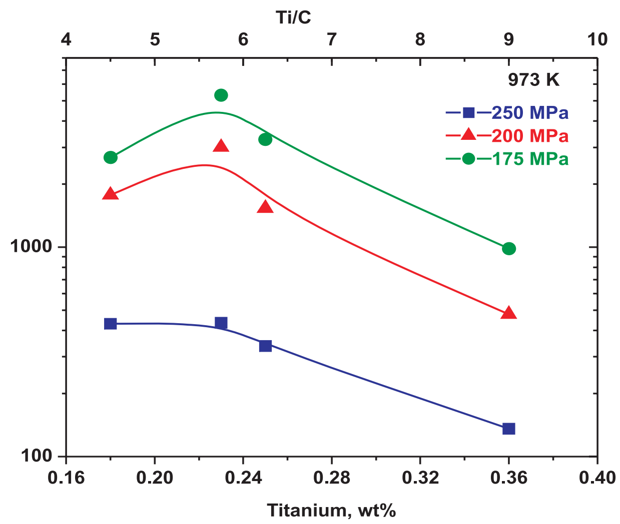


Fig. 2 : Influence of titanium on creep rupture life of D9I SS (phosphorous= 0.025 wt%, silicon = 0.75 wt% and carbon = 0.04 wt%).

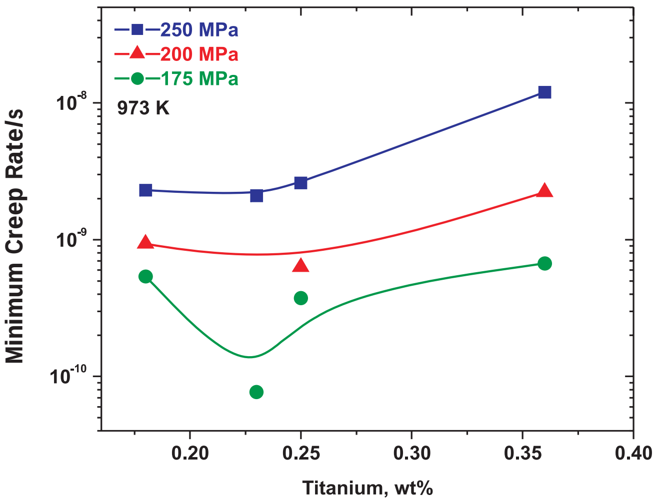


Fig. 3 : Influence of titanium on minimum creep rate of D9I SS (phosphorous= 0.025 wt%, silicon = 0.75 wt% and carbon = 0.04 wt%).

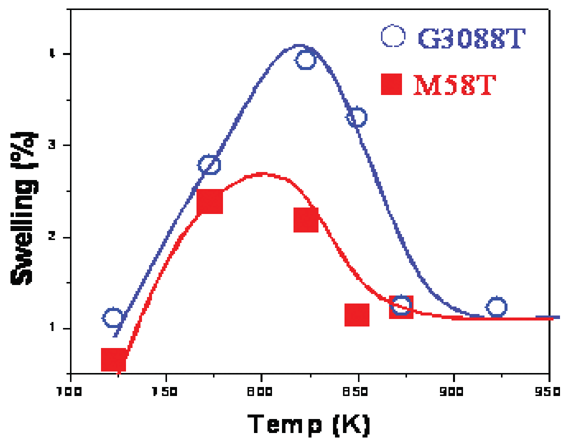


Fig 4 : Temperature dependence of void swelling measured by surface profilometry for the D9I SS alloys with two different phosphorous concentrations. The chemical composition of heats are G3088T: P=0.034, Si=0.74, Ti=0.25; M58T: P=0.047, Si=0.77 and Ti=0.31.

VOID SWELLING

Study of radiation damage up to high doses of about 150 dpa, would require three to four years in a nuclear reactor. In contrast, a few hours of ion irradiation in an accelerator can effectively simulate some crucial aspects of the neutron damage. The ion-irradiation damage thus produced is characterized by many techniques like precision profilometry, position lifetime spectroscopy, high resolution electron microscopy, besides theoretical modeling, which enable a meaningful inter-comparison of results from accelerator and nuclear reactors. Accelerator experiments can play a useful role in short listing the most potential swelling resistant candidate alloys for further extensive research. On a per atom basis, silicon and phosphorous are most effective to suppress void growth over the entire temperature range of swelling in austenitic SS. Initially we have taken up study of two heats of modified D9 SS which have 0.034 and 0.047 wt% phosphorous content, the composition of other elements being similar. The pre-injection of helium, to simulate the effect of helium produced by (n, alpha) reactions in a reactor, was carried out at room temperature by implanting helium at different energies from 200 keV to 700 keV in order to obtain a uniform concentration of 30 appm helium around the peak damage region of 5.0 MeV Ni^{2+} ions. These pre-injected specimens were subsequently irradiated with 5.0 MeV Ni^{2+}ions, using a 1.7 MV Tandetron accelerator, to a dose of about 9.0×10^{16} ions/cm^2 which corresponds to ~100 dpa at the damage peak, as calculated invoking modified Kinchin-Pease analytic solution for the calculation of damage. The ion irradiations were conducted at a damage rate of 7×10^{-3} dpa/s at various irradiation temperatures between 700 and 970 K. For carrying out the step height measurements, the specimen was partially masked with a stainless steel mask with a knife edge during ion irradiation, so that only the unmasked region was irradiated. As the bombarded region swells, the surface becomes elevated and a step forms at the interface between the masked and unmasked regions. Measurement of this step height provides the total integrated swelling that has occurred along the path of the bombarding ion. The step height was measured using a surface profilometer. The one-dimensional step height measurement gives the volumetric swelling. Temperature dependence of void swelling is plotted in Fig.4. The void swelling was found to be lower for the heat containing higher amount of phosphorous and the peak swelling is also lower at 2.5 %. The reduction in swelling by phosphorous addition is more pronounced above 800K.

SUMMARY

Creep properties of modified alloy D9 SS at 973 K varied significantly with the titanium content in the range of 0.16 to 0.30 wt%. Maximum creep rupture life was obtained when the titanium content was about 0.22 to 0.24 wt%. Void swelling reduced with increase in the phosphorous content from 0.034 and 0.047 wt%.

(Reported by M.D. Mathew, Convener, Task Force on Development of Advanced Materials for Clad and Wrapper Applications)

PFBR Full-scope Training Simulator

Introduction

PFBR Operator Training Simulator is a full-scope, replica type simulator being developed at Computer Division with the objective of providing comprehensive training to operators in the Prototype Fast Breeder Reactor plant operations. The scope of simulator covers the entire plant. Being a replica simulator, it completely replicates the reference plant configuration, control system, operator interface and information systems. It will have the control room identical to the actual plant.

The simulator is essentially made up of mathematical models of PFBR subsystems running in a computer system to replicate the operational characteristics of the plant. PFBR simulation involves developing models for various sub-systems like Neutronics, Primary & Secondary Sodium Systems, Steam Water System, Electrical System and associated control logics. PFBR Training Simulator is designed to simulate the steady state and dynamic responses of the plant in real-time to operator actions.

To ensure safety in real plant operations, it is mandatory as per AERB guidelines to train and qualify the operators in plant operations before commissioning the real plant. The simulator is helpful in training the operators about the process dynamics, operations in normal and abnormal situations, various malfunctions & incidents as well as plant start-ups etc.

Simulator Architecture

The full-scope, replica simulator consists of Simulation Computer, Process Computers, I/O system, Distributed Digital Control System, Instructor Station and Control Room Panels & Consoles, with a Simulator Network to interconnect all the components.

The **simulation computer** executes the integrated simulator code in real time to mimic the plant dynamics. It is based on powerful computer system with UNIX as operating system. The **process computers** receive the plant information from Simulator system, process, and update the stored 'plant parameter database'. The graphic display stations on the operator console and panels receive the data

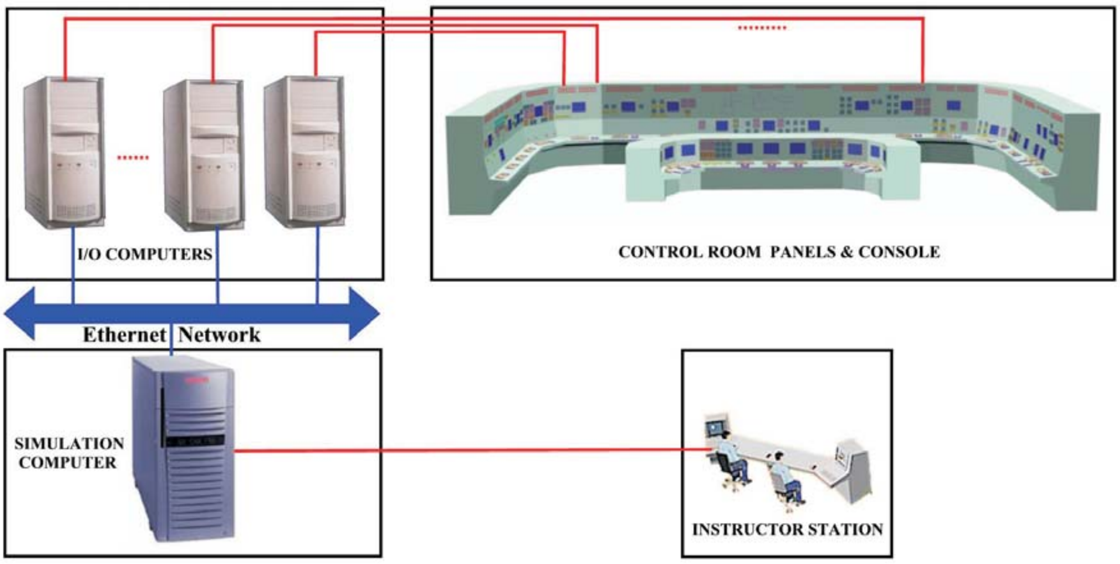


Fig. 1 : Simulator Hardware Layout

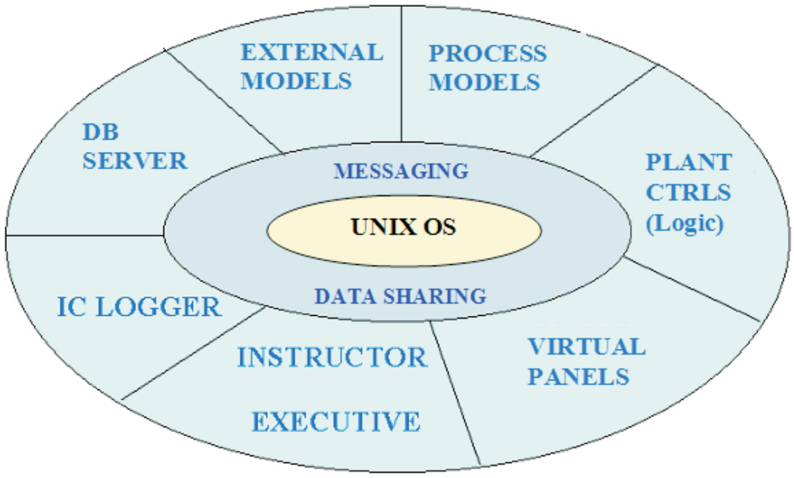


Fig. 2 : Architecture of Simulator Software

from these process computers and display the plant information in different formats. The process computers are based on Dual Intel Xeon processors.

The **input/output system** takes commands from the control panel/ console, perform appropriate action and show the results on the panel/ console. The I/O system contains the required number of digital input, digital output, analog input, analog output signal boards, and is placed behind the control panel. The I/O systems are connected to the simulator network (Fig-1) along with simulation computer, process computer etc. For interconnecting the various systems including Local Control Centres(LCC), separate Safety Class-1, Safety Class-2, and Non-Nuclear Safety systems data highways and plant backbone are established as **Distributed Digital Control System (DDCS)**). LCC provides interface between the field and the control room. In the simulator the signal processing hardware and other hardwired instruments are simulated through computers located in LCC. The plant data is communicated through data highways and plant backbone to the control room.

The **instructor station** is used by instructor to control and monitor the operations of simulator and create various incidents/ malfunctions during training sessions. The important operations include run, step, back track, freeze, replay and snapshot. The station is based on PIV @ 3GHz and 21" monitor etc. The **simulator control room** panels and consoles provide the human-machine interface using which the trainees operate and monitor the plant operations. They are exact replica of PFBR control room panels and consoles. It includes hardwired instruments, window annunciations and display stations. Fig.1 depicts the hardware layout of the simulator.

The modeling software provides simulation model libraries, tools to build and integrate components and environment for running the simulator in real time. It includes Instructor, Executive, Database Server, IC logger and Messaging & Data Sharing Mechanism.

The **Executive** controls and synchronizes operation of the various simulator components. It ensures process synchronization and exchange of messages and data between real-time processes of the simulator. The **Instructor** module provides user interface to the simulator executive to control and monitor operations of simulator and conduct training sessions. The **Messaging and Data Sharing Mechanism** is an essential part of simulator which enables processes to exchange messages and share data between them. The **Database server** provides a single database for all the components of the simulator with multi-user access. The **Logger** provides a uniform, centralized mechanism to save and restore information about the state of the simulator and the user input.

The modeling software provides the application-specific tools for:

- simulating the process models of conventional plant systems
- simulating plant controls
- emulating control panels and FDT with soft-screens

Process models for non-conventional nuclear subsystems are developed as External or Foreign models and integrated into the simulator environment.

The organization of simulator software components are shown in Fig 2.

Reference Plant Subsystems being simulated

The PFBR subsystems identified for simulation are listed below:

- Neutronics System
- Reactor Assembly
- Primary Sodium System
- Secondary Sodium Circuit – 2 Nos
- Safety Grade Decay Heat Removal Circuit – 4 Nos
- Steam Water System
- Generator and Electrical Systems
- Operation Grade Decay Heat Removal System
- Condenser Cooling Water System
- Instrumentation & Control of Real Time Computer Systems and Safety Logic Systems
- Fuel Handling Operation

The malfunctions and incidents represent the unusual occurrences experienced during the plant operation which require adequate handling by the plant operator. In order to train the operator for such an eventuality, an exhaustive list of such possible incidents and malfunctions related to PFBR has

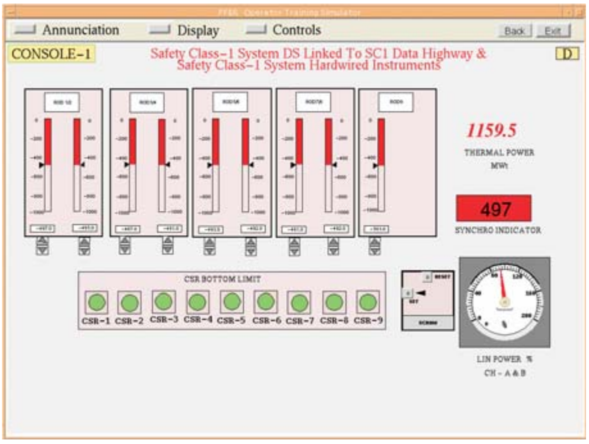


Fig. 3 : Neutronics Modeling

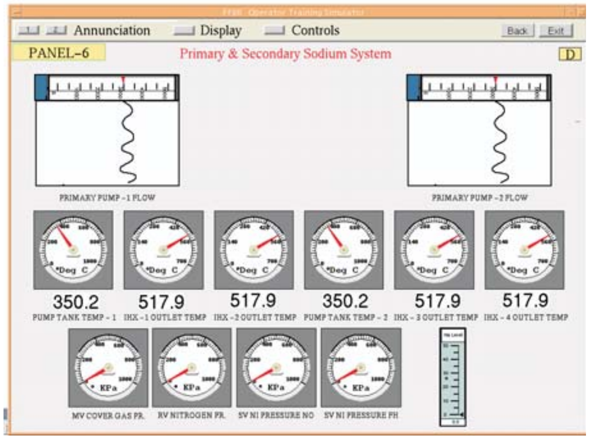


Fig. 4 : Primary & Secondary Heat Transport Systems Modeling

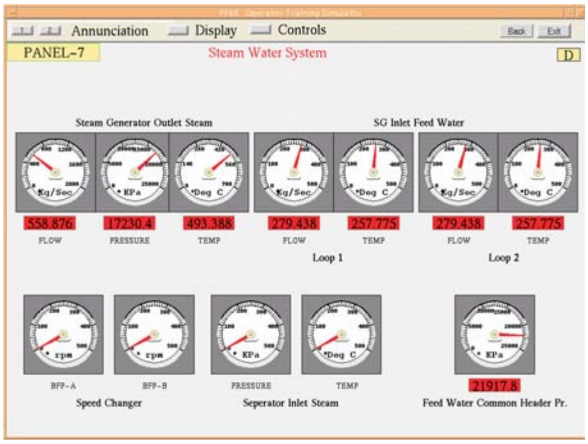


Fig. 5 : Steam Water System Modeling

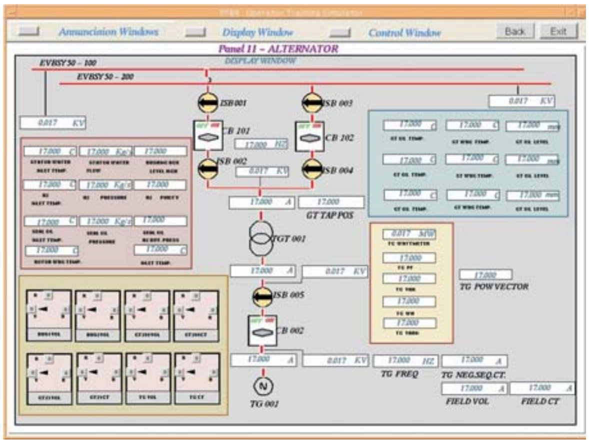


Fig. 6 : Electrical System Modeling

been identified for modeling and their simulation is in progress.

Development of Models

All conventional sub-systems like hydraulic, steam, air/gas and electrical as well as non-process elements such as actuators and transducers are simulated using the modeling software. Process Models for nuclear subsystems such as Neutronics, Core, Primary Sodium, Secondary Sodium, Safety Grade Heat Removal Systems are developed from scratch and adopted as external models in the simulator environment.

During the development stage of simulator, the functions of the reference plant control room and operator interface are emulated using VDU based graphics systems called virtual panels. Virtual Panels are screen based soft-panels which emulate control panels and consoles with animated panel equipment icons. The virtual panels of the simulated subsystems of PFBR are shown in Fig. 3, 4, 5 & 6.

The simulator development is in progress and models are being integrated and tested. The simulator being developed will go a long way in providing the required training to operators & engineers for smooth operation of PFBR. Simulator can also be used to verify the effect of design modifications in PFBR. The developed simulator models will be verified and validated by an independent team consisting of experts from NPCIL and BARC.

(Reported by S. Athinarayanan, Computer Division, EIG)

Forum for Young Officers

Integrity of Fuel Pellet

D. Naga Sivayya

D. Naga Sivayya obtained his B.Tech. degree in Mechanical Engineering from Jawaharlal Nehru Technological University, Hyderabad in 2004. He is from 48th batch of BARC Training School and joined IGCAR as Scientific Officer (SO/C) in September 2005.

Ceramic fuels are inherently brittle, and therefore they are prone to crack during power rise due to high thermal stresses. In a typical Fast Reactor fuel pin with mixed oxide fuel, the centreline temperature is in the order of 2500 K and the fuel surface temperature is around 1223 K during normal operating condition. However during over-power transients, the centreline temperature may reach up to melting point. Even during normal operating condition, large temperature gradient across the pellet radius induces high thermal stress, which leads to pellet cracking. The radial pellet cracking aids in establishing the fuel-clad contact, there by improving the gap conductance. But if the cracking leads to pellet fragments, which may occupy the adjacent fuel-clad gap, then it may obstruct the expansion of the pellet and may even lead to clad failure due to local stress. The cracking of fuel pellets is also important to evaluate the FCMI (Fuel-Clad Mechanical Interaction), fission gas release, and hence swelling. So to check and ensure the fuel integrity at high thermal gradients, a study was carried out to find the crack initiation, propagation, number of cracks forming and their lengths as function of power.

The fracture behaviour of the fuel depends on the temperature. Up to 1470 K, of fuel is brittle and from 1470 K to 1670 K, it is sub-brittle which is characterized by measurable plastic strain before fracture. After 1670 K the fuel behaves almost ductile and considerable amount of plastic deformation occurs before fracture. The regions in the fuel pellet are shown in the Fig. 1. The extent of the regions will change depending on the power.

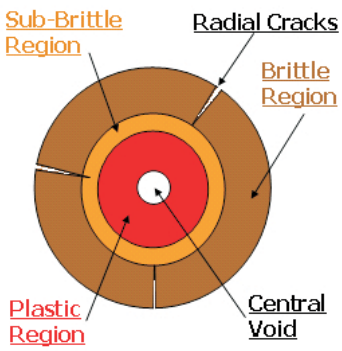


Fig. 1 : Cracking regions in Fuel Pellet

Temperature Profile

During power increase from startup to full power at 450 W/cm Linear Power (LP), the thermal gradient keeps on changing. For the linear power up to 200 W/cm, the fracture behaviour of the entire pellet cross section is brittle. At 450 W/cm, the brittle region is limited to only 0.4 mm from the periphery of the pellet. The temperature profile at the linear power 450 W/cm is shown in Fig. 2.

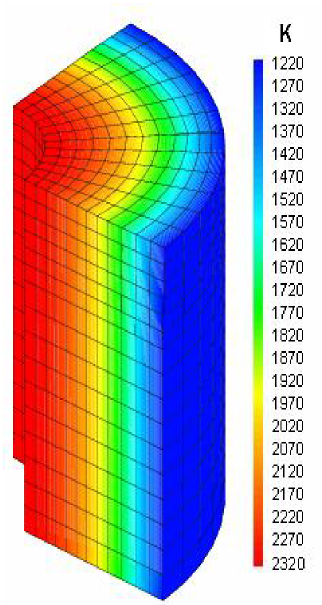


Fig. 2 : Temperature Profile at 450 W/cm

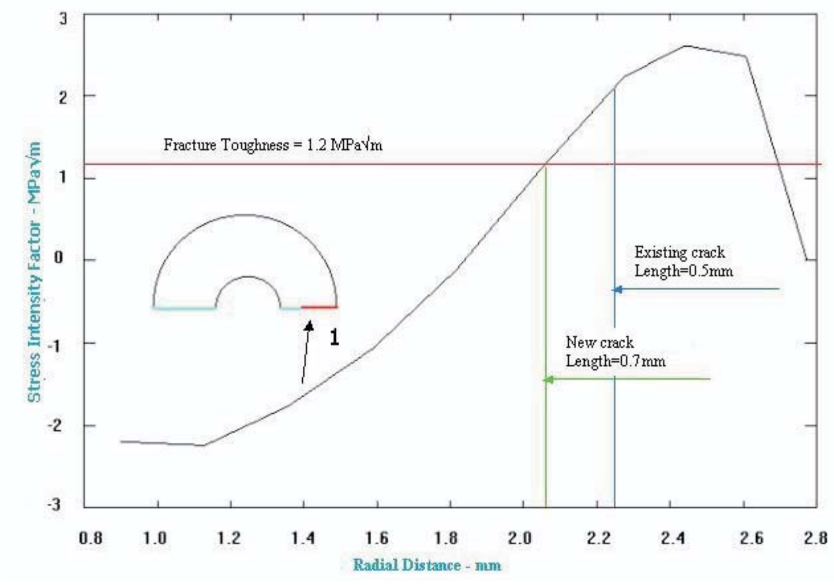


Fig. 3 : Stress intensity factor as a function of Radial crack length at 100 W/cm

Finite Element code CAST3M is used for the thermal and structural analysis. The fuel pellet is modeled using 3D CUB8 elements. The meshing is done in such a way that crack length can be modified easily as and when required. And also provisions are made to have multiple cracks with varying crack lengths.

Criteria for the crack initiation and propagation

Due to thermal gradient in radial direction, tensile stress is induced in the outer layers of fuel pellet and compressive stress is induced in the inner layers. The magnitude of these stresses will increase with power rise. At particular power when the stresses are more than the fracture strength, a crack will initiate at the maximum flaw location due to stress concentration. Crack initiation relieves the tensile stress in the cracked portion. And as the power rises further, these stresses will again increase leading to another crack formation mostly random in real case but for the analysis it is assumed that the cracks form symmetrically.

Fracture mechanics approach is used for the crack propagation. From the nominal stress around the crack tip, Stress Intensity Factor (K_I) is calculated and compared with the fracture toughness (K_{IC}).

If $K_I < K_{IC}$ No Crack propagation.

$K_I > K_{IC}$ Crack Propagation continues.

The crack length for different cracks is incremented by changing the mesh until the stability of crack is reached. Up to 50 W/cm LP, the tensile strength in the pellet does not exceed the fracture strength of the pellet, so there will be no cracking. At 100 W/cm LP, cracking takes place as the tensile stress crosses the fracture stress. With initial approximation of minimum of 0.1 mm crack length, the crack propagation was checked. Fig. 3 explains a case of crack advancement from 0.5 mm to 0.7 mm.

The stress intensity factor at the crack tip of 0.5 mm is 2.2 MPa√m, where as fracture toughness is 1.2 MPa√m. So, the crack advances. The analysis was carried out for increasing power levels and verified more crack formation & propagation. With increase in power, the pellet as well as the clad expands. In

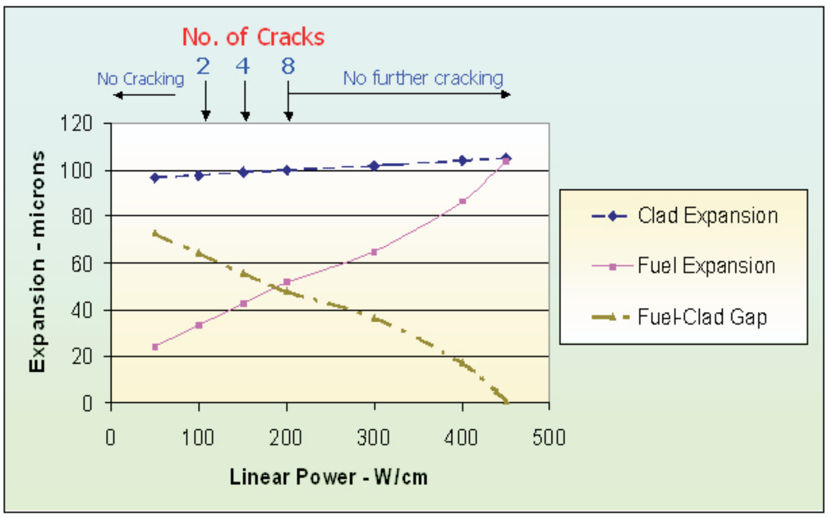


Fig. 4 : No. of cracks and Fuel-Clad gap variation with Linear Power

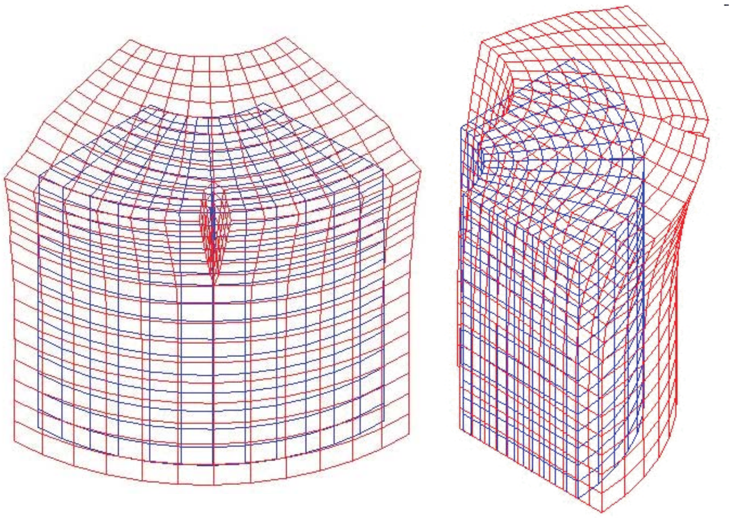


Fig. 5 : Pellet Deformation at 450 W/cm

addition, cracking promotes further expansion of pellet, which decreases the Pellet-Clad gap. Fig. 4 shows the maximum pellet expansion, clad expansion and minimum pellet-clad gap variation with the linear power of the pellet. On the top of the plot, the number of cracks formed is indicated.

Conclusion

This analysis is carried out to establish the analytical capability of CAST 3M for fuel modelling studies. From the analysis, at 450 W/cm, totally 8 cracks are formed with a maximum crack length of 0.75 mm from periphery of the pellet. The integrity of the pellet is ensured by the remaining un-cracked portion (with 1.1 mm radius) of the pellet. The deformation of the pellet is shown in Fig. 5. Parametric study carried out on the number of cracks and crack length reveals that the increase in number of cracks decreases the maximum radial expansion and increase in crack length widens the crack opening which in turn increases the maximum radial expansion of the pellet.

(D. Naga Sivayya and Colleagues, Nuclear Engineering Group)

NEWS & Events

CEA-DAE Collaborative meeting on

"Nanoscience: nanomaterials – production and characterization; interfaces - self-assembled monolayers"

October 4, 2007

A meet on the CEA-DAE collaboration on the theme, "Nanoscience: nanomaterials – production and characterization; interfaces - self-assembled monolayers" was held at IGCAR Kalpakkam on October, 4, 2007. A six member CEA Delegation comprising of Dr. Pascal BOULANGER:CEA/DSM/DRECAM, Dr. Nathalie HERLIN-BOIME : CEA/DSM/DRECAM, Dr. Arianna Filoramo: CEA/DSM/DRECAM, Dr. Roberto Calemczuk : CEA/DSM/DRFMC, Doris Neumann-Maazi : CEA/DRI and Hughes de Longevialle: CEA/DRI, along with Dr. J.V. Yakhmi, Associate Director (P), BARC, participated in the one day meet at Kalpakkam. The technical programme comprised of presentations by CEA

Shri. S.C. Chetal, Director, Reactor Engineering Group, IGCAR with the CEA Delegation of CEA-DAE Collaborative meeting on "Nanoscience: nanomaterials – production and characterization; interfaces - self-assembled monolayers"

and IGCAR scientists and visits to the laboratories. Topics for collaboration in the area of Chemical Sensors and participation in Synchrotron experiments were discussed.

(Reported by C. S. Sundar, Materials Science Division)

Visit of CEA, France delegation
October 17-18, 2007

A three member CEA delegation comprising of Dr A. Alamo (DEN/DSOE), Dr. P. Chaix (DEN/DSOE) and Dr. C. Robertson (DEN/DMN) visited IGCAR during October 17 and 18, 2007. Presentations on "CEA Basic Research Programs for Nuclear Energy Applications", "Advanced Steels and ODS Alloys for Nuclear Applications", and "Strain Localization in Irradiated Austenitic Stainless Steels, were made by the visiting CEA Scientists, followed by in-depth discussions. The main objective of the discussion session was to put into action the Implementing Agreement *"Investigation of irradiation-induced microstructure in ODS materials using JANNUS facilities and multi-scale modelling" that* was signed in Cadarache on 24th September 2007. The scientific and technical aspects of the collaborative programme that deals with investigation of the stability of nano-sized yttria particles in iron matrix, under various irradiation conditions and mechanical loading was discussed in detail to evolve the various steps of experimentation and simulation.

French delegation seen along with Shri S.C. Chetal, Director, Reactor Engineering Group

(Reported by C. S. Sundar, Materials Science Division)

India-Japan Specialists' Meeting on Safety in Nuclear Energy
November 12-13, 2007

Dr. Baldev Raj, Director, IGCAR and Prof.Y. Fuji-ie, Former Chairman, Atomic Energy Commission of Japan, with the participants of the "India-Japan Specialists' Meeting on Safety in Nuclear Energy"

The India-Japan Specialists' meeting on Safety in Nuclear Energy was held at IGCAR, Kalpakkam during 12-13 November, 2007. A thirteen-member Japanese delegation led by Prof.Y.Fuji-ie, Former Chairman, Atomic Energy Commission of Japan participated in the specialist meeting. From Indian side twenty members from IGCAR and BHAVINI attended the meeting. The meeting started with introductory remarks by Dr. Baldev Raj, Director, IGCAR and Prof. Fuji-ie, leader of the Japanese delegation. In his introductory remarks Dr. Baldev Raj, gave an overview of the current status of fast reactor development in India. In his talk Prof. Fuji-ie, touched upon "Nuclear Development in Japan" and "Basic idea of securing nuclear system safety". In all there were eight presentations, four from Japanese delegation and four from Indian participants. Mr. A. Yoshida from O-arai Research and Development Center, JAEA, talked on "The Operating experience of Japanese fast experimental reactor Joyo" and Dr. Y. Kani, Leader of the Fast Reactor Programme in Japan and the Deputy Director General, Fast Breeder Reactor Research and Development Center, JAEA gave a talk on "Safety approach and safety evaluation of Japanese prototype fast reactor Monju". Mr. N. Suda from the Nuclear Safety Technology Centre, Japan, in his talk gave the details of the "System for prediction of environmental emergency dose information (SPEEDI)". Shri S.C. Chetal, Director, Reactor Engineering Group, discussed the "Safety criteria & design provisions of Prototype Fast Breeder Reactor in India" and Shri. P.V. Ramalingam, Director, Reactor Operation & Maintenance Group, in his talk covered the "Operating experience of Fast Breeder Test Reactor". Shri. M. Rajan, Director, Safety Group touched upon the "R&D studies concerning sodium fire at Indira Gandhi Centre for Atomic Research" and Dr. P. Chellapandi, Associate Director, Nuclear Engineering Group, REG discussed "Beyond design basis events and containment related aspects of Prototype Fast Breeder Reactor in India" in his talk.

Possible areas for further cooperation were discussed in the concluding session. The members of the Japanese delegation visited Fast Breeder Test Reactor and Prototype Fast Breeder Reactor, under construction by BHAVINI.

(Reported by M. Sai Baba, S&HRPS)

Visit of Parliamentary Standing Committee on
Science & Technology, Environment & Forests
December 21, 2007

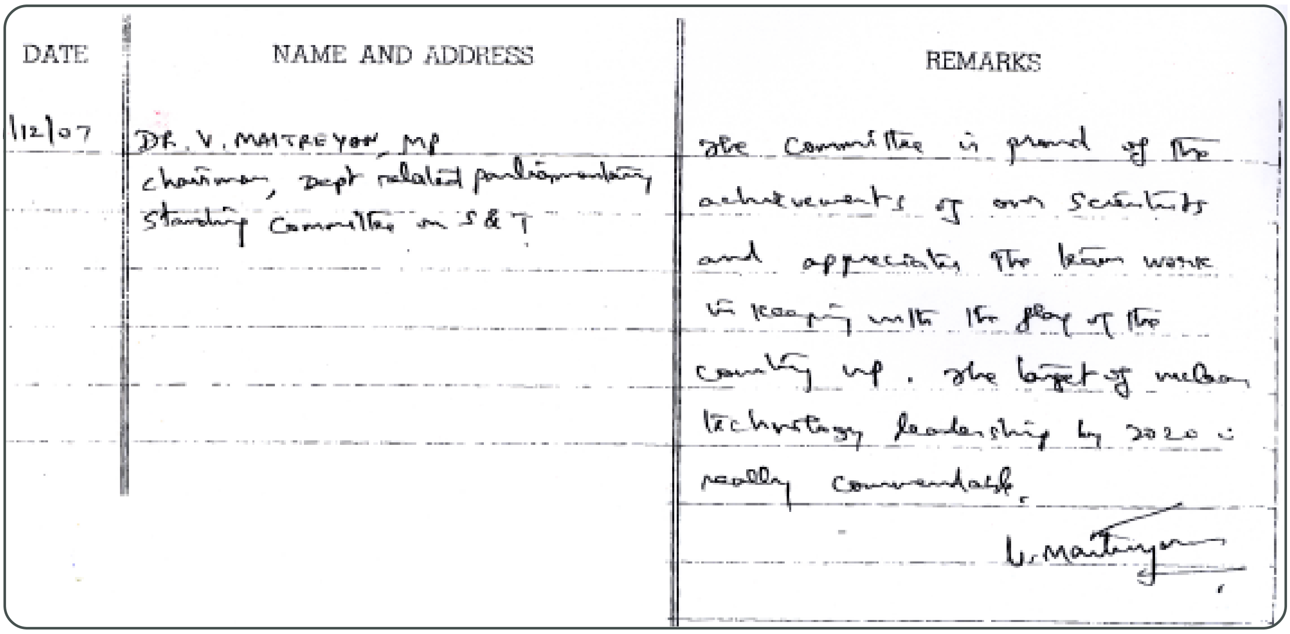
Dr. V. Maitreyan, Chairman and *Members of the* "Parliamentary Standing Committee on Science & Technology, Environment & Forests" with *Dr. Baldev Raj, Director, IGCAR and senior colleagues of IGCAR during their* visit to *IGCAR*

A delegation of members of the "Parliamentary Standing Committee on Science & Technology, Environment and Forests" under the Chairmanship of Honourable Member of Parliament, Dr. V. Maitreyan visited the Centre on 21 December, 2007. The delegation was received by Dr. Baldev Raj, Director, IGCAR, Heads of other DAE units at Kalpakkam and senior colleagues of the Centre. Dr. Baldev Raj, Director, IGCAR in his talk presented a status report on the Fast Breeder Test Reactor and the R&D activities of the Centre and gave a perspective of the future growth of fast breeder reactor program. An interesting and thought provoking discussion followed the presentation. The members of the standing committee expressed their appreciation for the progress made by the Centre in the development of fast breeder reactor and associated fuel cycle technologies

The members of the delegation visited; Fast Breeder Test Reactor, Radiometallurgy Laboratory and Engineering development and testing facilities of Fast Reactor Technology Group. They also visited the Prototype Fast Breeder Reactor, under construction by BHAVINI.

(Reported by M. Sai Baba, S&HRPS)

Remarks by Dr. V. Maitreyan, MP, Chairman, Department related Parliamentary Standing Committee on S & T



DATE	NAME AND ADDRESS	REMARKS
/12/07	DR. V. MAITREYAN, MP chairman, Dept related parliamentary standing Committee on S & T	The Committee is proud of the achievements of our scientists and appreciates the team work in keeping with the glory of the country up. The target of nuclear technology leadership by 2020 is really commendable. V. Maitreyan

Reproduced Message:

"The committee is proud of the achievements of our scientists and appreciates the team work in keeping with the glory of the country up. The target of nuclear technology leadership by 2020 is really commendable" - Dr. V. Maitreyan, MP

Symposia/Conferences

Sixteenth National Symposium & Workshop on Thermal Analysis (THERMANS 2008)

Indira Gandhi Centre for Atomic Research, Kalpakkam

February 4-6, 2008 (Symposium)
February 7-8, 2008 (Workshop)

The Sixteenth National Symposium and Workshop on Thermal Analysis-THERMANS - 2008 is being organized at Indira Gandhi Centre for Atomic Research, Kalpakkam, India during February 4-8, 2008. The Symposium and Workshop is sponsored by Board of Research in Nuclear Sciences (BRNS), Department of Atomic Energy (DAE) in association with the Indian Thermal Analysis Society (ITAS). In this Symposium, it is planned to focus on the theme "Thermal Analysis in Nuclear Technology and Allied Areas". The deliberations of the symposium will cover the following topics:

- High temperature thermochemistry and phase equilibrium studies.
- Thermochemical and thermophysical properties of nuclear materials.
- Solid state reactions and kinetics.
- Novel materials such as conducting polymers, ionic liquids.
- Nanomaterials.
- Polymers, composites and high energy materials.
- Glass and ceramics
- Catalysts
- Bio materials.
- Molten salts.
- Phase diagram computations and modeling.

For more information please visit the conference URL : http://www.itasindia.org

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International Conference on

Nanoscience and Technology

(ICONSAT-2008)

Convention Centre, Chennai Trade Centre, Chennai

February 27-29, 2008

An International Conference on Nanoscience and Technology (ICONSAT-2008) is to be held at Convention Centre, Chennai Trade Centre, Tamil Nadu, INDIA during February 27-29, 2008. This Conference, sponsored by the National Mission on Nano Science and Technology of the Department of Science and Technology, Govt. of India, is being organized by Indira Gandhi Centre for Atomic Research, Kalpakkam. ICONSAT-2008 which will bring together leading researchers from all over the World, in addition to the Indian scientists and students, will provide a forum to interact on the current developments and future trends in the multidisciplinary area of Nanoscience and Nanotechnology. The details of the technical programme can be found in the Conference Website: http://www.iconsat2008.com

As a part of ICONSAT-2008, two satellite events are also being organized: On February 26th, a day prior to the Conference, we are conducting a Workshop on "Nano Science & Technology for Health Care : Medical Diagnosis, Imaging and Drug Delivery", which will be for the benefit of Research scholars and professionals from medical and pharmaceutical fraternity. On Februray 28th, the National Science Day, Prof. C.N.R. Rao will conduct a programme entitled "Nano World". About 250 students from various schools and Colleges in the Chennai region are expected to participate in this interactive session.

Academia-IGCAR Meet (AIM-2007)

October 12, 2007

Guided by the success of the Centre's major initiative launched on October 2nd last year, IGCAR organized One-Day Academica-IGCAR Meet (AIM-2007) at Kalpakkam on Friday, October 12, 2007 for the Academia in science and engineering disciplines. A team of 250 resolute researchers, from various colleges and universities in Tamil Nadu, with excellent track of research and promising problems for exploration were short-listed for participation. The Meet focused on reinforcing the existing collaborations, and also on identifying new enabling partners in India's march towards its cherished vision of becoming a global leader in Sodium Cooled Fast Breeder Reactor (FBR) and associated fuel cycle technologies by 2020 AD. Academia from various others districts of the State, who have a strong desire to collaborate, also joined their Chennai colleagues in large numbers.

Chief Guest Prof. Dr. Tmt. Nalini Ravindran, Director of Collegiate Education, Govt of TN listening to Director IGCAR's address

IGCAR has been awarded the First prize in the category of Mass Awareness Campaign for the year 2007 by Public Relations Society of India (PRSI). Shri J. Daniel Chellappa, Technical Co-ordination & Public Awareness Cell, IGCAR is seen receiving the award from Shri K.K. Acharya, Managing Director of Chemical Petroleum Corporation Ltd. In the presence of Dr. Ajit Pathak, the President of PRSI on December 15, 2007 during 29th All India Public Relations Conference, December 13-15, 2007 at Chennai.

AIM-2007 provided an excellent platform for showcasing their expertise and the infrastructure of their institutions. They presented relevant project proposals for joint ventures and shared their excitements in pursuing science and engineering R & D with IGCAR scientists. They were keyed-up at the Centre's top-notch research culture and the commitment of our scientists. The day's programme included brain-storming session with Dr.Baldev Raj Distinguished Scientist and Director IGCAR, visits to laboratories of their interest, technical presentations by the Heads of the respective facilities, one-on-one interactions with their chosen scientists, business networking, feed-back session and panel discussion for formulating the roadmap to take the initiatives ahead. The progress of the collaborative ventures and the offshoots of AIM-2007 will be documented for periodic monitoring and further directions by the Centre.

(Reported by J. Daniel Chellappa and P.V.Ramalingam, PRAI Committee)

AWARDS AND HONOURS

- Dr. Baldev Raj has been awarded the prestigious the **National Metallurgist Award-2007** (Research-Academy) by Ministry of Steel, Govt. of India and Indian Institute of Metals. He has been awarded the prestigious **Life Time Achievement Award** of Indian Institute of Welding. He has also received Stanley Ehrilich Gold Medal during the National Symposium on Acoustics (NSA-2007).

- Shri S.C. Chetal, Reactor Engineering Group has been conferred **National Design Award** by the Institution of Engineers, India.

- Dr. M. Vijayalakshmi, Physical Metallurgy Division has been awarded the **Metallurgist of the Year Award** for the year 2007 by Ministry of steels, Govt. of India and Indian Institute of Metals.

- Dr. C.K.Mukhopadhyay, Non-Destructive Examination Division has been selected to receive the **ISNT National NDT Award** under the category excellence in contribution to research & development, jointly sponsored by ISNT & M/s. Electronic & Engineering Co., Mumbai, for the year 2007.

- Dr. A. K. Tyagi, Materials Science Division has been awarded the **MRSI Medal** for the year 2008 by Materials Research Society of India (MRSI).

- IGCAR has won the **First Prize** for the category "Mass Awareness Campaign" for the year 2006-07. The apex national PR body, Public Relations Society of India (PRSI) has honoured the Centre for its team efforts in the mass campaign for the role of Fast Breeder Reactors in ensuring the energy security for India.

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